Wilmington Riverfront Transportation Infrastructure Project

Appendix I: Natural Resources Technical Report

Appendix E: 2D Scour Report (Part 1 of 2 Files)

March 29, 2024





Appendix E – 2D Modeling, Scour and Drainage Analysis Report

South Wilmington Infrastructure Improvements

Wilmington, DE

2D MODELING, SCOUR, AND DRAINAGE ANALYSIS REPORT

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I. Introduction

The Riverfront Development Corporation (RDC), in coordination with DelDOT and the City of Wilmington, is working on a large-scale brownfield redevelopment project, the South Market Street Master Plan Project. The redevelopment project will ultimately guide the future development of the South Market Street corridor along the Christina River within the City of Wilmington. The Master Plan is a multi-phase redevelopment project. The first phase of the redevelopment is Area 1, which is subsequently followed by Area 2 and Area 3. See Figure 1 for the approximate limits for each of the three phases.

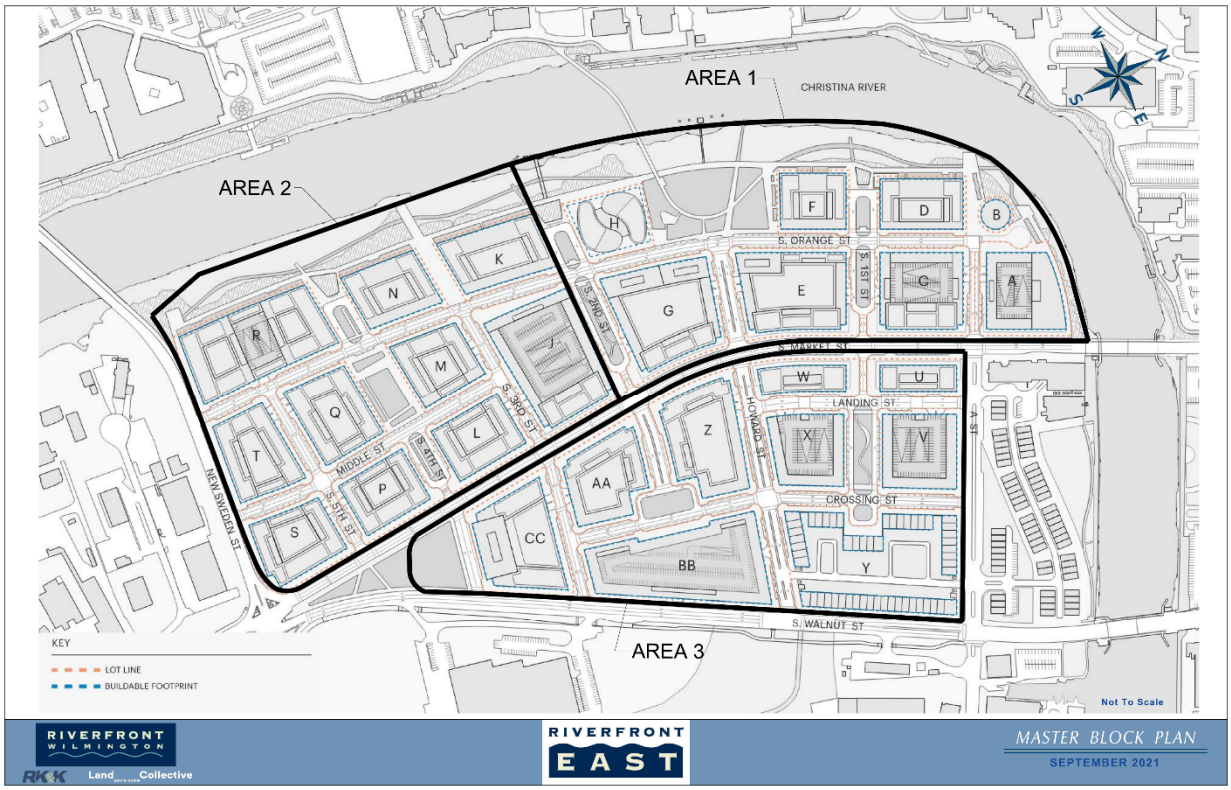

Figure 1: Project Limits

The project will also provide roadway improvements throughout the Market Street corridor; parking bump outs, drainage mitigation and upgrades, street landscaping and lighting will provide the corridor with improved pedestrian experiences as well as efficient traffic flow to support the new development.

During the design phase of Areas 1 and 2, it was noted that South Market Street and its associated existing bridge (BR 1-688) over the Christina River is an emergency evacuation route for the downtown waterfront area. South Walnut Street and its associated existing bridge (BR 1-687) over the Christina River is also directly adjacent to the proposed development. Therefore, the Delaware Department of Transportation (DelDOT) requested additional analyses be conducted in accordance with their Bridge Scour Modeling Directive (See Appendix A for a copy of the directive received by

RK&K) to determine what impacts, if any, the project may have on the existing bridges. Additionally, due to the existing low-lying nature of Areas 1, 2, and 3, DelDOT requested that these analyses consider and evaluate impacts, if any, the waterfront development may have on water surface elevations and limits of storm inundation. Due to the complex nature of flood flows within the downtown waterfront area, proximity of the Market Street bridge to severe meander bend, and proposed increase in final grades of Area 1, 2, and 3, the use of a 2-dimensional (2D) hydrodynamic model was requested by DelDOT. Analyses, including a wide range of riverine and tidal scenarios, were evaluated in detail using TUFLOW. Surface-water Modeling System (SMS), Version 13.1, was used for the graphical user interface (GUI), which all components needed for TUFLOW modeling were compiled. The use of TUFLOW allows for:

- Spatial analysis of velocities and water surface elevations within a channel and floodplain surface areas and not only at individual cross-sections
- Calculation of varying velocities and water surface elevations laterally across channels and floodplains
- More effective modelling of flow transitions, ineffective flow areas, channel and floodplain bend loses, and flow expansion and contraction using a finite volume explicit solution

In addition to the 2D model request, initial discussions, and coordination with DelDOT considered incorporating the existing and proposed storm drain system into the model; however, it was determined that the minor conveyance through the storm drain is negligible compared to the major conveyance through the Christina River and its floodplain. Therefore, the storm drains were not included in the TUFLOW model.

The remainder of this report details the modeling methodology, scenarios evaluated, and evaluation and presentation of the results including scour at the South Market Street and South Walnut Street bridges and analysis of the proposed storm drain network separate from TUFLOW.

II. 2D Modeling Methodology

A. Modeling Directive

Per the DelDOT provided Bridge Scour Modeling Directive (Directive), three Scenarios were considered and evaluated:

- Scenario 1: A steady-flow scenario with design upland flow (from the stream or river) for the hydraulic design event and the scour design event with the downstream boundary is set to the MHW elevation of the tidal receiving water daily astronomical tide.

- Scenario 2: A steady-flow scenario with design upland flow (from the stream or river) for the hydraulic design event and the scour design event with the downstream boundary is set to

the MLW elevation of the tidal receiving water daily astronomical tide.

- Scenario 3: An unsteady-flow scenario with the source of flooding being the ebb and flood tides from the tidal receiving water (no upland flow from the stream or river) with the downstream boundary conditions being set to the design, 100-year, and 200-year storm surge hydrographs from the tidal receiving water. Scenario 3, "no upland flow," should be simulated for a total period of 60 hours, which comprises the entire surge period in Delaware.

Since South Market Street and South Walnut Street have clear spans greater than 20-feet and are classified as principle arterial roadways, the 50-year storm event is the hydraulic design event per Table 104-5 of DelDOT's 2022 Bridge Design Manual (BDM). In accordance with 2022 BDM and Federal Highway Administration's (FHWA) Hydraulic Engineering Circular No. 18, Evaluating Scour at Bridges (HEC-18), Fifth Edition. The 100-, 200-, and overtopping events are scour events considered.

In addition to the hydraulic design and scour events outlined above, DelDOT requested that the 2D modeling also consider and evaluate the 1-, 2-, 10-, and 25-year storm events and potential consequences of sea level rise (SLR). The tailwater elevations as developed by the 2D modeling, with and without SLR, were evaluated to determine the influences to the proposed drainage network and scour potential at the two bridges.

B. Hydrologic Inputs, Tidal Elevations, and Model Boundary Conditions

Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) 10003CV001D for New Castle County, served as the basis for hydrologic inputs for Scenarios 1, 2, and 3 including:

- Riverine discharges (Scenarios 1 and 2): flow through the Christina River is generated from rainfall/runoff from the upland watershed. Flow direction is downstream towards the Delaware River

- Tidal stillwater elevations (Scenario 3): flow through the Christina River is generated by the flood and ebb of tides associated with the surge hydrograph due to a coastal driven event. The Delaware River and ultimately the Atlantic Ocean are the tidal controls for the Christina River. Flow in the Christina River is both upstream (flood tide) and downstream (ebb tide). Water surface elevations refer to flood levels for identified storms resulting from astronomical tides and storm surge excluding the effects of waves.

Hydrologic inputs are used for the up and downstream modeling boundary conditions. The use of boundary conditions allow water to enter and/or leave the modeling domain in a justifiable manner.

For Scenarios 1 and 2, riverine discharges enter the modeling domain through the upstream boundary condition and leave the modeling domain at the specified MHW or MLW elevation through downstream boundary condition. For Scenario 3, water enters and leaves the modeling domain through the downstream boundary condition at an elevation specified by the surge hydrograph.

The FEMA FIS provided hydrologic peak inputs for the 10-, 50-, 100-, and 500-year storm events. Data for the 25-year storm was noted as not being calculated for the latest Flood Risk Project or not available from the previous effective FIS dated February 4, 2015. Since the FEMA FIS did not include inputs for the 1-, 2-, 25-, and 200-year storm events, additional computations were made to complete the analysis.

Discharges and stillwater elevations from the FEMA FIS were plotted in Microsoft Excel, on separate graphs, with their corresponding storm event to determine regression equations relating storm event to estimated discharges and stillwater elevations. Based on the regression equations, the 25- and 200-yr peak discharges and stillwater elevations were interpolated. Since FEMA FIS data did not go below the 10-yr storm event, it is not recommended to interpolate data for the 1- and 2-yr storm event based on the regression equations. To estimate stillwater elevations for the 1- and 2-yr storm events, a stage-duration curve was generated based water surface elevation data was taken from United States Geological Survey (USGS) stream gage 01480120. Water surface elevation data referencing North American Vertical Datum 1988 (NAVD88) has been available since October 2015; therefore, it is anticipated that estimates for the 1- and 2-yr storm event water surface elevations are captured within the available data. Due to the tidal influence of the Christina River, conservative estimates for the stillwater elevations for the 1- and 2-yr recurrence intervals are based on data points where recorded water surface elevations are above mean higher high water (MHHW). See Appendix B for supporting data interpolation figures and computations.

To assess impacts of SLR per the Bridge Scour Modeling Directive:

- 1.7-ft to 4.7-ft of SLR is expected between the years 2000 and 2100.
- 3.25-ft of SLR should be used as the intermediate SLR scenario
- The amount of SLR that has already occurred since 2000 should be removed from the 3.25-ft total

Assuming a linear relationship between SLR and years estimates that approximately 0.715-ft of SLR has occurred since the year 2000; therefore, an additional 2.535-ft should be incorporated into the analysis to assess impacts of SLR. While bridge rehabilitations operations have occurred for the bridges at South Market Street and South Walnut Street, it should be noted that the original structures for each bridge date back to the 1920s and 1950s, respectively. Bridge conditions/geometry in year 2100 will likely vary from current existing conditions as year 2100 is

beyond the service life of each bridge. See Appendix B for supporting SLR figures and computations.

Table 1 below provides a summary of all riverine discharges and tidal stillwater elevations including SLR for ease of comparison. Riverine discharges were not determined for the 1- and 2-yr recurrence intervals as they were not necessary for analysis per the Directive.

Table 1: Riverine Storm Discharges and Tidal Stillwater Elevations

Storm Event	Riverine Discharge	Stillwater Elevation	2.54-ft Sea Level Rise Stillwater Elevation[4]	Remark
1	--	3.2	5.7	See Note 1
2	--	3.6	6.1	See Note 1
10	13,100	6.9	9.4	See Note 2
25	18,700	7.4	9.9	See Note 3
50	22,900	7.8	10.3	See Note 2
100	27,600	8.3	10.8	See Note 2
200	33,900	9.5	12.0	See Note 3
500	41,700	10.8	13.3	See Note 2

Notes:

1. Stillwater elevation extracted from Stage Duration Curve based on USGS Gage 01480120
2. Discharge and stillwater elevation from FEMA FIS 10003CV001D, Table 17: Coastal Transect Parameters, Transect 24
3. Discharge and stillwater elevation interpolated based on FEMA FIS 10003CV001D, Table 17: Coastal Transect Parameters, Transect 24
4. 2.54-ft added to Stillwater Elevation to account for sea level rise

While the FEMA FIS 10003CV001D lists the 100-year stillwater elevation as 8.3-ft for the general downtown Wilmington area, the base flood elevation in the immediate vicinity of the project area is elevation 9-ft as shown on The Delaware Department of Natural Resources and Environmental Control (DNREC) Flood Planning Tool.

To determine appropriate values for MHW and MLW for the downstream boundary conditions for Scenarios 1 and 2, National Oceanic and Atmospheric Administration (NOAA) published elevations associated with the two closest tide stations were referenced. The two closest tide stations are Delaware City, Delaware and Marcus Hook, Pennsylvania. The downstream boundary condition is approximately 3 miles downstream of Area 3 near the confluence of the Christina River and Delaware River which is approximately half-way between these two tide stations. Therefore, downstream boundary conditions for MHW and MLW for 2D modeling and MHHW for the stage duration curve are based on an average of the published values. To be consistent with other data inputs, elevations needed to reference NAVD88. Vertical datum options for the Delaware City station did not include NAVD88; however, the Marcus Hook station vertical datum options did

was subtracted from elevations based on mean lower low water (MLLW) as the vertical datum. 2.98-ft was derived from comparison of published elevations for Marcus Hook when selecting MLLW and NAVD88 as the reference vertical datum. Table 2 below provides a summary of published NOAA values and values used. Figure 2 below shows the location of model boundary conditions.

Table 2: NOAA Published Tidal Elevations

Description	Delaware City, DE Station (MLLW)	Delaware City, DE Station (NAVD88)	Marcus Hook, PA Station (MLLW)	Marcus Hook, PA Station (NAVD88)	Average Value for Model Downstream Boundary Condition (NAVD88)
Mean Low Water	0.18	-2.80	0.18	-2.80	-2.80
Mean High Water	5.62	2.64	5.79	2.81	2.73
Mean Higher High Water	6.00	3.02	6.17	3.19	3.11

For scenarios 1 and 2 a steady-flow scenario was developed using a step-flow hydrograph as the upstream boundary for the Christina River. The use of a step-flow hydrograph simulates steady flow for each of the modeled events while incorporating the effects of floodplain wetting and volume fluxes as the discharges ramp up to the next design storm. The time component was evaluated to ensure that the model is run long enough for steady state conditions to occur during each return interval. Figure 1 shows the hydrograph used as the upstream boundary conditions for the Christina River.

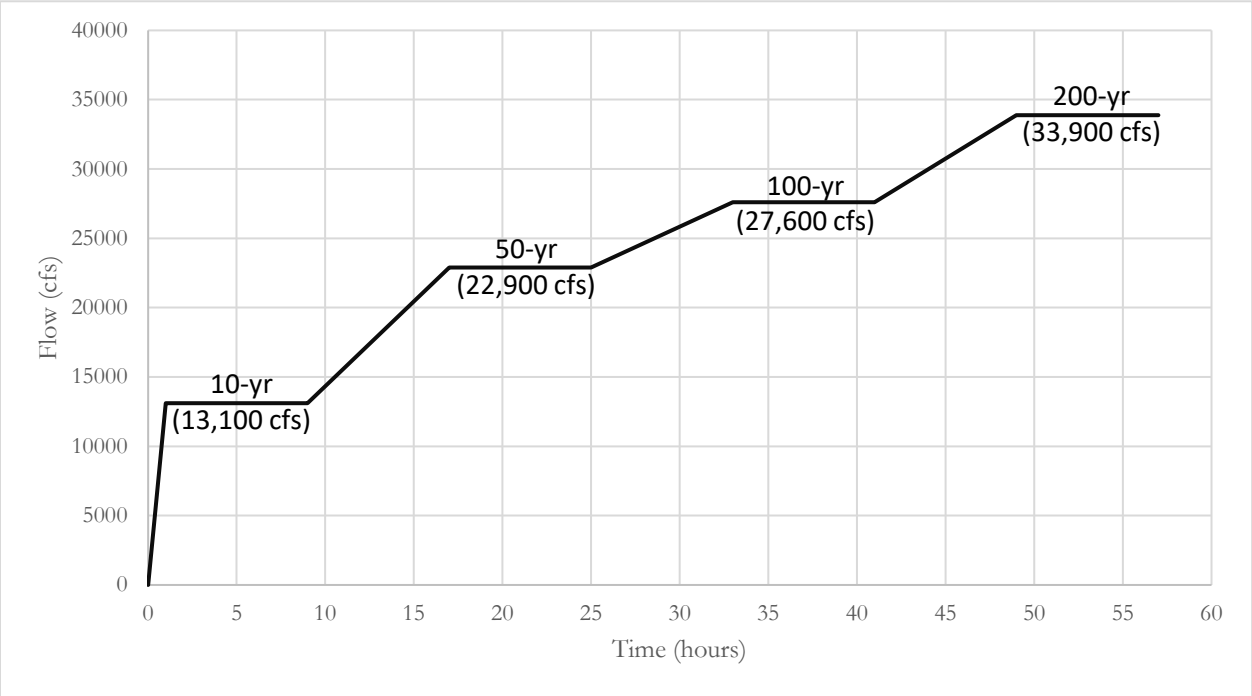

Figure 2: Christina River Step-Flow Hydrograph

The confluence of the Christina River and Brandywine Creek occurs approximately 1.3 miles downstream of the Area 3 project limits; therefore, it is unlikely that riverine discharges from Brandywine Creek influence hydraulics in proximity of the proposed development during Christina River peak riverine discharges. However, a constant flow of 200 cfs within Brandywine Creek was applied over the duration of the model simulations to bring water into the domain and ensure positive flow is maintained downstream towards the Delaware River.

For scenario 3 an unsteady-flow scenario was evaluated by routing a synthetic tide + storm surge hydrograph through the modeling domain for 60 hours, which comprises the entire surge period in Delaware per the Directive. The synthetic tide + storm surge hydrograph elevation, $S_{tot}(t)$, was developed based as combination of a synthetic tide hydrograph elevation, $H_t(t)$, and a synthetic storm surge hydrograph elevation, $S_t(t)$, based on FHWA HEC-25 Tidal Hydrology, Hydraulics and Scour at Bridges, First Edition methodology. Below are HEC-25 equations for $H_t(t)$, $S_t(t)$, and $S_{tot}(t)$ and resulting hydrographs:

Synthetic Daily Tide Hydrograph: $H_t(t) = a \times \cos\left(\frac{360t}{T}\right) + Z$

a = half the difference of MHW and MLW referencing mean sea level (MSL) datum
t = time (hours)
T = half the tidal day
Z = MSL to NAVD88 conversion

Synthetic Storm Surge Hydrograph: $S_t(t) = S_p\left(1 - e^{-\left|\frac{D}{(t-t_0)}\right|}\right)$

S_p = Peak surge elevation for selected return period (ft)
D = half storm duration
t = Time (hr)
t_0 = Time of peak surge or land-fall (hr)

Synthetic Tide + Storm Surge Hydrograph: $S_{tot}(t) = S_t(t) + H_t(t)$

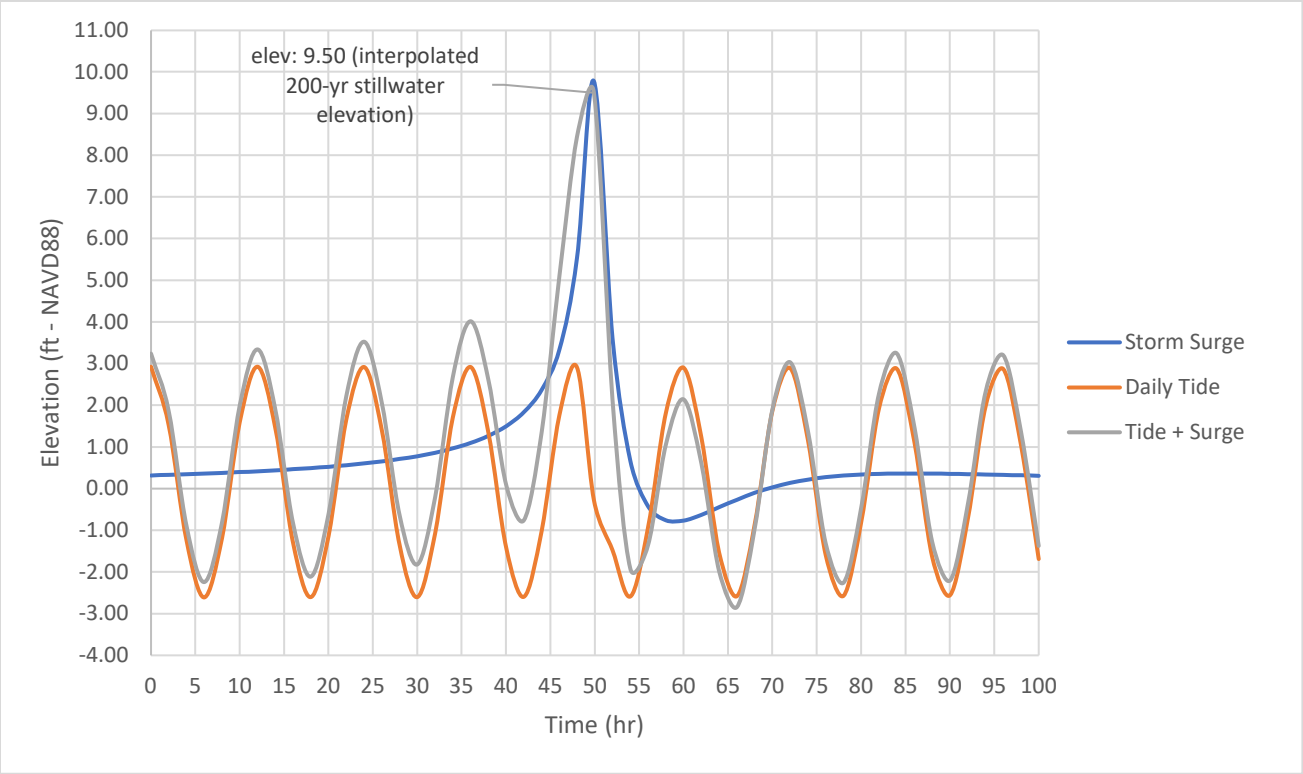

Figure 3: 200-yr Synthetic Tide + Storm Surge Hydrograph

Since FEMA stillwater elevations account for astronomical tides as well as anticipated storm surge, S_p, entered into the synthetic storm surge hydrograph equation was adjusted as needed to have peak $S_{tot}(t)$ match the FEMA stillwater elevation. Since the HEC-25 synthetic methodology produces hydrographs of similar shape corresponding to different elevations depending on the storm event of interest, one tidal hydrograph up to the 200-yr storm event was routed through the domain and results are based on when elevations, as determined by the model, are reached as less storms are essentially "nested" within the hydrograph above.

C. Surface Development

Three separate surfaces were developed representing:

- Existing Conditions
- Proposed Conditions – Area 1 Only
- Proposed Conditions – Full Build (Areas 1, 2, and 3)

Topobathymetric elevation data, referencing NAVD88, as developed by the USGS and NOAA was used as the base elevation data for all three surfaces. The use of topobathymetric elevation data, which includes topographic and bathymetric LiDAR data points, was necessary so that the 2D modeling domain is large enough to extend out horizontally placing the up and downstream

modeling boundary conditions sufficiently distant from proposed Areas 1, 2, and 3. This minimized the influence of the boundary conditions on hydrodynamic results.

Several other sources of elevation data were used in the immediate vicinity of the project area to depict the most detailed surfaces as feasible including:

- Compilation of topographic survey data covering Areas 1 and 2
- Digital elevation model of the Wilmington Wetland Park to the east of South Walnut Street
- Bathymetric data for the Christina River as collected by Aqua Survey as part of RK&K's efforts in the project vicinity
- 2022 Bathymetric data for the Christina River as collected by the United States Army Corps of Engineers
- Geographic Information Systems (GIS) data representing existing building footprints

GIS data representing existing building footprints does not inherently have any elevation data associated with it; however, buildings are obstructions to flow patterns when the floodplain is accessed during flooding events. Therefore, existing building footprints were inserted into the existing surface at a set elevation above ground to accurately represent flow patterns between buildings.

Using the existing conditions surface as a foundation, proposed conditions surfaces representing Area 1 Build only and Full Build were created. Additional elevation data sources that were used to create the proposed condition surfaces included:

- Roadway surfaces created by the RK&K design team where available
- Linework created by the RK&K design team representing potential future buildings within Areas 1, 2, and 3

As with the GIS data representing existing building footprints, linework for potential future buildings does not inherently have any elevation data associated with it; therefore, this linework was merged into the proposed surfaces at a set elevation above ground so that proposed flow patterns could be captured and compared with existing flow patterns.

D. TUFLOW Modeling Domain

The TUFLOW modeling domains used for the various Scenarios covers the downtown Wilmington waterfront and extends approximately from:

- The confluence of the Christina River and Little Mill Creek in the east
- Martin Luther King, Jr. Boulevard in the north

- I-495 in the east and south

Initial domain setup included evaluation of modeling Scenarios 1 and 2. The modeling domain was slightly expanded in all horizontal directions when evaluating modeling Scenario 3 to limit the artificial influence of where water and limits of inundation are constrained by the set domain.

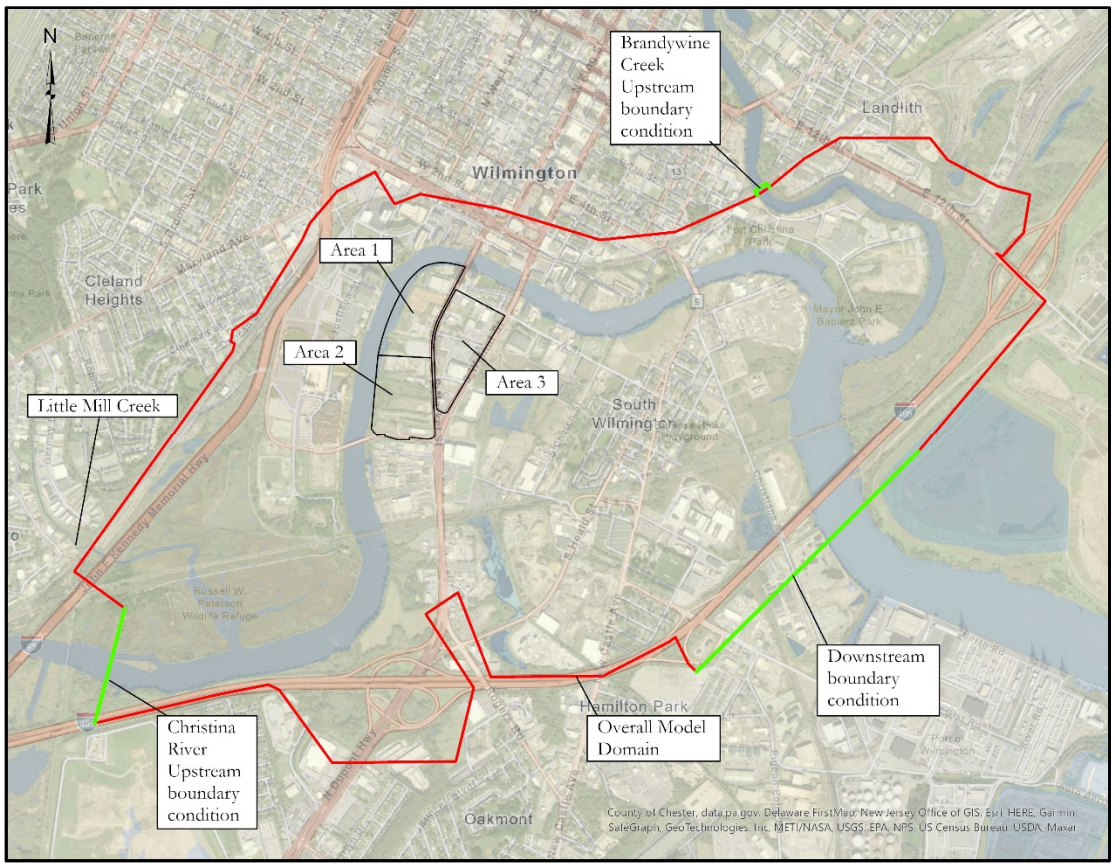

Figure 4: 2D Modeling Domain

TUFLOW, Version 2018-03-AE, was used to carry out the computations for all modeling scenarios within the modeling domain. TUFLOW solves the full 2D St. Venant Equations which are depth averaged momentum and continuity equations also referred to as the 2D shallow water equations.

During the initial steps of determining the appropriate model domain, a sensitivity analysis was completed where a cartesian grid spacing ranging from 5-ft to 20-ft was tested while holding all other variables constant. A results comparison when using a 5-, 10-, and 20-ft grid size showed little variation between the computed results while a 5-ft grid yields the longest runtimes, and a 20-ft grid yields the shortest runtimes. Based on the need to balance simulation runtimes (which can become excessively long for 2D models), datafile output sizing, and results accuracy, a cartesian grid size of 10-ft was selected and ultimately used for all modeling scenarios.

E. Additional Inputs

Additional inputs required for the 2D modeling include:

- Selection of a computational timestep (the time interval at which the 2D model engine will solve)
- Existing and proposed land-use data
- Incorporation of bridge geometry

TUFLOW uses adaptive timestepping which allows the model solver to automatically adjust the computational timestep as the simulation progresses to help ensure that model stability is maintained. While a computational timestep of one second was selected for initial conditions, the timestep throughout the simulation varied and was adjusted by the solver as needed.

Detailed one-meter resolution land-use cover data representing existing conditions that covers the entire project area and domain is publicly available from the Chesapeake Conservancy. A Manning's n-value was assigned to each land-use category to be used in the computations. The Chesapeake Conservancy land-use data covers the major categories including but not limited to: open water, impervious area, forests, wetlands, and urban open land. For each of the proposed conditions, the existing landuse data was modified and updated to include the new locations of buildings, open space, and roads.

The geometry for five bridges based on previous RK&K modeling efforts, RK&K design work, and DelDOT record as-built/rehabilitation plans were included in the model domain including:

- Norfolk Southern crossing just downstream of the Christina River and Little Mill Creek confluence
- New Sweden Bridge
- South Market Street Bridge
- South Walnut Street Bridge
- East 4th Street Bridge

The second Norfolk Southern and I-495 bridges downstream of East 4th Street where not included as those bridges are sufficiently far enough downstream of the project area that they are not anticipated to have any impacts on hydrodynamic results in the vicinity of the project area.

III. 2D Modeling Results and Scour Analysis

A. Background Discussion

The downtown Wilmington waterfront is a low-lying area, much of which is below FEMA's 10-year stillwater elevation of 6.9-ft; therefore, frequent inundation occurs even during lower intensity storms. Past improvements within the downtown waterfront include raising of Market Street to be above the 10-year water surface elevation to facilitate passage of vehicles during lower storm events; however, frequent nuisance inundation persists due the general low-lying nature of the area. Comparing existing topography to the FEMA base flood elevation (BFE) of 9-ft shows that only select isolated areas within the project vicinity are above this elevation. When floodwaters reach these high elevations, impacts to vehicular travel and/or evacuation are well beyond the project limits, extending throughout South Wilmington. As shown in figures in Appendix C, tidal surge elevations within the Christina River and subsequently the Delaware River control the limits of inundation throughout South Wilmington. While the final grades of Areas 1, 2, and 3 are proposed at elevation 10.5-ft, 1.5-ft above the FEMA 100-year BFE per the City of Wilmington's code, impacts to water surface elevations are negligible and barely tangible considering the scale at which a tidal surge event impacts South Wilmington and beyond.

Due to the exclusion of the pipe network from the 2D models, the ability to compare time required to drain roadways and upland areas is limited. The 2D models are controlled by the underlying modeling surface which means that topographic low points or sumps where existing and/or proposed drainage infrastructure exists are sinks in which flow can enter during periods of high-water surface elevations, but ultimately gets "trapped" as floodwaters recede, and flow paths are cutoff by the topography. A preliminary analysis of timing was performed looking at tidally controlled events and it showed that there is a slight delay in the time it takes for floodwaters to reach South Market Street under Full Build Conditions due to the increased final grade elevations. This represents a slight increase in time that South Market Street could be utilized for emergency evacuation during the period with which floodwaters are rising due to a tidal storm surge, but prior to the tidal storm event making landfall where floodwater elevations can rise rapidly and/or the beginning of heavy inland rainfall as heavy inland rainfall can further exacerbate storm surge flooding as water can no longer drain towards the Christina and Delaware River. Additionally, the existing and proposed storm drain networks associated all three proposed areas discharge to the Christina River at approximately elevation 0.4-ft or lower, with most outfalls discharging near elevation -2.7-ft. Therefore, the storm drain network cannot fully drain South Market Street and upland areas while water surface elevations are above MLW with timing being dependent on each storm event. See Section IV: Drainage Analysis for additional discussions on the proposed storm drain infrastructure.

Based on the DelDOT record as-built/rehabilitation plans, the low chord elevation for South Market Street and South Walnut Street bridges are well above the 200-year storm even considering

SLR; therefore, evaluation of pressure flow and overtopping events were not required. Results for each modeling scenario were compared against each other to evaluate which scenario produced the "worst-case" hydraulic and scour condition. As part "worst-case" evaluation, Scenario 3 showed that tidal flood flows produced more conservative scour depth estimates than tidal ebb flow; therefore, tidal flood flows results are presented below.

The bridge scour routine developed by FHWA and built-in to SMS was used to extract average hydraulic parameters for each of the modeling scenarios. Per FHWA guidance, average, not maximum, hydraulic parameters should be used in scour computations. Figure 5 below shows the general layout used for extracting hydraulic parameters and presenting of results. In Figure 5, the left (LOB) and right overbank (ROB) areas, used to denote hydraulics outside of the main channel, are based on riverine or tidal ebb flow towards the Delaware River. The location of the LOB and ROB are reversed for tidal flood flow as the bridge scour routine computations are carried out left-to-right in the direction of flow. The labeling of piers and abutments were left consistent with the labeling shown in Figure 5 regardless of modeling scenario. For South Walnut Street, the geometry of each pier, including pier width, length, and shape, is incorporated into the SMS routines so that flow patterns around these obstructions are accurately modeled. Scour results will be discussed in further detail in the next section. See Appendix D for figures detailing the bridge scour routine layouts used for each modeling scenario.

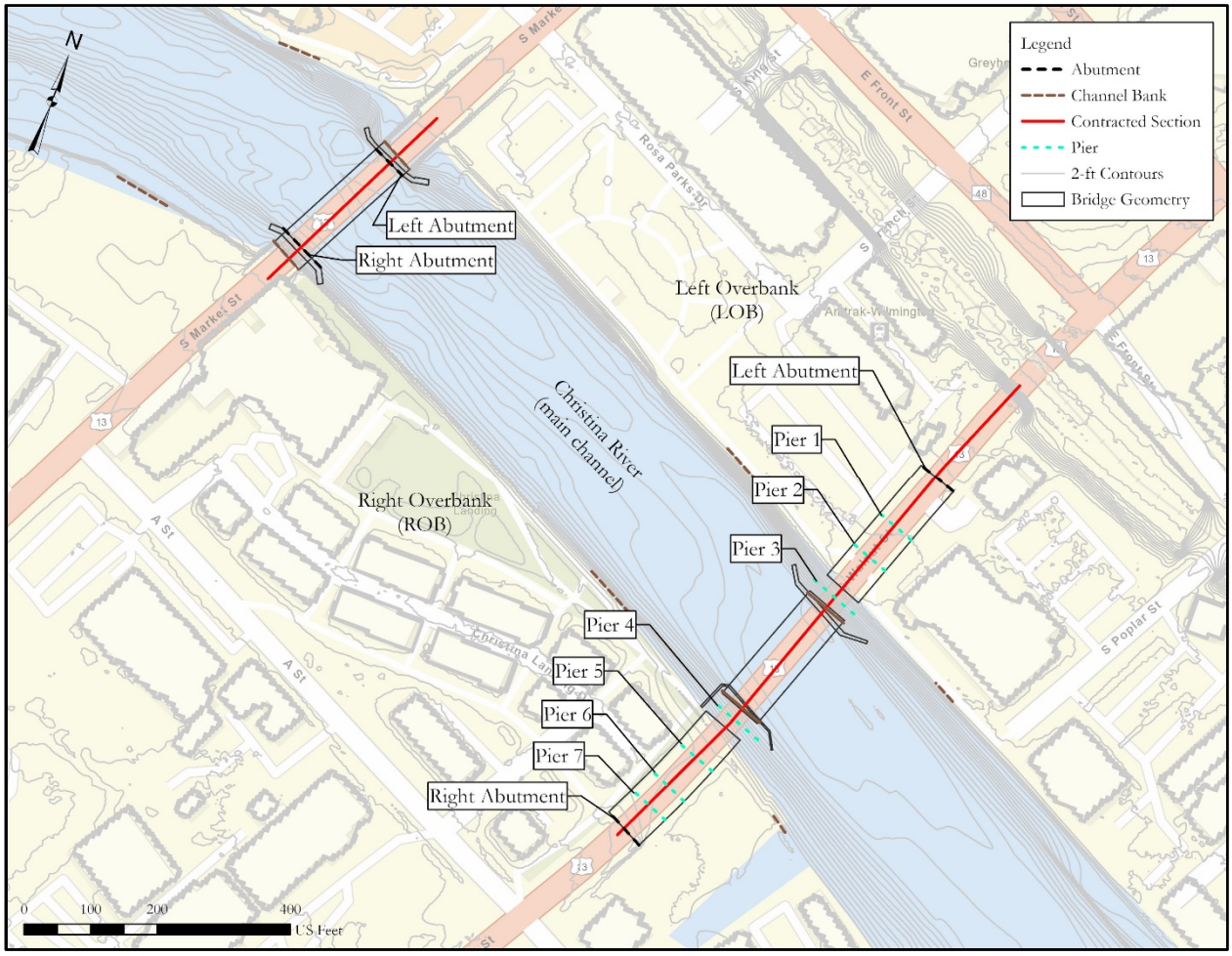

Figure 5: South Market and Walnut Analysis Layout

While results below are based on the latest FEMA, NOAA, and FHWA synthetic tidal storm input parameters, it is likely that the extent of flooding and/or scour depths produced by actual storm events will be unique to each storm event as parameters such as rainfall intensity, rainfall depth, tidal surge elevation, tidal surge duration, forward speed of the storm, and storm angle of approach to the coast are unique to each storm.

B. Hydraulic Design and Check Flood Frequency Results

When comparing existing conditions and the two build out conditions across the three Scenarios requested in the Directive, results indicate that the project has negligible impact to water surface elevations, channel velocities, and subsequently estimated scour depths. Modeling Scenario 2, riverine discharges paired with mean low water boundary conditions, generated the lowest water surface elevations and highest channel velocities within the Christina River. Modeling scenario 3, no riverine discharges and only tidal surge flow, generated the highest water surface elevations and lowest channel velocities within the Christina River and adjacent floodplain.

Per Figure 104-5 of the 2022 BDM, South Market Street and South Walnut Street should use the 50-year hydraulic design frequency and 200-year scour design and check flood frequency for analysis. Tables 3-6 present the average extracted channel velocities and water surface elevations within the Christina River for the three modeling scenarios and three build conditions for hydraulic design frequency and check flood frequency.

Table 3. Average Contracted Section 50-yr Channel Velocities (fps)

Build Scenario	South Market Street			South Walnut Street		
	Scenario 1 (Riverine Flow & MHW)	Scenario 2 (Riverine Flow & MLW)	Scenario 3 (Tidal Surge Only)	Scenario 1 (Riverine Flow & MHW)	Scenario 2 (Riverine Flow & MLW)	Scenario 3 (Tidal Surge Only)
Existing Conditions	4.38	4.83	1.94	4.09	4.56	1.73
Area 1 Build Conditions	4.38	4.83	1.91	4.08	4.56	1.70
Full Build Conditions	4.38	4.83	1.86	4.08	4.56	1.66
Max. Percent Change (%)	0.00	0.00	-4.30	-0.25	0.00	-4.22

Table 4. Average Contracted Section 50-yr Channel WSELs (ft)

Build Scenario	South Market Street			South Walnut Street		
	Scenario 1 (Riverine Flow & MHW)	Scenario 2 (Riverine Flow & MLW)	Scenario 3 (Tidal Surge Only)	Scenario 1 (Riverine Flow & MHW)	Scenario 2 (Riverine Flow & MLW)	Scenario 3 (Tidal Surge Only)
Existing Conditions	4.61	1.66	7.79	4.41	1.39	7.78
Area 1 Build Conditions	4.61	1.66	7.81	4.41	1.39	7.80
Full Build Conditions	4.61	1.66	7.83	4.41	1.39	7.81
Max. Difference	0.00	0.00	0.04	0.00	0.00	0.03

Table 5. Average Contracted Section 200-yr Channel Velocities (fps)

Build Scenario	South Market Street			South Walnut Street		
	Scenario 1 (Riverine Flow & MHW)	Scenario 2 (Riverine Flow & MLW)	Scenario 3 (Tidal Surge Only)	Scenario 1 (Riverine Flow & MHW)	Scenario 2 (Riverine Flow & MLW)	Scenario 3 (Tidal Surge Only)
Existing Conditions	5.88	6.42	1.00	5.49	6.05	0.91
Area 1 Build Conditions	5.88	6.41	0.99	5.49	6.04	0.91
Full Build Conditions	5.87	6.41	0.93	5.48	6.04	0.85
Max. Percent Change (%)	-1.00	-1.00	-7.00	-1.00	-1.00	-6.00

Table 6. Average Contracted Section 200-yr Channel WSELs (ft)

Build Scenario	South Market Street			South Walnut Street		
	Scenario 1 (Riverine Flow & MHW)	Scenario 2 (Riverine Flow & MLW)	Scenario 3 (Tidal Surge Only)	Scenario 1 (Riverine Flow & MHW)	Scenario 2 (Riverine Flow & MLW)	Scenario 3 (Tidal Surge Only)
Existing Conditions	6.36	4.44	9.49	6.00	3.97	9.49
Area 1 Build Conditions	6.36	4.44	9.48	6.00	3.97	9.49
Full Build Conditions	6.36	4.44	9.49	6.00	3.97	9.50
Max. Difference	0.00	0.00	-0.01	0.00	0.00	0.01

In the 200-year storm, for Scenarios 1 and 2, it was noted that negligible increases in water surface elevations of 0.1- to 0.2-feet for the Area 1 Build and Full Build Conditions show slightly worse limits of inundation in isolated locations as compared to Existing Conditions. For Scenario 1, this can be seen from the intersection of Christina Avenue and Canal Street to Commerce Street where it appears that 200-year floodwaters access roadside swales along Canal Street and are conveyed northeast to Commerce Street. Similarly, for Scenario 2, this can be seen northeast of A Street from approximately South Walnut Street to Townsend Street. See Appendix C for inundation mapping and the limits described above. These negligible increases in water surface elevations appear to be attributable 200-year floodwaters escaping the Christina River's right bank south of the Norfolk Southern crossing just downstream of the Christina River and Little Mill Creek confluence. As noted in Section III.A, the existing pipe network is excluded from the 2D models; therefore, the capacity of the existing pipe network to intercept, re-direct, and reduce this overland flooding is not accounted for in this model. Considering the distance between where water escapes the Christina River's right bank and increases in inundation limits are seen in the mapping, it is anticipated that the existing pipe network would reduce this overland flooding; therefore, the limits of inundation should be considered approximate.

C. Scour Analysis

Scour analyses were completed for the South Market Street and South Walnut Street bridges in accordance with the 2022 BDM and FHWA's HEC-18, 5th Edition, for all three modeling scenarios. In addition to the 200-year storm, the scour analysis considered the 100-year storm per HEC-18 Table 2.1 which recommends the 100-year storm be used as the scour design frequency event. The scour analyses considered:

- Contraction scour: removal of channel bed material due to the constriction of flow through a bridge opening or natural narrowing of a channel.

- Local scour: removal of channel bed material around abutments and piers due to flow acceleration and flow vortices caused by obstructions.

For each bridge crossing, standalone contraction scour and National Cooperative Highway Research Program (NCHRP) 24-20 local abutment scour was calculated. The NCHRP equations are more recently formulated and use contraction scour as the starting computation to which additional factors are applied to for turbulence that develops near the abutments during storm event discharges. Local pier computations were calculated for the South Walnut Street bridge crossing.

Contraction and local scour also considered:

- Live-bed scour: scour that occurs when bed material is transported from the upstream reach into the bridge crossing section.

- Clear-water scour: scour that occurs without bed material being transported from the upstream reach or bed material is sufficiently suspended in the water column that it does not interact with scour actively occurring at the sediment-structure interface.

Live-bed scour is considered to occur when the computed average channel velocity exceeds the critical velocity (velocity needed to initiate particle movement) for the D_{50} particle size (average particle size) of the bed material considered. Per HEC-18, a reasonable lower limit of D_{50} equal to 0.2 mm can be used for scour computations. 0.2 mm is approximately the average size of fine sand particles.

Overall, comparison of computed average velocities from the 2D modeling to that of the critical velocity of fine sand shows that bed material within the main channel of the Christina River will be actively transported during storm events; therefore, live-bed scour was considered the dominant scour condition within the Christina River. Overbank areas (flow area outside of the main channel) in the vicinity of the two bridges is generally vegetated and/or developed urban land with little or no sediment supply. Therefore, clear-water scour was considered the dominant scour condition for overbank flow. See Appendix E for supporting scour computations. Note that all supporting scour depth computations in Appendix E have been rounded to one decimal place for presentation in the tables below.

i. South Market Street

The South Market Street bridge includes:

- Roadway approaches
- North and south bascule piers
- Bascule pier guide-banks

- Bascule span (the bridge deck over the Christina River)

The roadway approaches and piers on either side of the bridge deck form one continuous structure; therefore, essentially all flow constricts through the bridge opening and the piers/guide-banks act as vertical abutments as opposed to standalone piers where water can flow around the structures in either direction. Since the roadway approaches and piers form one continuous structure, local pier scour computations were not part of the analysis for this bridge crossing.

As with the 50-year hydraulic design results above, results indicate that the project has negligible impact to estimated scour depth. For standalone contraction and NCHRP scour:

- Modeling Scenario 2 results in the lowest estimated scours depths
- Modeling Scenario 3 result in the highest estimated scour depths

Tables 7-10 below present scour results for contraction scour and NCHRP total scour. Table values shown as '--' indicate flow did not occur in that location or was considered to have non-erosive velocities.

Table 7. 100-year Contraction Scour Depths (ft)

Build Scenario	Scenario 1 (Riverine Flow & MHW)			Scenario 2 (Riverine Flow & MLW)			Scenario 3 (Tidal Surge Only)		
	LOB	Channel	ROB	LOB	Channel	ROB	LOB	Channel	ROB
Existing Conditions	--	1.3	--	--	0.3	--	--	4.7	--
Area 1 Build Conditions	--	1.3	--	--	0.3	--	--	4.7	--
Full Build Conditions	--	1.3	--	--	0.3	--	--	4.7	--
Max. Difference	--	0.0	--	--	0.0	--	--	0.0	--

Table 8. 100-year NCHRP Scour Depths (ft)

Build Scenario	Scenario 1 (Riverine Flow & MHW)		Scenario 2 (Riverine Flow & MLW)		Scenario 3 (Tidal Surge Only)	
	Left Abutment	Right Abutment	Left Abutment	Right Abutment	Left Abutment	Right Abutment
Existing Conditions	20.9	20.9	17.6	17.6	28.2	28.2
Area 1 Build Conditions	20.8	20.8	17.6	17.6	28.2	28.2
Full Build Conditions	20.8	20.8	17.6	17.6	28.2	28.2
Max. Difference	-0.1	-0.1	0.0	0.0	0.0	0.0

Table 9. 200-year Contraction Scour Depths (ft)

Build Scenario	Scenario 1 (Riverine Flow & MHW)			Scenario 2 (Riverine Flow & MLW)			Scenario 3 (Tidal Surge Only)		
	LOB	Channel	ROB	LOB	Channel	ROB	LOB	Channel	ROB
Existing Conditions	--	1.9	--	--	1.1	--	--	4.6	--
Area 1 Build Conditions	--	1.8	--	--	1.0	--	--	4.5	--
Full Build Conditions	--	1.8	--	--	1.0	--	--	4.6	--
Max. Difference	--	-0.1	--	--	-0.1	--	--	-0.1	--

Table 10. 200-year NCHRP Scour Depths (ft)

Build Scenario	Scenario 1 (Riverine Flow & MHW)		Scenario 2 (Riverine Flow & MLW)		Scenario 3 (Tidal Surge Only)	
	Left Abutment	Right Abutment	Left Abutment	Right Abutment	Left Abutment	Right Abutment
Existing Conditions	22.6	22.6	19.9	19.9	29.5	29.5
Area 1 Build Conditions	22.4	22.4	19.8	19.8	29.5	29.5
Full Build Conditions	22.4	22.4	19.8	19.8	29.6	29.6
Max. Difference	-0.2	-0.2	-0.1	-0.1	0.1	0.1

ii. South Walnut Street

The South Walnut Street bridge includes:

- Roadway approaches
- North and south abutments
- Five overbank piers supporting seven spans (the bridge deck outside of the main channel)
- North and south bascule piers
- Bascule pier guide-banks
- Bascule span (the bridge deck over the Christina River)

Unlike the South Market Street Bridge, the piers at the South Walnut Street Bridge crossing are individual members that do not form one continuous structure with the abutments/roadway approaches to obstruct flow. Water can flow in either direction around the piers and the bridge abutments are set considerably farther back from the Christina River. Due to this geometry, once floodwaters reach approximately elevation 6.5- to 7.0-ft, water can flow outside the main channel of the Christina River in the left and right overbank areas.

As with the South Market Street results above, results indicate that the project has negligible impact to estimated scour depths at the South Walnut Street bridge. For standalone contraction scour:

- Modeling Scenario 2 results in the lowest estimated scours depths

- Modeling Scenario 3 result in the highest estimated scour depths

Due to the setback of the abutments, storm flow appears to only reach the left abutment during Modeling Scenario 3 when storm flows escape the banks of the Christina River. However, due to the low discharges, velocities, and depths of storm flows in the overbank areas, negligible or no scour is anticipated to occur at the abutments. For pier scour:

- Modeling Scenario 3 results in the lowest estimated scours depths.
- Modeling Scenario 2 results in the highest estimated scour depths.

Tables 11-18 below present scour results for contraction scour, NCHRP scour, and pier scour.

Table 11. 100-year Contraction Scour Depths (ft)

Build Scenario	Scenario 1 (Riverine Flow & MHW)			Scenario 2 (Riverine Flow & MLW)			Scenario 3 (Tidal Surge Only)		
	LOB	Channel	ROB	LOB	Channel	ROB	LOB	Channel	ROB
Existing Conditions	--	1.4	0.8	--	0.8	0.0	0.0	4.6	0.0
Area 1 Build Conditions	--	1.4	0.8	--	0.8	0.0	0.0	4.6	0.0
Full Build Conditions	--	1.4	0.8	--	0.8	0.0	0.0	4.5	0.0
Max. Difference	--	0.0	0.0	--	0.0	0.0	0.0	-0.1	0.0

Table 12. 200-year Contraction Scour Depths (ft)

Build Scenario	Scenario 1 (Riverine Flow & MHW)			Scenario 2 (Riverine Flow & MLW)			Scenario 3 (Tidal Surge Only)		
	LOB	Channel	ROB	LOB	Channel	ROB	LOB	Channel	ROB
Existing Conditions	--*	1.8	0.5	--	1.3	0.6	0.0	4.3	0.0
Area 1 Build Conditions	--*	1.8	0.5	--	1.3	0.6	0.0	4.3	0.0
Full Build Conditions	--*	1.8	0.5	--	1.3	0.6	0.0	4.3	0.0
Max. Difference	--	0.0	0.0	--	0.0	0.0	0.0	0.0	0.0

* Non-scourable velocities

Table 13. Scenario 1 100-year Pier Scour Depths (ft)

Build Scenario	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7
Existing Conditions	--	--	30.2	19.5	--	--	--
Area 1 Build Conditions	--	--	30.2	19.5	--	--	--
Full Build Conditions	--	--	30.2	19.5	--	--	--
Max. Difference	--	--	0.0	0.0	--	--	--

Table 14. Scenario 2 100-year Pier Scour Depths (ft)

Build Scenario	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7
Existing Conditions	--	--	30.4	18.1	--	--	--
Area 1 Build Conditions	--	--	30.4	18.1	--	--	--
Full Build Conditions	--	--	30.4	18.1	--	--	--
Max. Difference	--	--	0.0	0.0	--	--	--

Table 15. Scenario 3 100-year Pier Scour Depths (ft)

Build Scenario	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7
Existing Conditions	9.9	14.4	15.0	17.9	14.4	14.4	14.4
Area 1 Build Conditions	9.9	14.4	14.9	17.6	14.4	14.4	14.4
Full Build Conditions	9.9	14.4	14.3	17.1	14.4	14.4	14.4
Max. Difference	--	--	-0.7	-0.8	--	--	--

Table 16. Scenario 1 200-year Pier Scour Depths (ft)

Build Scenario	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7
Existing Conditions	--*	--*	32.4	22.3	2.1	--	--
Area 1 Build Conditions	--*	--*	32.2	22.2	2.1	--	--
Full Build Conditions	--*	--*	32.2	22.2	2.0	--	--
Max. Difference	--	--	-0.2	-0.1	-0.1	--	--

* Non-erosive velocities

Table 17. Scenario 2 200-year Pier Scour Depths (ft)

Build Scenario	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7
Existing Conditions	--	--	32.7	17.2	--	--	--
Area 1 Build Conditions	--	--	32.6	17.1	--	--	--
Full Build Conditions	--	--	32.6	17.1	--	--	--
Max. Difference	--	--	-0.1	-0.1	--	--	--

Table 18. Scenario 3 200-year Pier Scour Depths (ft)

Build Scenario	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7
Existing Conditions	8.7	11.9	12.0	14.3	9.0	9.7	9.9
Area 1 Build Conditions	8.7	11.9	12.0	14.2	9.2	9.8	10.1
Full Build Conditions	8.7	11.9	11.9	14.2	8.7	9.5	9.8
Max. Difference	0.0	0.0	-0.1	-0.1	-0.3	-0.2	0.2

D. Sea Level Rise Considerations

Per the Directive and sections above, sea level rise was incorporated into the modeling scenarios and considered in the scour computations. Scenario 3 is the only case where water surface elevations are

high enough to impact piers outside of the immediate vicinity of the main channel at South Walnut Street. Additionally, adding 2.54-ft to the MHW and MLW downstream boundary conditions for Scenarios 1 and 2 would likely produce model/scour results that are intermediary or similar to those presented above. Therefore, Scenario 3 Full Build condition was selected to be the baseline case to estimate what impacts sea level rise may have on the scour conditions at the bridges.

As discussed in Section II.B above, a tidal hydrograph (synthetic tide + storm surge) with a peak elevation of 12.0-ft was routed through the modeling domain to simulate a sea level rise scenario. Input parameters used to generate the tidal hydrograph were adjusted so that the peak surge elevation modeled equaled the interpolated 200-year stillwater elevation of 9.5-ft plus 2.54-ft of SLR (rounded to 12.0-ft).

i. South Market Street

Scour depth estimates show that SLR may slightly worsen the scour condition at the South Market Street bridge considering standalone contraction scour and NCHRP abutment scour. While computations for these two types of scour rely on a ratio of parameters comparing hydraulics approaching the bridge and hydraulics through the bridge opening (i.e. flow approaching the bridge in the main channel vs. flow through the bridge in the main channel), the computations also rely on water depths and velocities at both locations as well. Further examination of the results show that increased water depth is the driving factor for increased scour depth estimates. Tables 19-22 below present scour results for contraction scour and NCHRP scour comparing Full Build conditions without and with SLR.

Table 19. 100-year Contraction Scour Depths (ft)

Build Scenario	Scenario 3 (Tidal Surge Only)		
	LOB	Channel	ROB
Full Build Conditions (without SLR)	--	4.7	--
Full Build Conditions (with SLR)	--	5.2	--
Max. Difference	--	0.5	--

Table 20. 200-year Contraction Scour Depths (ft)

Build Scenario	Scenario 3 (Tidal Surge Only)		
	LOB	Channel	ROB
Full Build Conditions (without SLR)	--	4.6	--
Full Build Conditions (with SLR)	--	5.3	--
Max. Difference	--	0.7	--

Table 21. 100-year NCHRP Scour Depths (ft)

Build Scenario	Scenario 1 (Riverine Flow & MHW)	
	Left Abutment	Right Abutment
Full Build Conditions (without SLR)	28.2	28.2
Full Build Conditions (with SLR)	30.7	30.7
Max. Difference	2.5	2.5

Table 22. 200-year NCHRP Scour Depths (ft)

Build Scenario	Scenario 1 (Riverine Flow & MHW)	
	Left Abutment	Right Abutment
Full Build Conditions (without SLR)	29.6	29.6
Full Build Conditions (with SLR)	31.7	31.7
Max. Difference	2.1	2.1

i. South Walnut Street

As with South Market Street, scour depth estimates show overall that SLR may slightly worsen the scour condition at the South Market Street bridge considering standalone contraction scour and NCHRP abutment scour. Tables 23-28 below present scour results for contraction scour and NCHRP total scour comparing Full Build conditions without and with SLR.

Table 23. 100-year Contraction Scour Depths (ft)

Build Scenario	Scenario 3 (Tidal Surge Only)		
	LOB	Channel	ROB
Full Build Conditions (without SLR)	0.0	4.5	0.0
Full Build Conditions (with SLR)	0.0	5.2	0.0
Max. Difference	--	0.7	--

Table 24. 200-year Contraction Scour Depths (ft)

Build Scenario	Scenario 3 (Tidal Surge Only)		
	LOB	Channel	ROB
Full Build Conditions (without SLR)	0.0	4.3	0.0
Full Build Conditions (with SLR)	0.0	5.2	0.0
Max. Difference	--	0.9	--

Table 25. 100-year NCHRP Scour Depths (ft)

Build Scenario	Scenario 3 (Tidal Surge Only)	
	Left Abutment	Right Abutment
Full Build Conditions (without SLR)	--	0.0
Full Build Conditions (with SLR)	--	0.0
Max. Difference	--	0.0

Table 26. 200-year NCHRP Scour Depths (ft)

Build Scenario	Scenario 3 (Tidal Surge Only)	
	Left Abutment	Right Abutment
Full Build Conditions (without SLR)	--	0.0
Full Build Conditions (with SLR)	--	0.0
Max. Difference	--	0.0

Table 27. 100-year Pier Scour Depths (ft)

Build Scenario	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7
Full Build Conditions (without SLR)	9.9	14.4	14.3	17.1	14.4	14.4	14.4
Full Build Conditions (with SLR)	14.4	14.4	14.7	18.8	12.3	12.7	12.8
Max. Difference	4.5	0.0	0.4	1.7	-2.1	-1.7	-1.6

Table 28. 200-year Pier Scour Depths (ft)

Build Scenario	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7
Full Build Conditions (without SLR)	8.7	11.9	11.9	14.2	8.7	9.5	9.8
Full Build Conditions (with SLR)	11.8	14.4	11.0	15.6	11.1	11.3	11.4
Max. Difference	3.1	2.5	-0.9	1.4	2.4	1.8	1.6

Unlike equations for contraction or NCHRP scour estimates, pier scour equations do not rely on a ratio of parameters comparing hydraulics approaching the bridge and hydraulics through the bridge opening. Pier scour estimates are based on hydraulics immediately upstream of the piers and are generally directly proportional to the required hydraulic parameters. Tables 27 and 28 above show that overall SLR increases estimates for pier scour depth; however, results do vary depending on velocities, water depths, and the angle of attack (the angle of flow with which water approaches the pier relative to the angle of the pier itself) for each scenario and pier. For example:

- Increases in scour depth estimates for Piers 1, 3, and 4 for the 100-year storm event appears to be mainly driven by an increase in velocity.

- Decreases in scour depth estimates for Piers 5, 6, and 7 for the 100-year storm event appears to be driven by a combination of decreases in angle of attack and velocity.
- Decreases in scour depth estimate for Pier 3 for the 200-year storm event appears to be driven by a decrease in flow angle of attack.

IV. Drainage Analysis

The proposed storm drain infrastructure to support the Area 1 development provides multiple outfall locations to the Christina River. The proposed pipe outfalls will improve outfall conditions by discharging at or above the calculated Mean Low Water (MLW) El. -2.78 and by installing tide check valves for backflow prevention when pipes are tidally inundated. The project will install an additional 9,150 linear feet of storm drain pipe to increase the amount of underground pipe storage capacity. The project also installs 294 additional drainage inlets to intercept runoff and provide flooding relief along the roadways.

DelDOT has concurred that the 50-year storm event is the hydrologic and hydraulic design event per Table 6-1 of DelDOT's 2022 Road Design Manual (RDM). Per the Road Design comments (email dated June 23, 2022) and the Bridge Scour Modeling Directive, DelDOT has requested analysis of more frequent storm events, in addition to the storm events noted in the Bridge Scour Modeling Directive. Therefore, the 1-yr, 2-yr, 10-yr, 25-yr, 100-yr, 200-yr, and 500-yr storm events have been analyzed in addition to the 50-year design storm event.

Also, per the directives, DelDOT has requested that multiple tailwater conditions be analyzed to better understand potential flooding impacts to Market Street, which is a designated emergency evacuation route. Therefore, each design storm was evaluated using the tailwater elevation corresponding to design storm and tidal storm surge that were generated from the TUFLOW 2D modeling analysis. DelDOT has expressed concern regarding the effects that Sea Level Rise (SLR) will have on the project area, therefore the additional anticipated SLR has been incorporated into the design analysis. The following table summarizes the design storms and tailwater conditions used to analyze the proposed storm drain network, as well as the existing conditions pipe network:

Table 29. Drainage Analysis Tidal Tailwater Elevations

Recurrence Interval	Elevation	Elevation + 2.54-ft Sea Level Rise (3.25' - SLR to date)	Source
1	3.2	5.74	Stage Duration Curve - RKK
2	3.4	5.94	Stage Duration Curve - RKK
10	6.9	9.44	FEMA FIS 10003CV001D
25	7.4	9.94	Interpolated from FEMA FIS - RKK
50	7.8	10.34	FEMA FIS 10003CV001D
100	8.3	10.84	FEMA FIS 10003CV001D
100	9	11.54	Project FEMA BFE
200	9.5	12.04	Interpolated from FEMA FIS - RKK
500	10.8	13.34	FEMA FIS 10003CV001D

DelDOT's Storm Drainage Design Computations spreadsheets were used to analyze the pipe capacity and hydraulic grade line (HGL) at the various design storms noted in the above table for each pipe network. The tailwater elevations were input as the starting tailwater elevation applied to the outfall pipe and the resultant HGL calculations for each network are included in Appendix F. Due to the majority of analyzed tailwater elevations exceeding the profile grade elevations of existing Market Street, computed HGL elevations depict surcharging at many roadway inlets. The HGL analysis performed do not include duration timing of the surcharge events as that analysis was outside of the scope of the Directives. However, the included HGL summary shows a decrease in the surcharging elevations compared to the existing conditions. The summary focuses on the four (4) profile sag locations on Market Street within the Area 1 project limits where the storm drain inlets intercept and remove roadway runoff and provide relief from flooding. The inlet top of grate and HGL elevations generated for each of the above tailwater conditions have been summarized for each roadway sag inlet in the HGL Summary Tables also included in Appendix F.

V. 2D Modeling, Drainage, and Scour Analysis Conclusions

Based on the Directive, modeling methodology, drainage and scour analysis presented in this report, the development of the waterfront including, Areas 1, 2, and 3, appears to have negligible impact on the water surface elevations in the vicinity of the project or scour depth estimates for the South Walnut Street and South Market Street bridges. Based on the Directive specified amount of SLR, it appears that SLR will slightly worsen scour depth estimates for both bridges analyzed regardless of the proposed development of Areas 1, 2, and 3.

References

BMT Commercial Australia Pty TUFLOW Classic/HPC User Manual, Build 2018-03

DelDOT Bridge Design Manual, Section 104 – Hydrology and Hydraulics, December 2022

DelDOT Road Design Manual, Chapter 6 Drainage and Stormwater Management, July 2008 & 2022 Edition

DelDOT Standard Construction Details (2022)

FEMA Flood Insurance Study Number 10003CV001D, New Castle County, Delaware, January 2020

FHWA Hydraulic Engineering Circular No. 18, *Evaluating Scour at Bridges*, Fifth Edition, April 2012

FHWA Hydraulic Engineering Circular No. 25, *Tidal Hydrology, Hydraulics, and Scour at Bridges* First Edition, December 2004

NOAA Tides & Currents, Datums, August 2020

USACE eHydro Christina River Hydrographic Survey, 2022

USGS National Water Information System: Web Interface, USGS 01480120 Christina River at Wilmington, DE

USGS Coastal National Elevation Database (CONED) Topobathymetric Model for New Jersey and Delaware, December 2015

South Wilmington Infrastructure Improvements

Wilmington, DE

2D MODELING, SCOUR, AND DRAINAGE ANALYSIS REPORT

Appendix A

DelDOT Modeling Directive

From: Wright, Stephen G. (DelDOT) <Stephen.Wright@delaware.gov>
Sent: Thursday, June 23, 2022 4:14 PM
To: Robert Shaffer <rshaffer@rkk.com>
Cc: Pappas, James (DelDOT) <James.Pappas@delaware.gov>; Vincent, Matthew (DelDOT) <Matthew.Vincent@delaware.gov>; Sisson, Steven (DelDOT) <Steven.Sisson@delaware.gov>; Baker, Bryce (DelDOT) <Bryce.Baker@delaware.gov>; Diane Gunn <dgunn@centuryeng.com>; Tara Cutillo <tcutillo@rkk.com>; Matt Kozak <mkozak@rkk.com>
Subject: RE: South Market Street

EXTERNAL EMAIL: Do not click links or open attachments unless you trust the 'Sender' and know the content is safe.

Bob,
After review DelDOT would like to make the following comments regarding the design parameters utilized in the design for the South Market Street infrastructure as part of the South Market Street Development. As per our last meeting, the intent is to separate out the Bridge scour comments, and the Road Design drainage comments. To this effect, Bryce has allowed me to attach the Bridge Scour Modeling Directive to this email as an attachment, whereas the Road Design comment are in the body below.

The South Market Street drainage network has been submitted to DelDOT for review with a 50-year frequency design storm event, with the downstream tailwater condition being shown at the 2-year riverine peak (coincident to the 100-yr storm) with the hydraulics of the drainage network controlled by that tailwater condition and the inline check valve at the discharge points. These design parameters provide a hydraulics and hydrology study with a proposed design tailwater condition of 3.68'.

The appropriate design storm for this project is defined in Chapter 6 of the Road Design manual. DelDOT Water Resources concurs with the decision to use a 50-year design storm for the hydrology of the project and the hydraulics of the proposed drainage network. DelDOT does request that all future hydraulics and hydrologic studies include more frequent storm events as well, including the 1-yr, 10-yr and 25-yr events.

Regarding the tailwater condition of the design; DelDOT has determined that as this network is discharging to a tidally controlled receiving body, the design storm for the discharge should be tidal storm surge and not riverine as has been submitted. As the design storm matches, and in accordance with the Bridge Scour Directive document, attached, Water Resources would like to see the following tidal storm surge design storms used as the tailwater condition for future submissions; all design storms referenced in the attached bridge scour modeling directive as well as the more frequent 1-yr, 2-yr, 10-yr and 25-yr tidal storm surge events.

It is anticipated that many of these design parameter conditions will return a flooding condition on South Market St. DelDOT is aware, and would encourage the design team to not hesitate to show this condition. We do not believe that a path forward can be achieved without a greater understanding of the projects constraints.

Stephen G. Wright, P.E.
Stormwater Engineer
Transportation Solutions – Engineering Support
Delaware Department of Transportation
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Transparent Efficient Accountable Measured

Scour Analyses for BR 1-687 on S. Walnut St. and 1-688 S. Market St. over the Christina River

Please refer to Section 104 of the DelDOT Bridge Design Manual (BDM) for guidance on Hydrologic and Hydraulic studies of state defined bridges. Per the BDM, the following directives will be required when analyzing the effects of development along the Christina River on scour of BR 1-688 on S. Market St. over the Christina River and BR 1-687 on S. Walnut St. over the Christina River.

- To comply with the standards set forth by the DelDOT Bridge Design Manual (BDM), a 2D model will be required to accurately represent the hydraulic impacts of modifying floodplains on BR 1-687 & BR 1-688. Section 104.3.5.3 of the BDM outlines the following conditions where a 2D model may be needed:
    - A structure is on a severe channel bend (making velocity vary between the inside and outside of the bend) and scour is a major concern.
    - A project is anticipated to cause WSE increases in a highly developed area, and flooding impacts need to be more accurately defined.
    - Hydraulics at the project site are affected by a confluence that changes location for different flood events and cause 2D characteristics in the floodplain.
    - Tidal areas
- In accordance with 104.3.5.3 and guidance from FHWA's Hydraulics Team, DelDOT would prefer 2D modeling to be completed using SRH-2D or TUFLOW.
- Section 104.3.4.1 of the BDM outlines the hydraulic scenarios that should be used to analyze backwater elevations and/or scour conditions when a stream is tidally influenced or controlled at the structure location. The most critical of these scenarios should be used.
    - Scenario 1: A steady-flow scenario with design upland flow (from the stream or river) for the hydraulic design event and the scour design event. The overtopping event and 100-year event may be required for projects in New Castle County. The downstream boundary is set to the MHW elevation of the tidal receiving water daily astronomical tide. Note that the downstream MHW elevation may be higher than the roadway overtopping elevation, in which case no overtopping flood profile will result from Scenario 1.
    - Scenario 2: A steady-flow scenario with design upland flow (from the stream or river) for the hydraulic design event and the scour design event. The overtopping event and 100-year event may be required for projects in New Castle County. The downstream boundary is set to the MLW elevation of the tidal receiving water daily astronomical tide. Note that the overtopping flood may be higher than the 100-year flood event, in which case the overtopping flood is not considered under Scenario 2.
    - Scenario 3: An unsteady-flow scenario with the source of flooding being the ebb and flood tides from the tidal receiving water (no upland flow from the stream or river). Downstream boundary conditions are the design, 100-year, and 200-year storm surge hydrographs from the tidal receiving water as well as the daily astronomical tide hydrograph, which generates the overtopping flood event. The astronomical high- and low-tide elevations (MHW and MLW) and the design storm surge hydrographs should be calculated based on the approach described in the FHWA's HEC-25, Highways in the Coastal Environment (2008). The unsteady HEC-RAS model under Scenario 3, "no upland flow," should be simulated for a total period of 60 hours, which comprises the entire surge period in Delaware. Stillwater elevations of the tidal receiving water can be obtained from FEMA's FISs.
- In the vicinity of BR 1-588, S. Market St. and S. Walnut St. are classified as principle arterials. Per Table 104-5 of the BDM, a hydraulic design flood frequency of 50-years will be used for structures

on principle arterials. Per Table 104-2 of the BDM, the 200-year scour design and check flood frequency should be used for structures with a 50-year hydraulic design flood frequency.

- In accordance with Section 104.3.4.6 of the BDM, the analysis must "consider and incorporate the sea level rise scenarios set forth by the DNREC Sea Level Rise Technical Committee…" This report predicts approximately 0.52 meters to 1.43 meteres of sea level rise by the year 2100 (referenced to the year 2000). The report recommends planning for the intermediate SLR scenario which is 0.99 m (3.25 ft) of sea level rise by the year 2100. Note that the amount of SLR that has already occurred between the year 2000 and now should be removed from the total 3.25'.

South Wilmington Infrastructure Improvements

Wilmington, DE

2D MODELING, SCOUR, AND DRAINAGE ANALYSIS REPORT

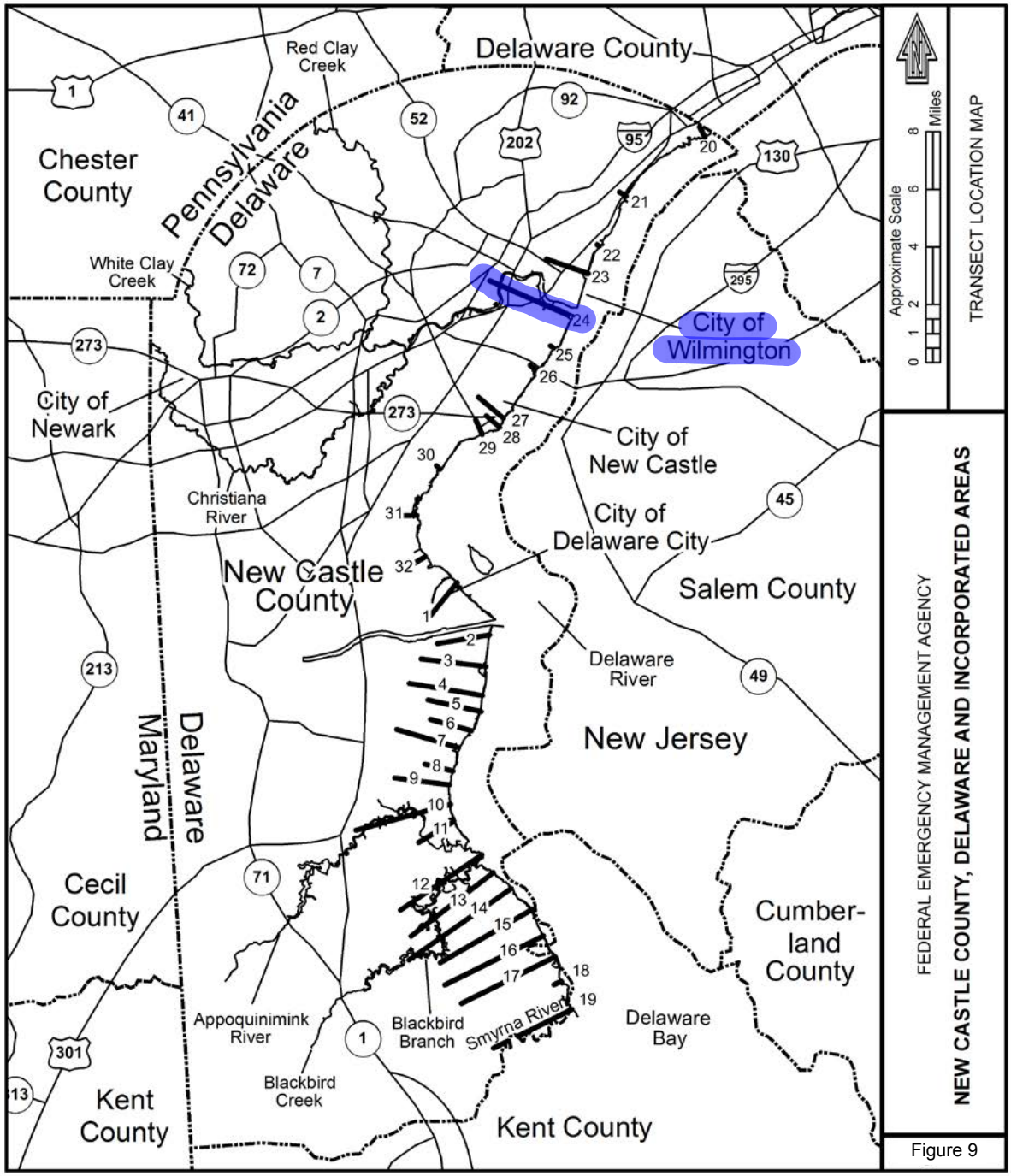
Appendix B

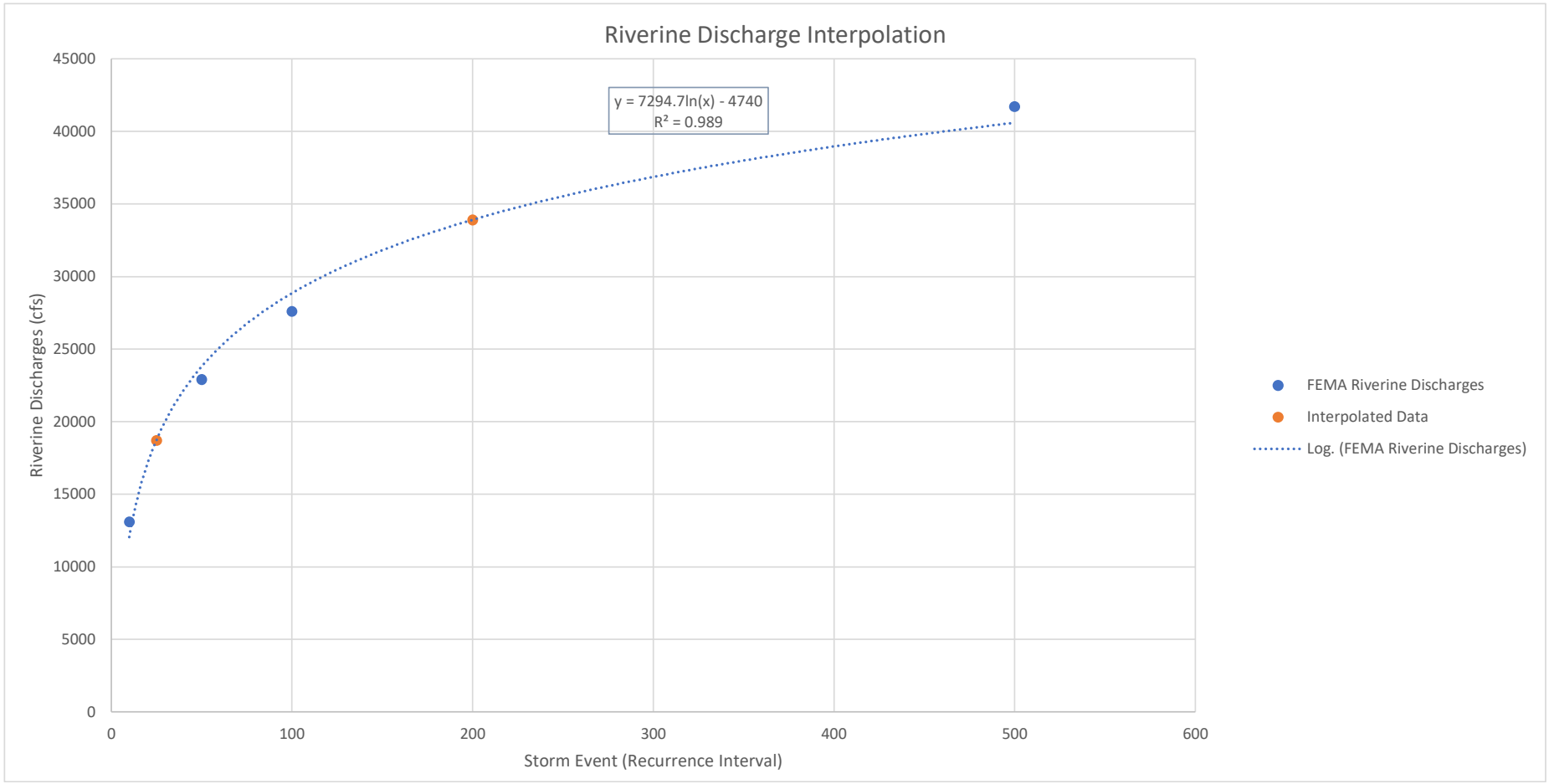
Supporting Hydrologic Inputs

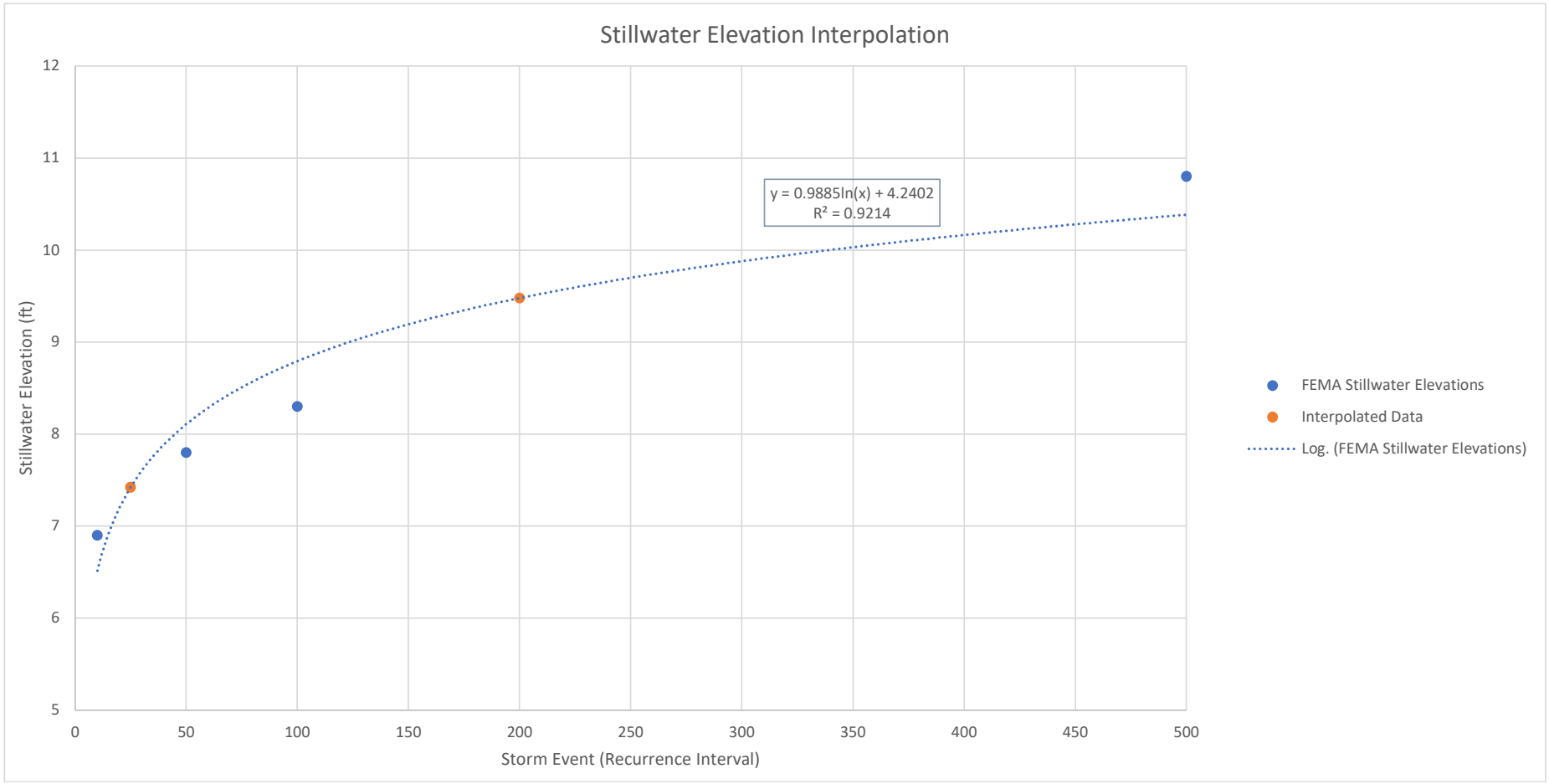
Pages from FEMA FIS 10003CV001D

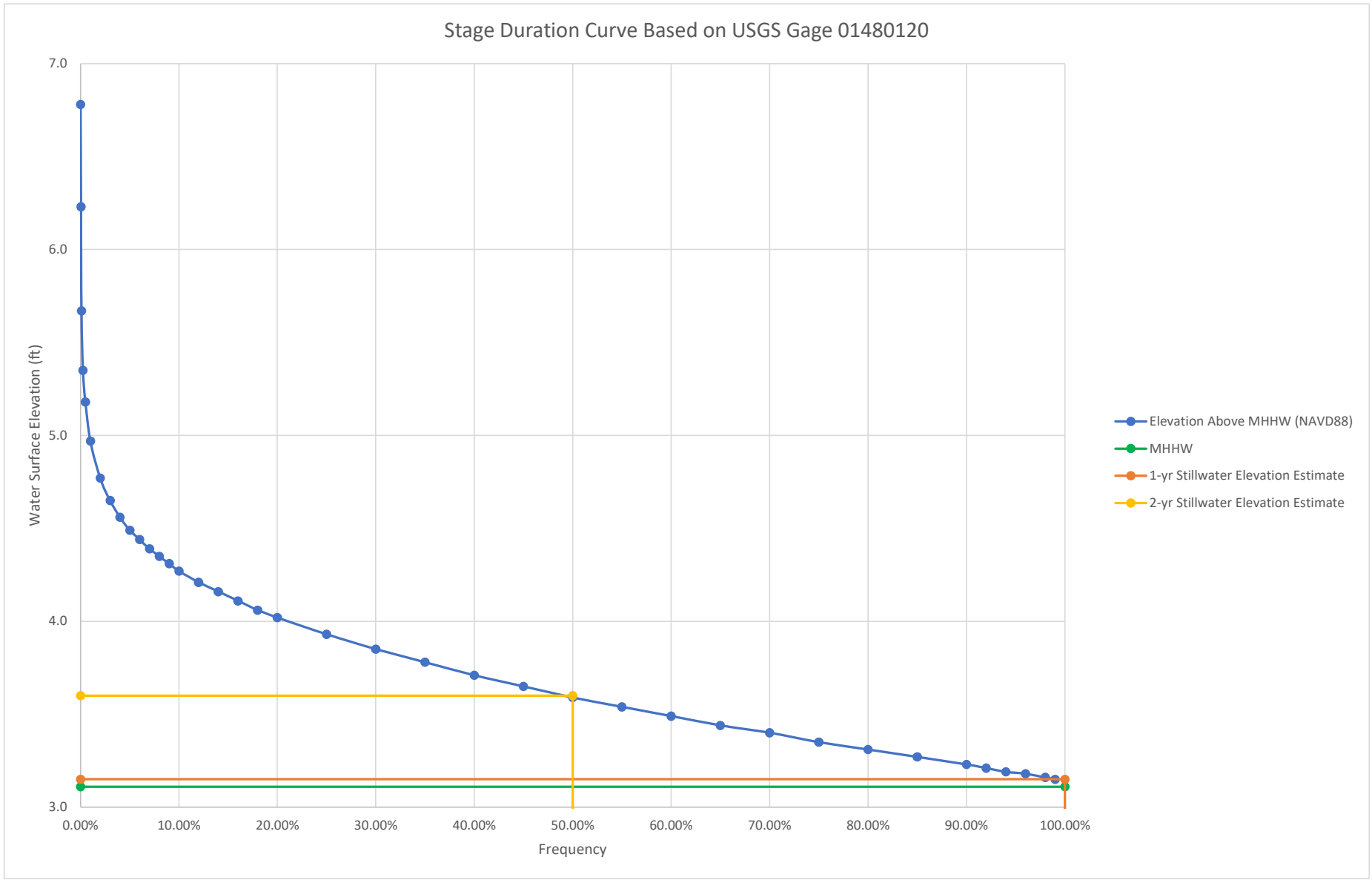
Pages from FEMA FIS 10003CV001D

Figure 9: Transect Location Map




Riverine Discharge Interpolation
y = 7294.7ln(x) - 4740
R² = 0.989
Riverine Discharges (cfs)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0
100
200
300
400
500
600
Storm Event (Recurrence Interval)
FEMA Riverine Discharges
Interpolated Data
Log. (FEMA Riverine Discharges)


Stillwater Elevation Interpolation
y = 0.9885ln(x) + 4.2402
R² = 0.9214
Stillwater Elevation (ft)
Storm Event (Recurrence Interval)
12
11
10
9
8
7
6
5
0
50
100
150
200
250
300
350
400
450
500
FEMA Stillwater Elevations
Interpolated Data
Log. (FEMA Stillwater Elevations)


Stage Duration Curve Based on USGS Gage 01480120
Water Surface Elevation (ft)
7.0
6.0
5.0
4.0
3.0
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%
100.00%
Frequency
Elevation Above MHHW (NAVD88)
MHHW
1-yr Stillwater Elevation Estimate
2-yr Stillwater Elevation Estimate

Elevations on Mean Lower Low Water

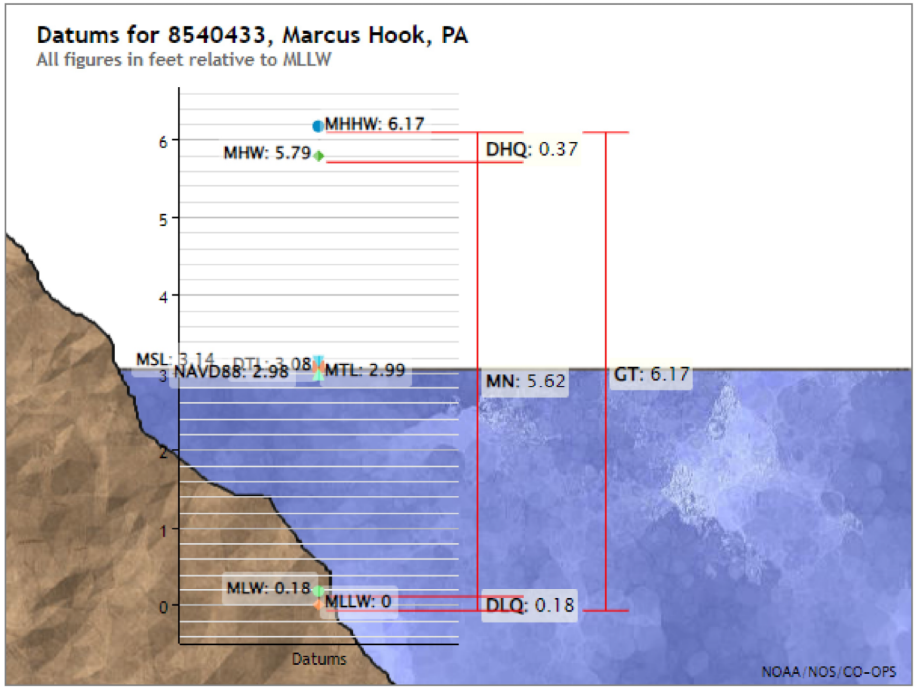
Station: 8540433, Marcus Hook, PA
Status: Accepted (May 7 2020)
Units: Feet
Control Station: 8551910 Reedy Point, DE

T.M.: 0
Epoch: 1983-2001
Datum: MLLW

Datum	Value	Description
MHHW	6.17	Mean Higher-High Water
MHW	5.79	Mean High Water
MTL	2.99	Mean Tide Level
MSL	3.14	Mean Sea Level
DTL	3.08	Mean Diurnal Tide Level
MLW	0.18	Mean Low Water
MLLW	0.00	Mean Lower-Low Water
NAVD88	2.98	North American Vertical Datum of 1988
STND	-21.65	Station Datum
GT	6.17	Great Diurnal Range
MN	5.62	Mean Range of Tide
DHQ	0.37	Mean Diurnal High Water Inequality
DLQ	0.18	Mean Diurnal Low Water Inequality
HWI	4.85	Greenwich High Water Interval (in hours)
LWI	12.13	Greenwich Low Water Interval (in hours)
Max Tide	10.10	Highest Observed Tide
Max Tide Date & Time	10/30/2012 06:48	Highest Observed Tide Date & Time
Min Tide	-3.57	Lowest Observed Tide
Min Tide Date & Time	03/06/2007 14:18	Lowest Observed Tide Date & Time
HAT	7.33	Highest Astronomical Tide
HAT Date & Time	05/19/2034 05:24	HAT Date and Time
LAT	-0.82	Lowest Astronomical Tide
LAT Date & Time	02/01/2014 12:48	LAT Date and Time

Tidal Datum Analysis Periods

08/01/2002 - 07/31/2014



Showing datums for

8540433 Marcus Hook, PA

Datum

MLLW

Data Units
- Feet
- Meters

- Present (1983-2001)
- Superseded (1960-1978)

Submit

Microsoft Search (Alt+Q)

Just start typing here to bring features to your fingertips and get help.

Tell me more

Elevations on NAVD88

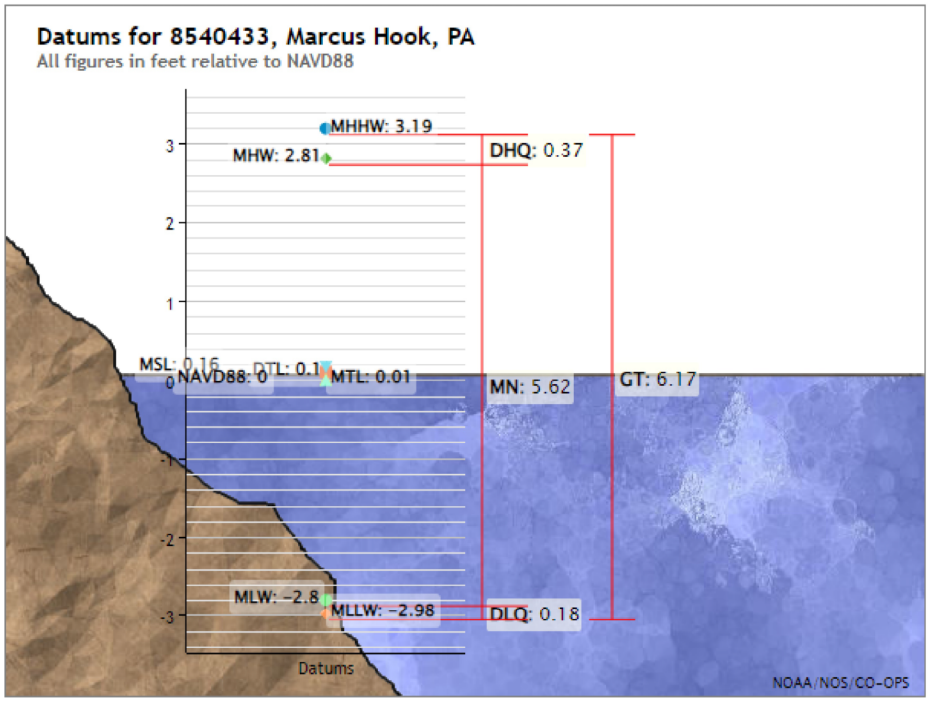
Station: 8540433, Marcus Hook, PA
Status: Accepted (May 7 2020)
Units: Feet
Control Station: 8551910 Reedy Point, DE

T.M.: 0
Epoch: 1983-2001
Datum: NAVD88

Datum	Value	Description
MHHW	3.19	Mean Higher-High Water
MHW	2.81	Mean High Water
MTL	0.01	Mean Tide Level
MSL	0.16	Mean Sea Level
DTL	0.10	Mean Diurnal Tide Level
MLW	-2.80	Mean Low Water
MLLW	-2.98	Mean Lower-Low Water
NAVD88	0.00	North American Vertical Datum of 1988
STND	-24.63	Station Datum
GT	6.17	Great Diurnal Range
MN	5.62	Mean Range of Tide
DHQ	0.37	Mean Diurnal High Water Inequality
DLQ	0.18	Mean Diurnal Low Water Inequality
HWI	4.85	Greenwich High Water Interval (in hours)
LWI	12.13	Greenwich Low Water Interval (in hours)
Max Tide	7.12	Highest Observed Tide
Max Tide Date & Time	10/30/2012 06:48	Highest Observed Tide Date & Time
Min Tide	-6.55	Lowest Observed Tide
Min Tide Date & Time	03/06/2007 14:18	Lowest Observed Tide Date & Time
HAT	4.35	Highest Astronomical Tide
HAT Date & Time	05/19/2034 05:24	HAT Date and Time
LAT	-3.80	Lowest Astronomical Tide
LAT Date & Time	02/01/2014 12:48	LAT Date and Time

Tidal Datum Analysis Periods

08/01/2002 - 07/31/2014



Showing datums for

8540433 Marcus Hook, PA

Datum

NAVD88

Data Units ◉ Feet ○ Meters

Epoch ◉ Present (1983-2001) ○ Superseded (1960-1978)

Submit

Elevations on Mean Lower Low Water

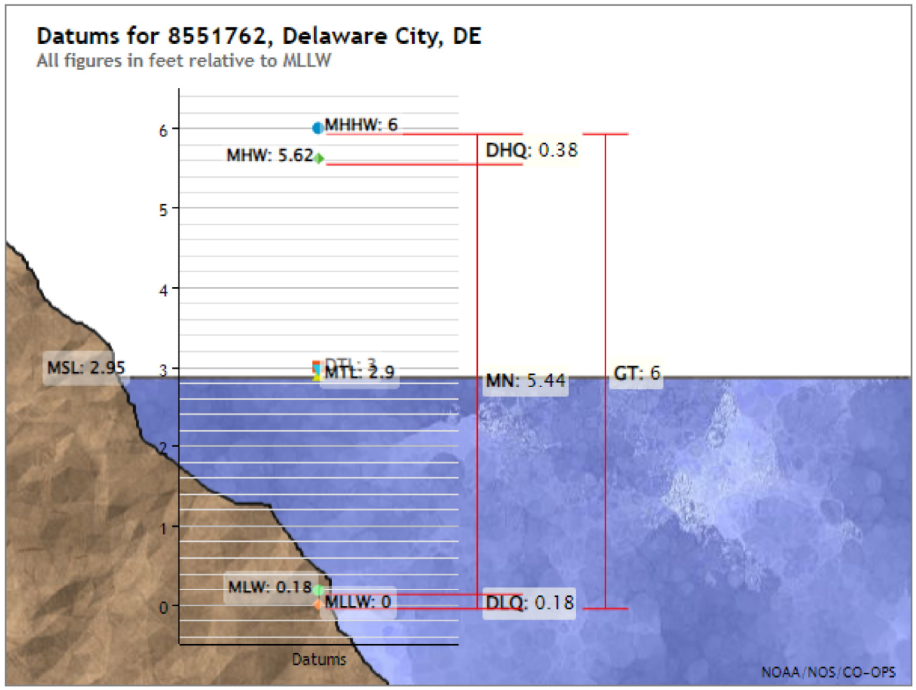
Station: 8551762, Delaware City, DE
Status: Accepted (Aug 31 2020)
Units: Feet
Control Station: 8551910 Reedy Point, DE

T.M.: 0
Epoch: 1983-2001
Datum: MLLW

Datum	Value	Description
MHHW	6.00	Mean Higher-High Water
MHW	5.62	Mean High Water
MTL	2.90	Mean Tide Level
MSL	2.95	Mean Sea Level
DTL	3.00	Mean Diurnal Tide Level
MLW	0.18	Mean Low Water
MLLW	0.00	Mean Lower-Low Water
NAVD88		
STND	-22.40	Station Datum
GT	6.00	Great Diurnal Range
MN	5.44	Mean Range of Tide
DHQ	0.38	Mean Diurnal High Water Inequality
DLQ	0.18	Mean Diurnal Low Water Inequality
HWI	3.87	Greenwich High Water Interval (in hours)
LWI	10.86	Greenwich Low Water Interval (in hours)
Max Tide	9.73	Highest Observed Tide
Max Tide Date & Time	10/30/2012 05:42	Highest Observed Tide Date & Time
Min Tide	-3.57	Lowest Observed Tide
Min Tide Date & Time	01/07/2018 03:18	Lowest Observed Tide Date & Time
HAT	7.12	Highest Astronomical Tide
HAT Date & Time	05/19/2034 04:30	HAT Date and Time
LAT	-0.94	Lowest Astronomical Tide
LAT Date & Time	02/12/2032 11:18	LAT Date and Time

Tidal Datum Analysis Periods

11/01/2001 - 10/31/2018



Showing datums for

8551762 Delaware City, DE

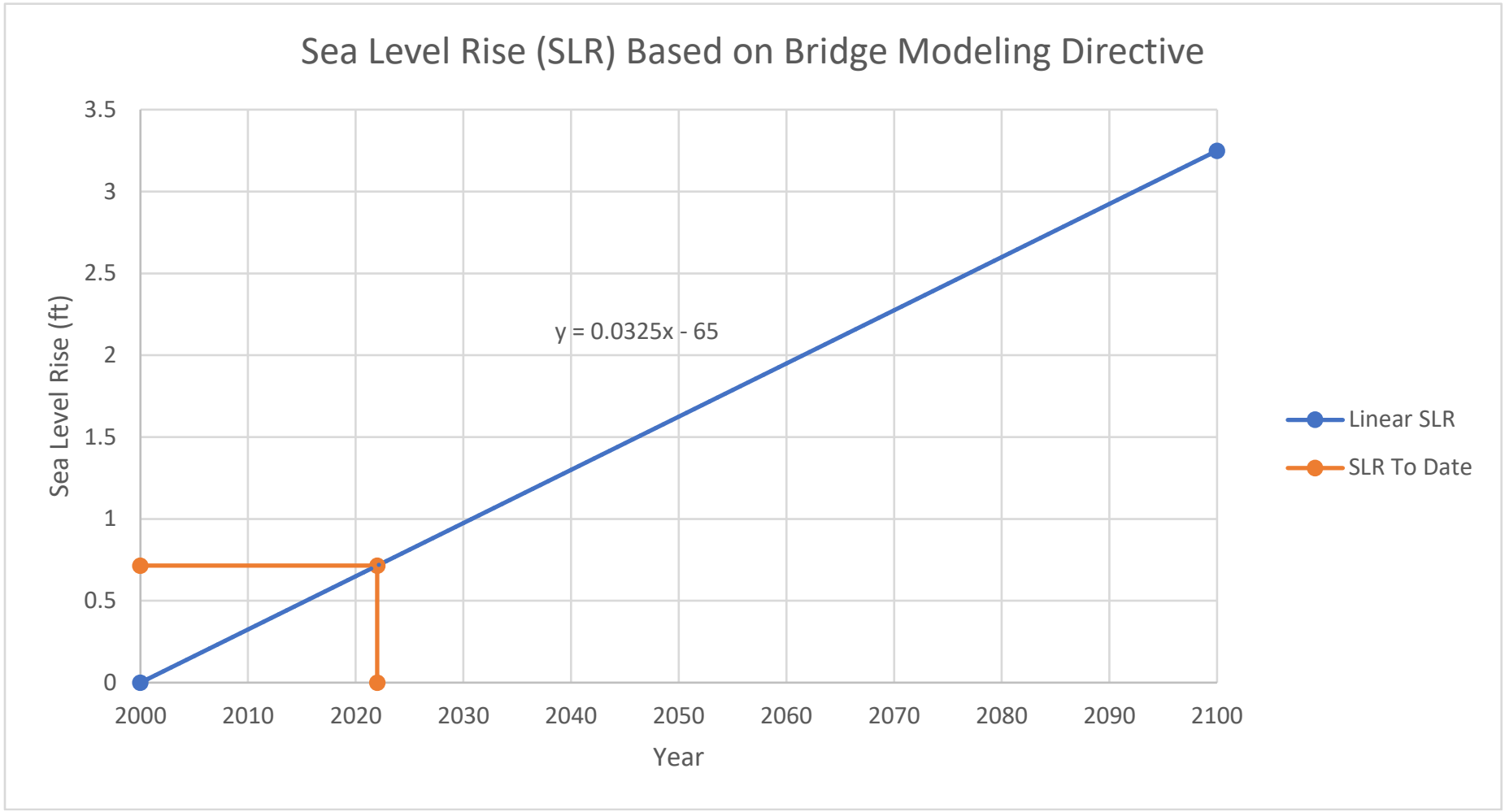
Datum

MLLW

Data Units ◉ Feet ○ Meters

Epoch ◉ Present (1983-2001) ○ Superseded (1960-1978)

Submit


Sea Level Rise (SLR) Based on Bridge Modeling Directive
Sea Level Rise (ft)
3.5
3
2.5
2
1.5
1
0.5
0
y = 0.0325x - 65
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year
Linear SLR
SLR To Date

South Wilmington Infrastructure Improvements

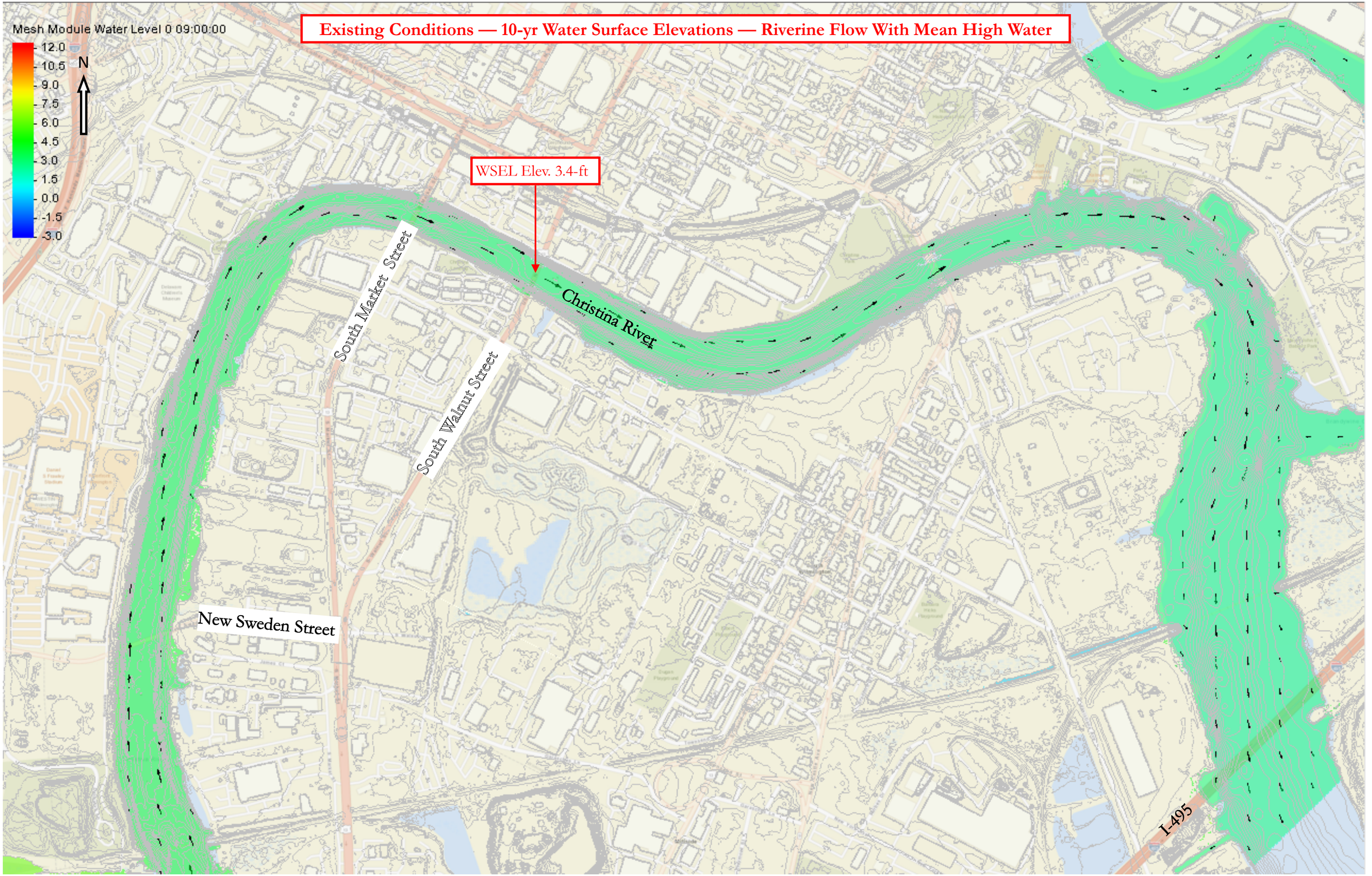
Wilmington, DE

2D MODELING, SCOUR, AND DRAINAGE ANALYSIS REPORT

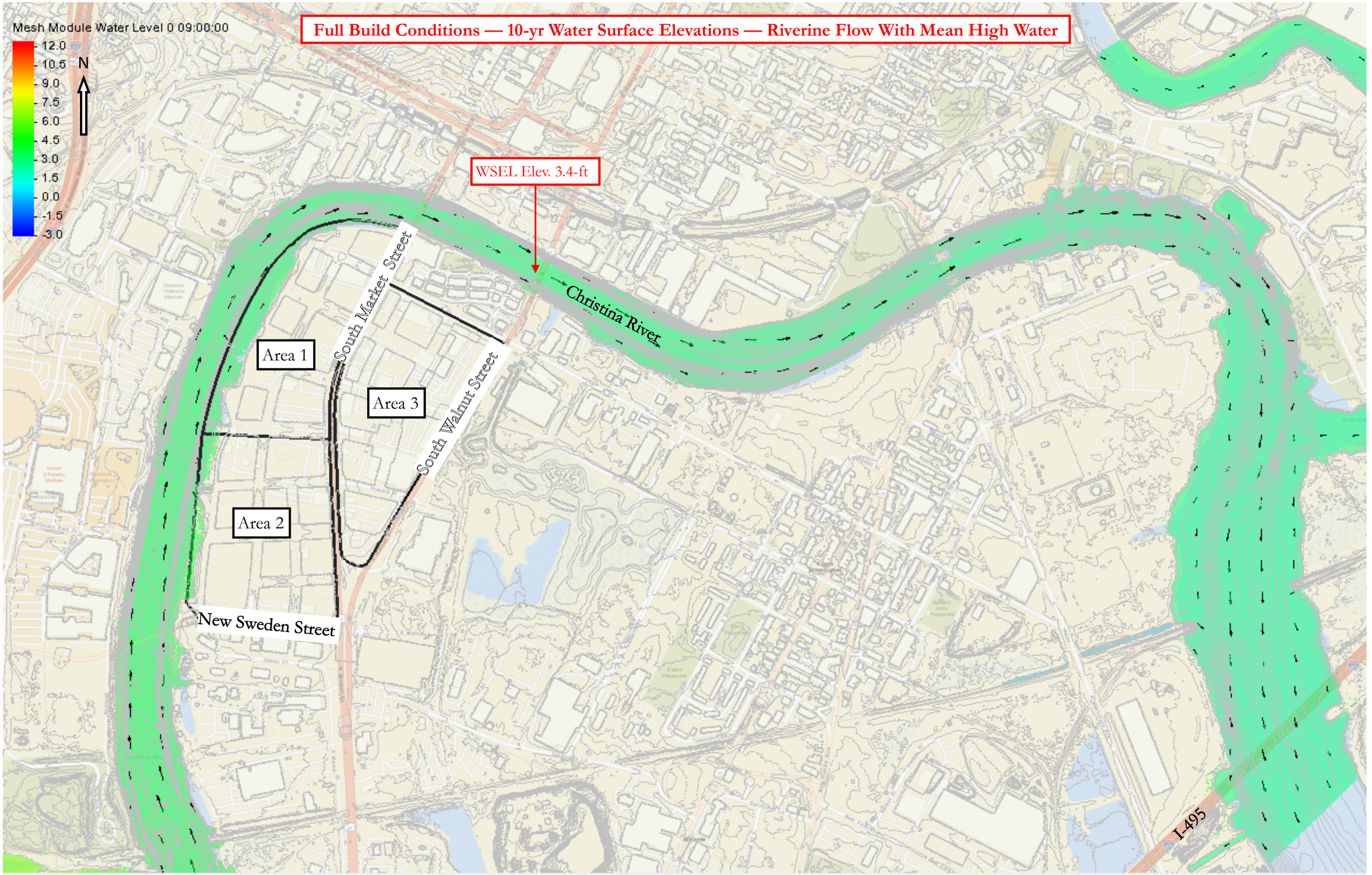
Appendix C

Inundation Mapping

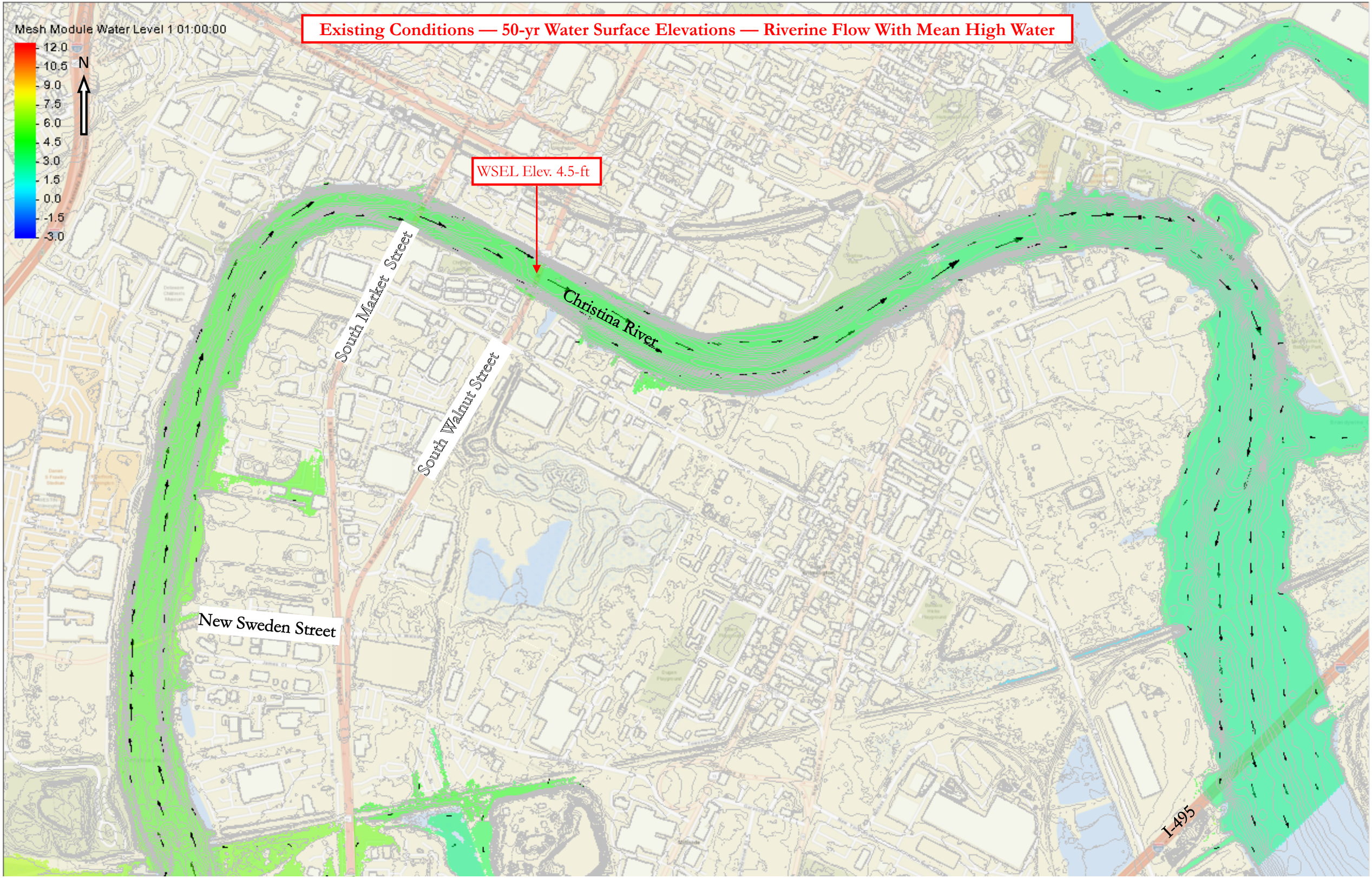
Existing Conditions — 10-yr Water Surface Elevations — Riverine Flow With Mean High Water



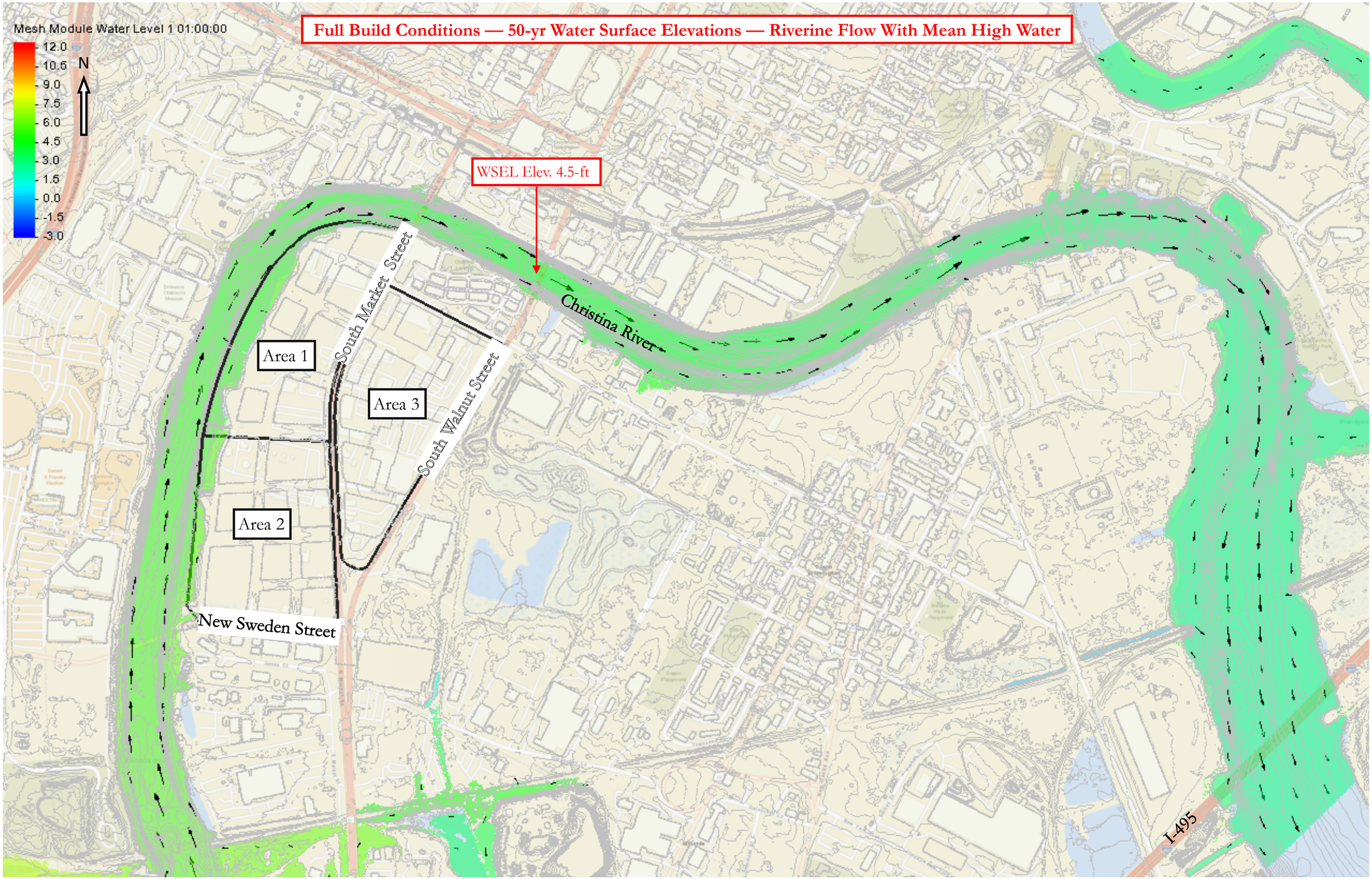
Full Build Conditions — 10-yr Water Surface Elevations — Riverine Flow With Mean High Water



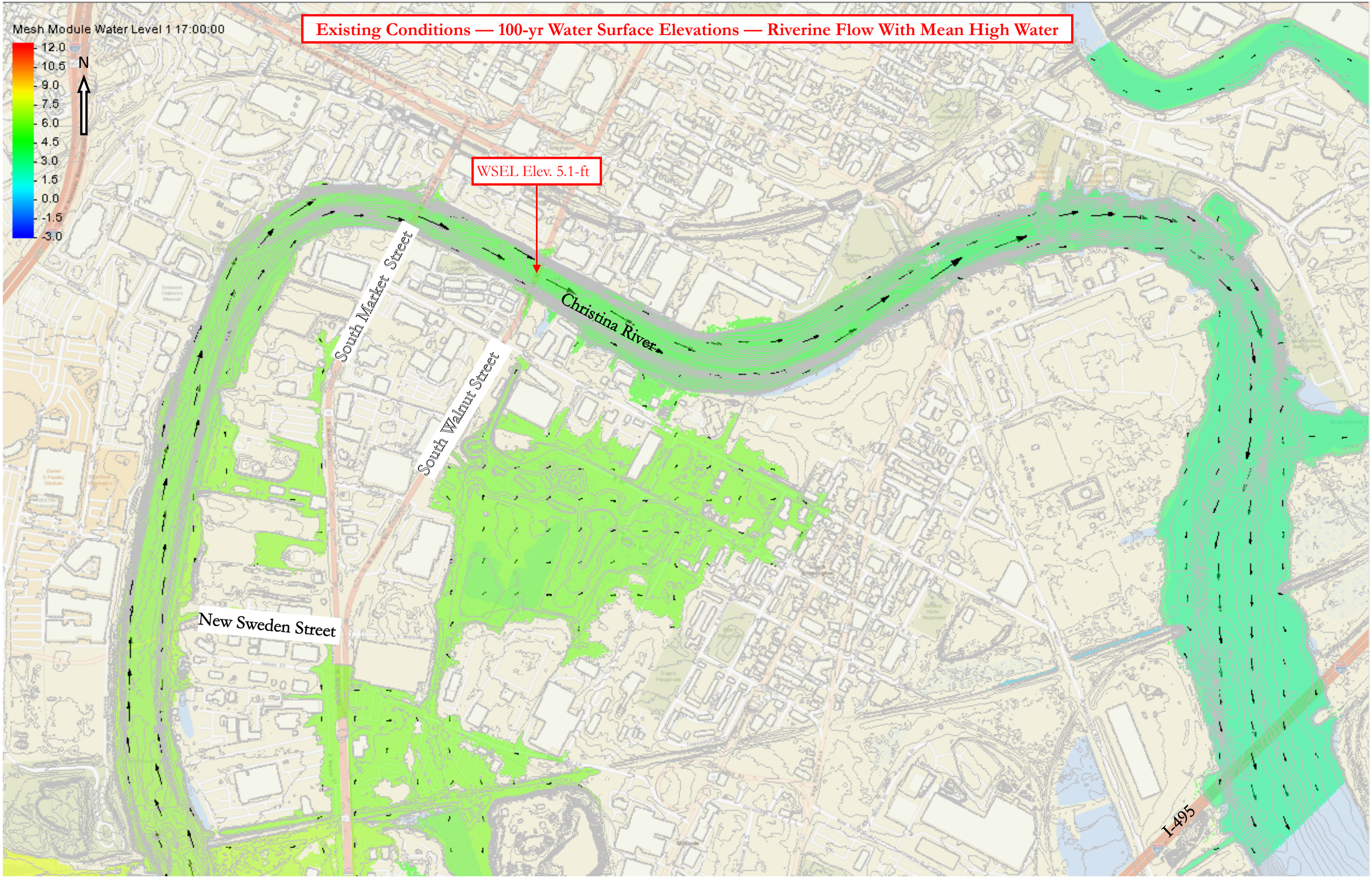
Existing Conditions — 50-yr Water Surface Elevations — Riverine Flow With Mean High Water



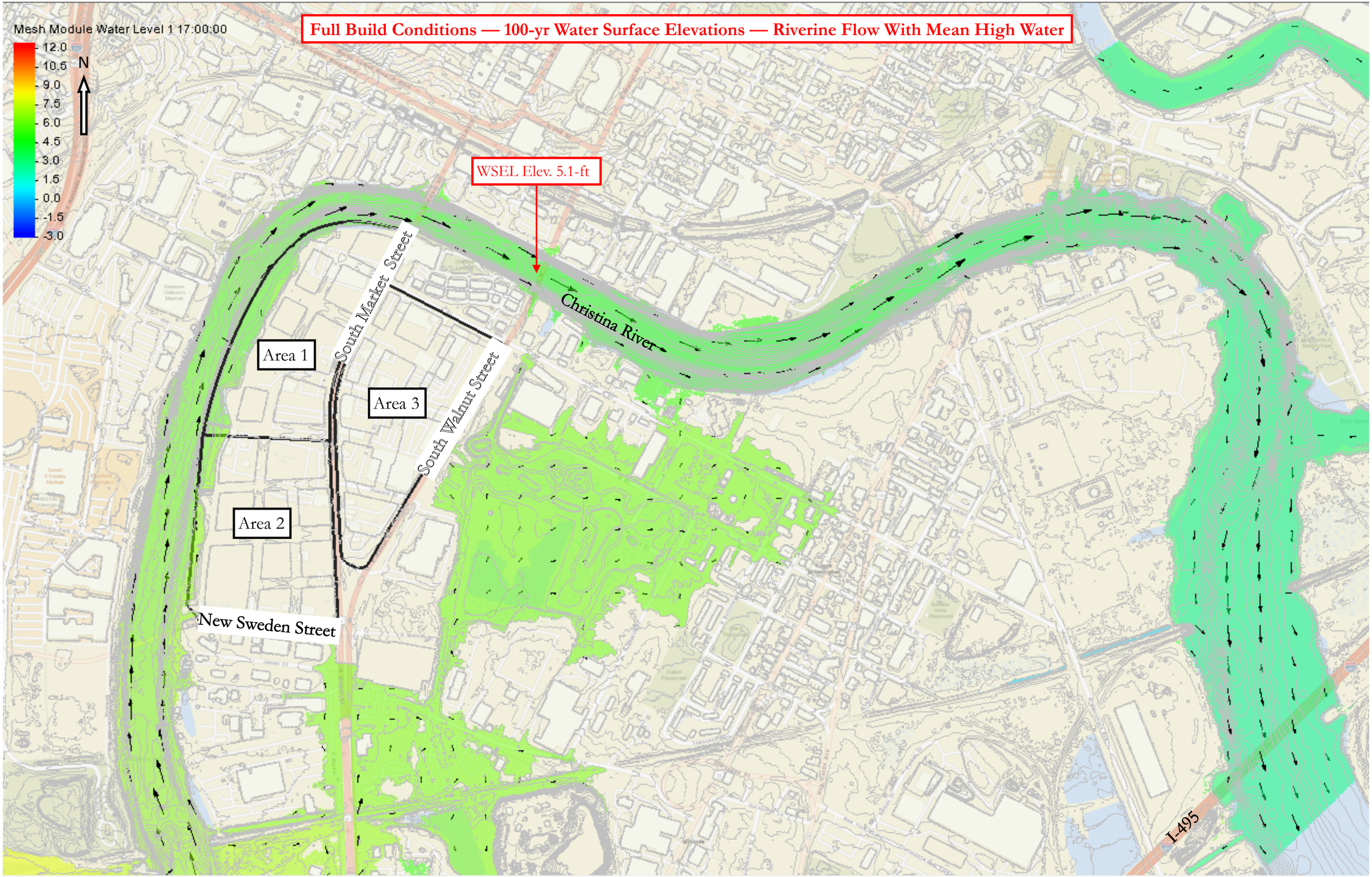
Full Build Conditions — 50-yr Water Surface Elevations — Riverine Flow With Mean High Water



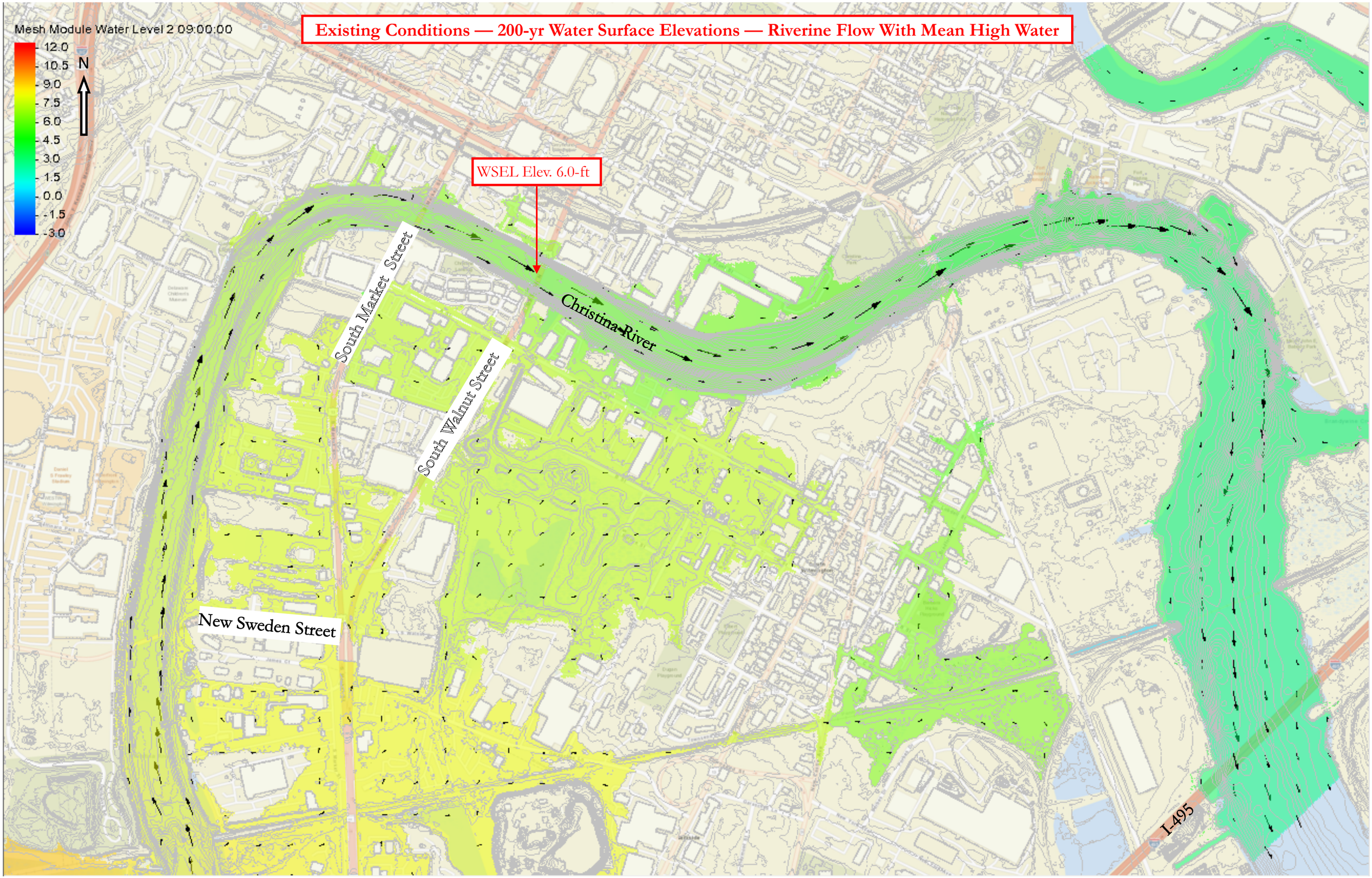
Existing Conditions — 100-yr Water Surface Elevations — Riverine Flow With Mean High Water



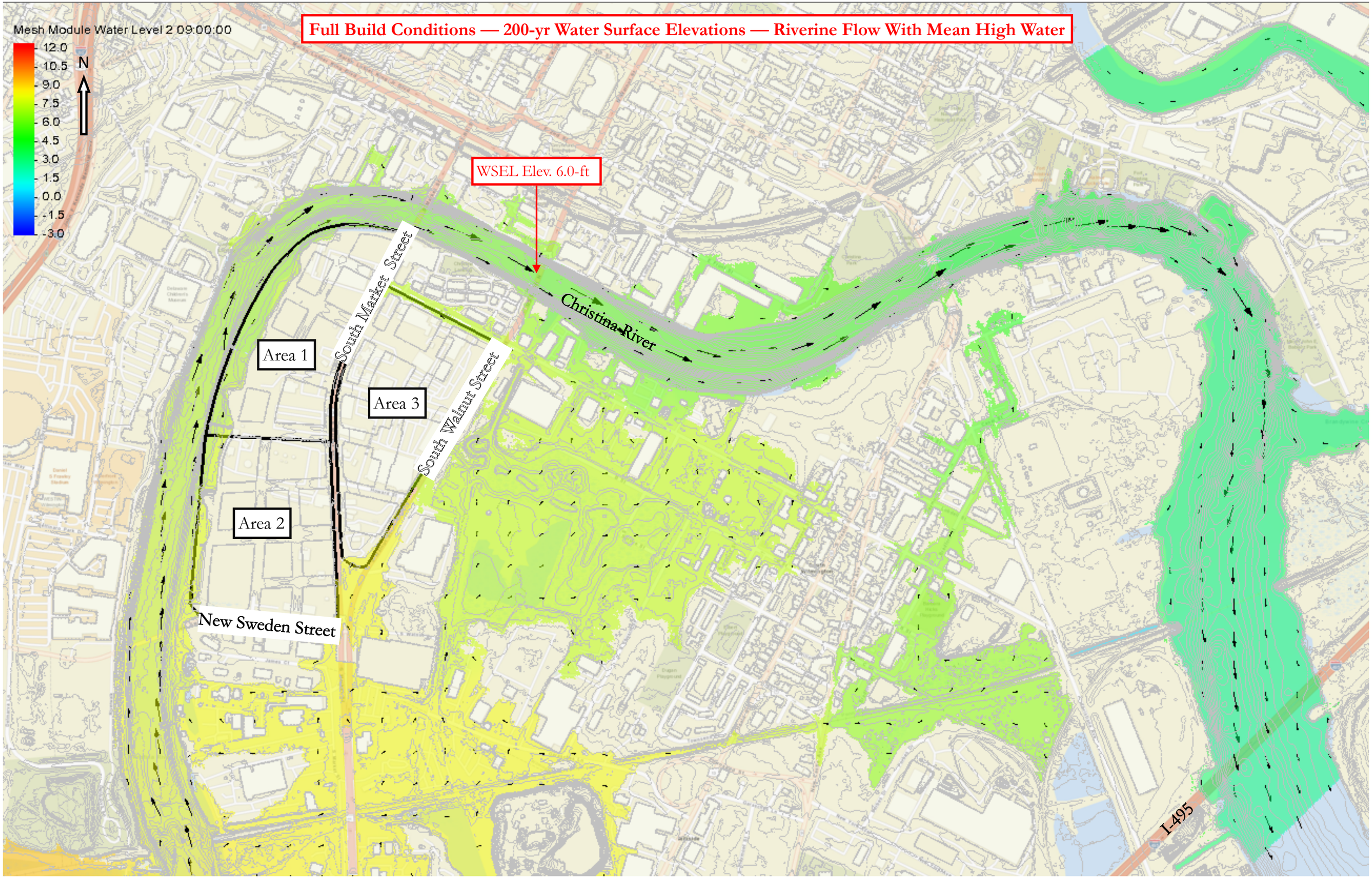
Full Build Conditions — 100-yr Water Surface Elevations — Riverine Flow With Mean High Water



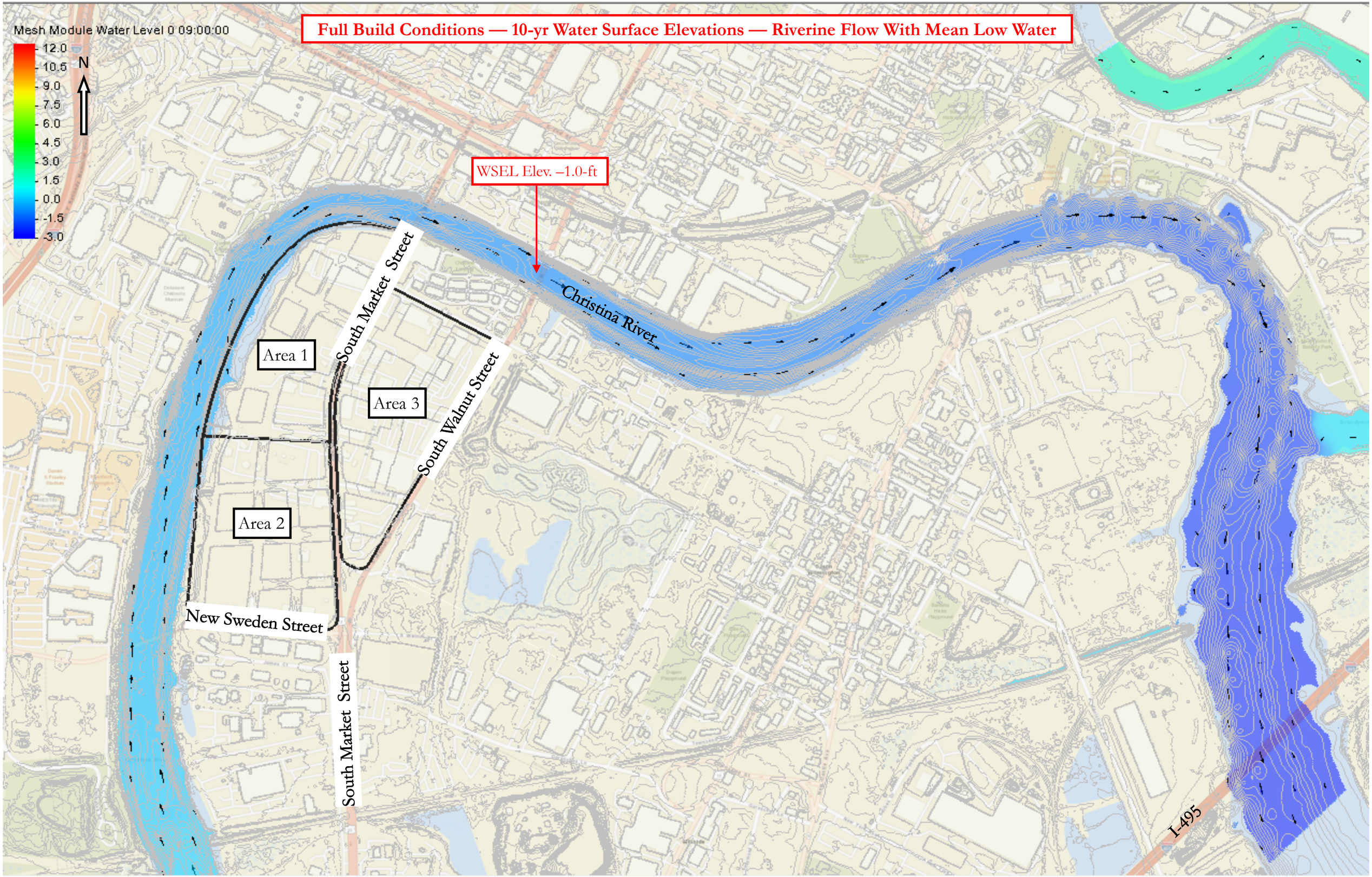
Existing Conditions — 200-yr Water Surface Elevations — Riverine Flow With Mean High Water



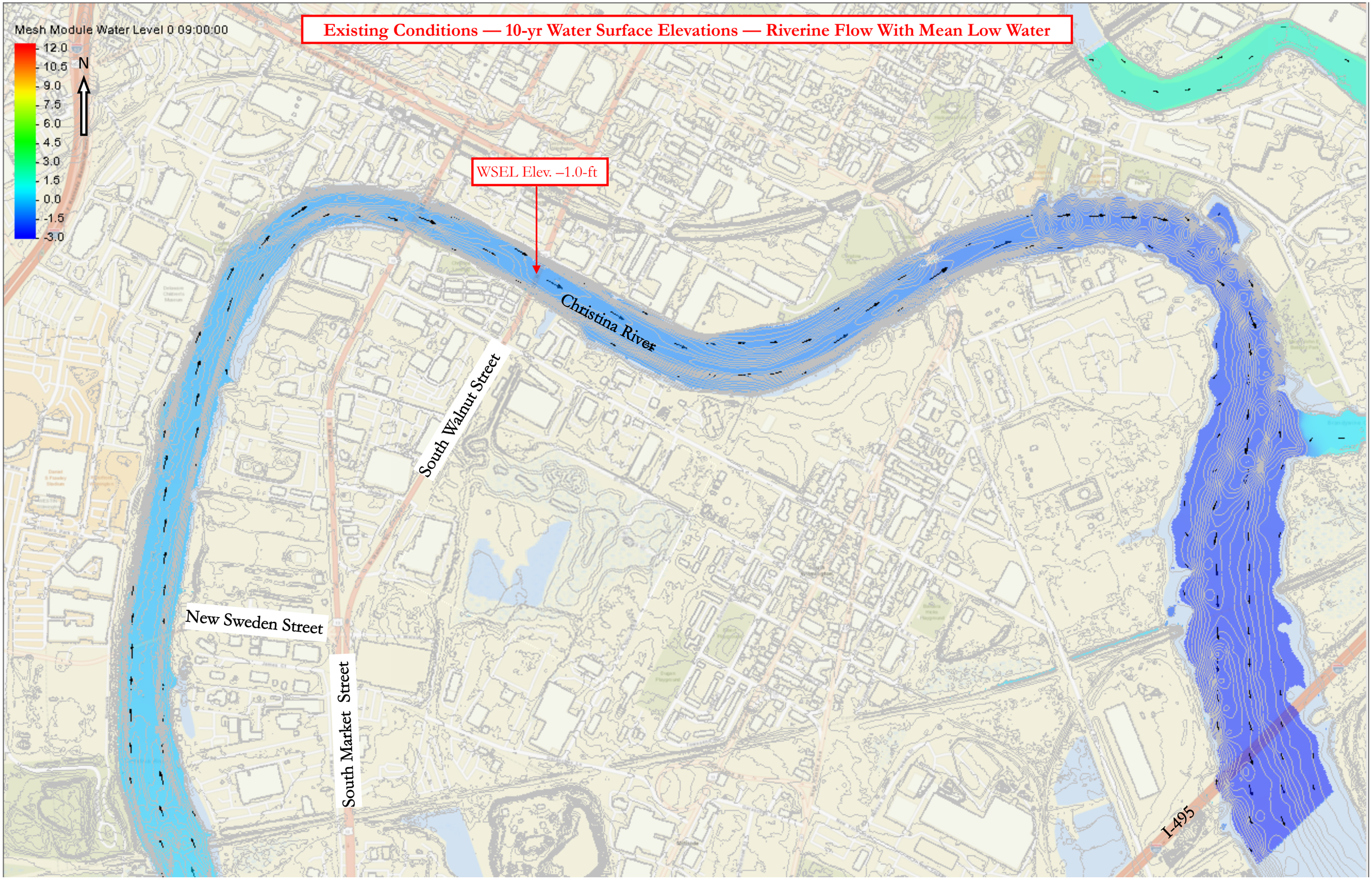
Full Build Conditions — 200-yr Water Surface Elevations — Riverine Flow With Mean High Water



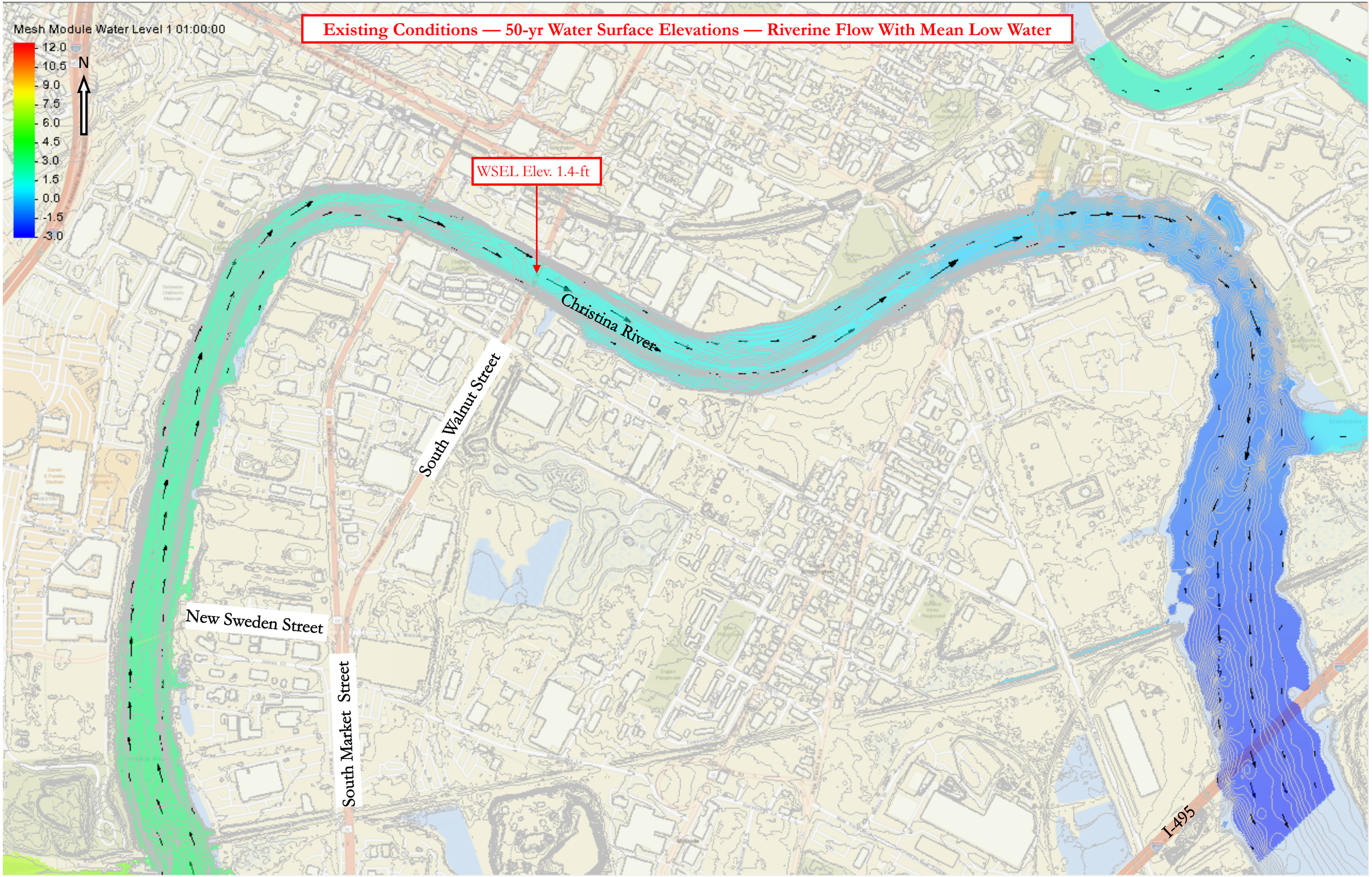
Full Build Conditions — 10-yr Water Surface Elevations — Riverine Flow With Mean Low Water



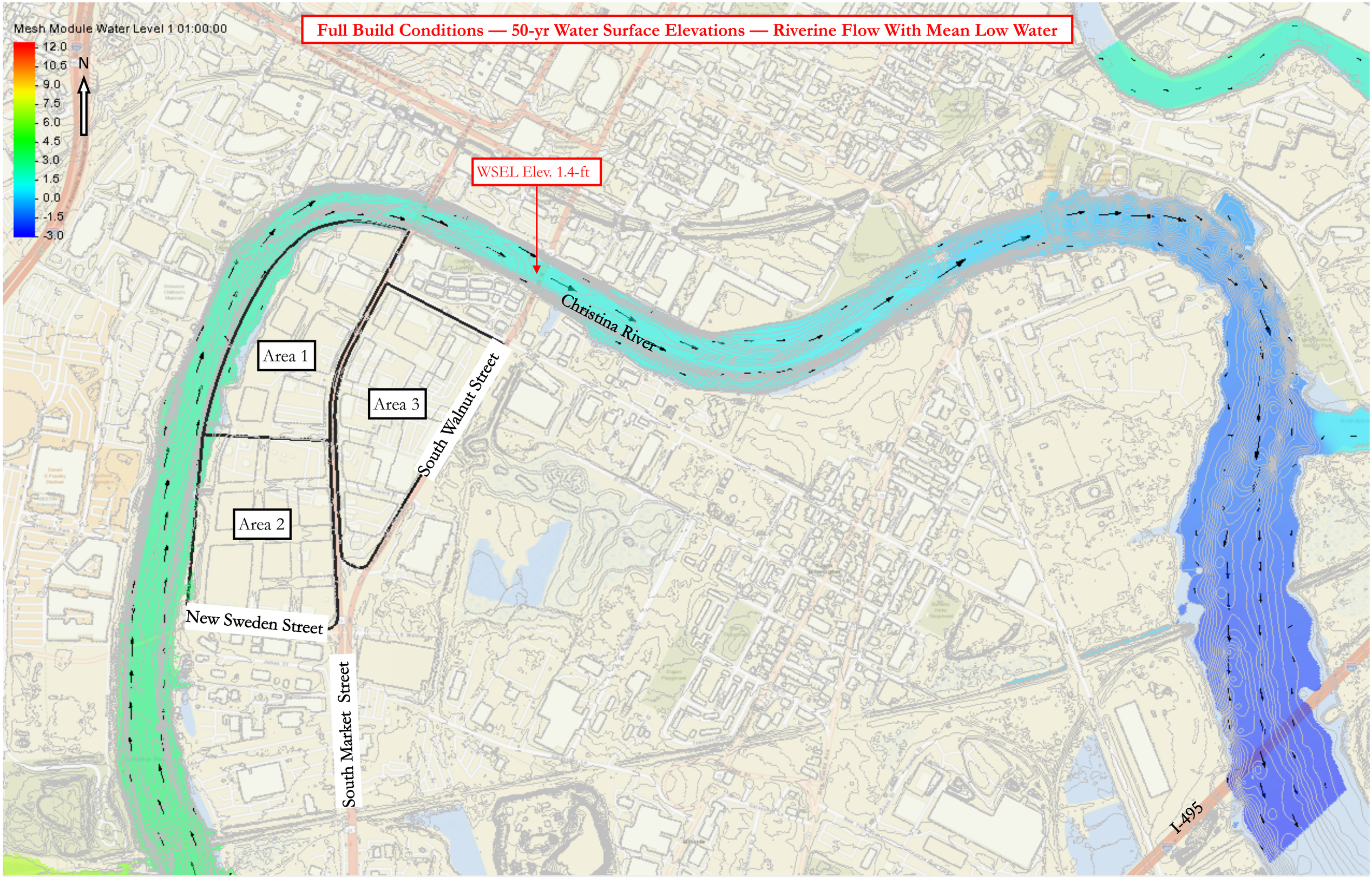
Existing Conditions — 10-yr Water Surface Elevations — Riverine Flow With Mean Low Water



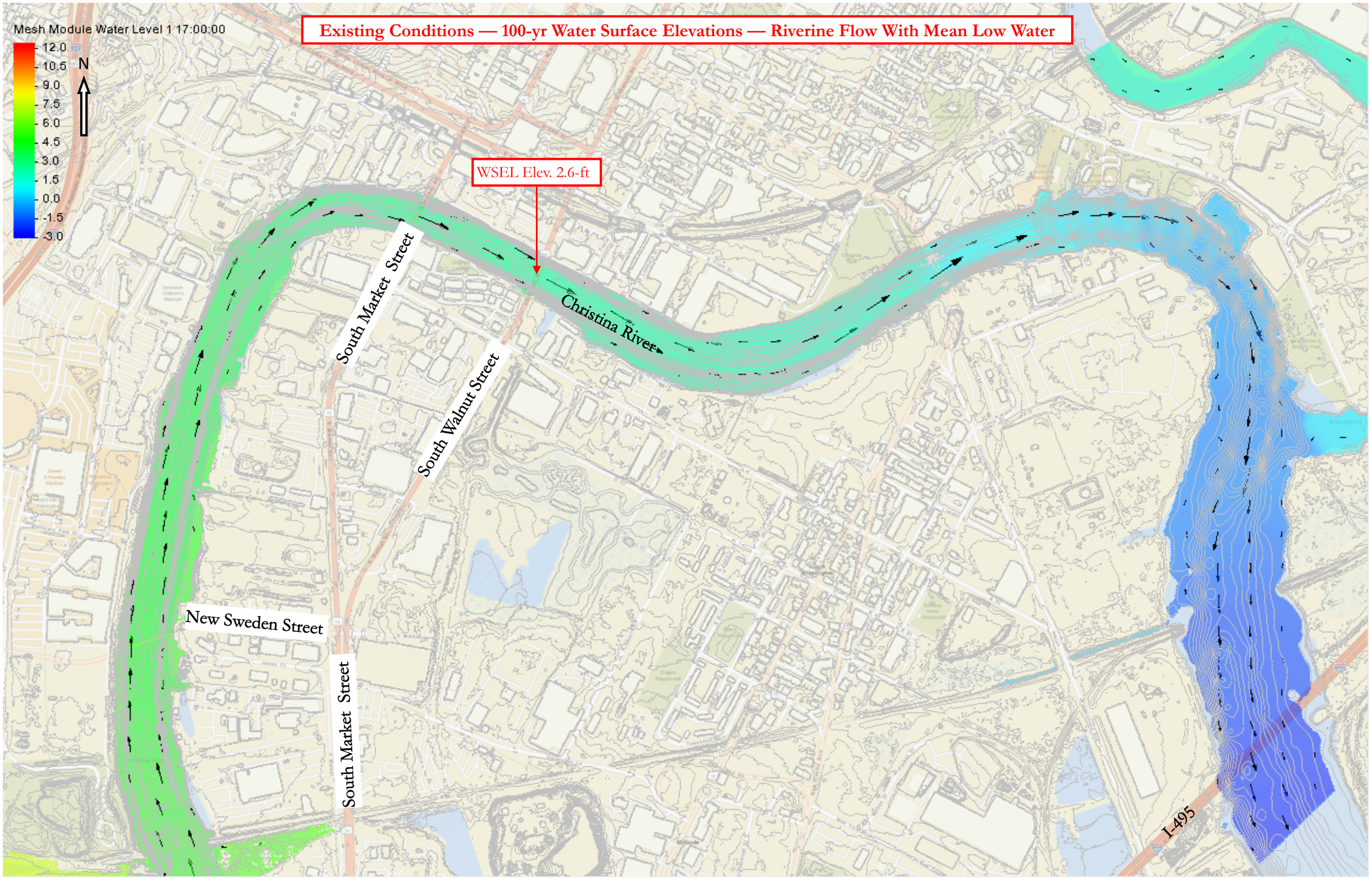
Existing Conditions — 50-yr Water Surface Elevations — Riverine Flow With Mean Low Water



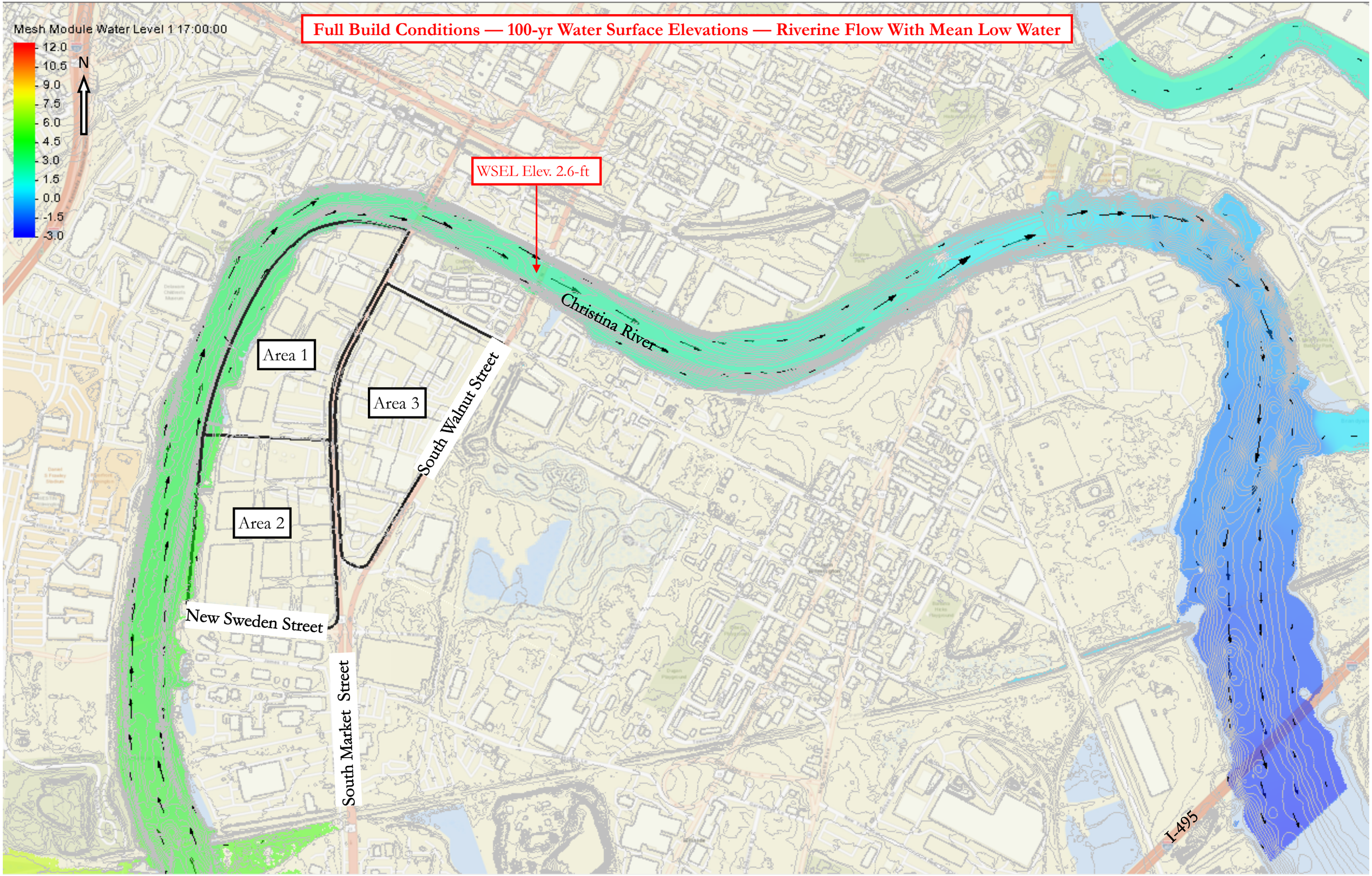
Full Build Conditions — 50-yr Water Surface Elevations — Riverine Flow With Mean Low Water



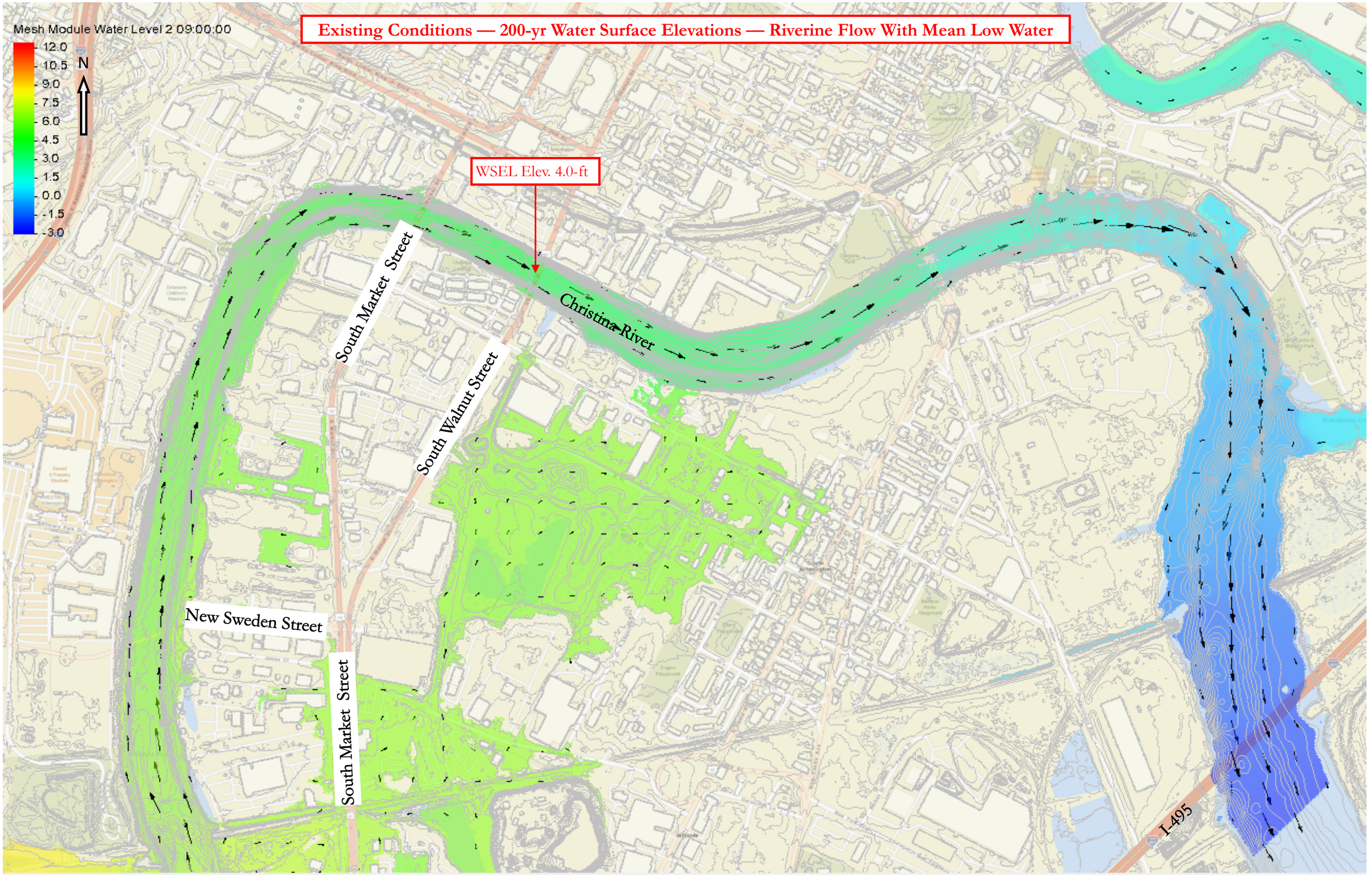
Existing Conditions — 100-yr Water Surface Elevations — Riverine Flow With Mean Low Water



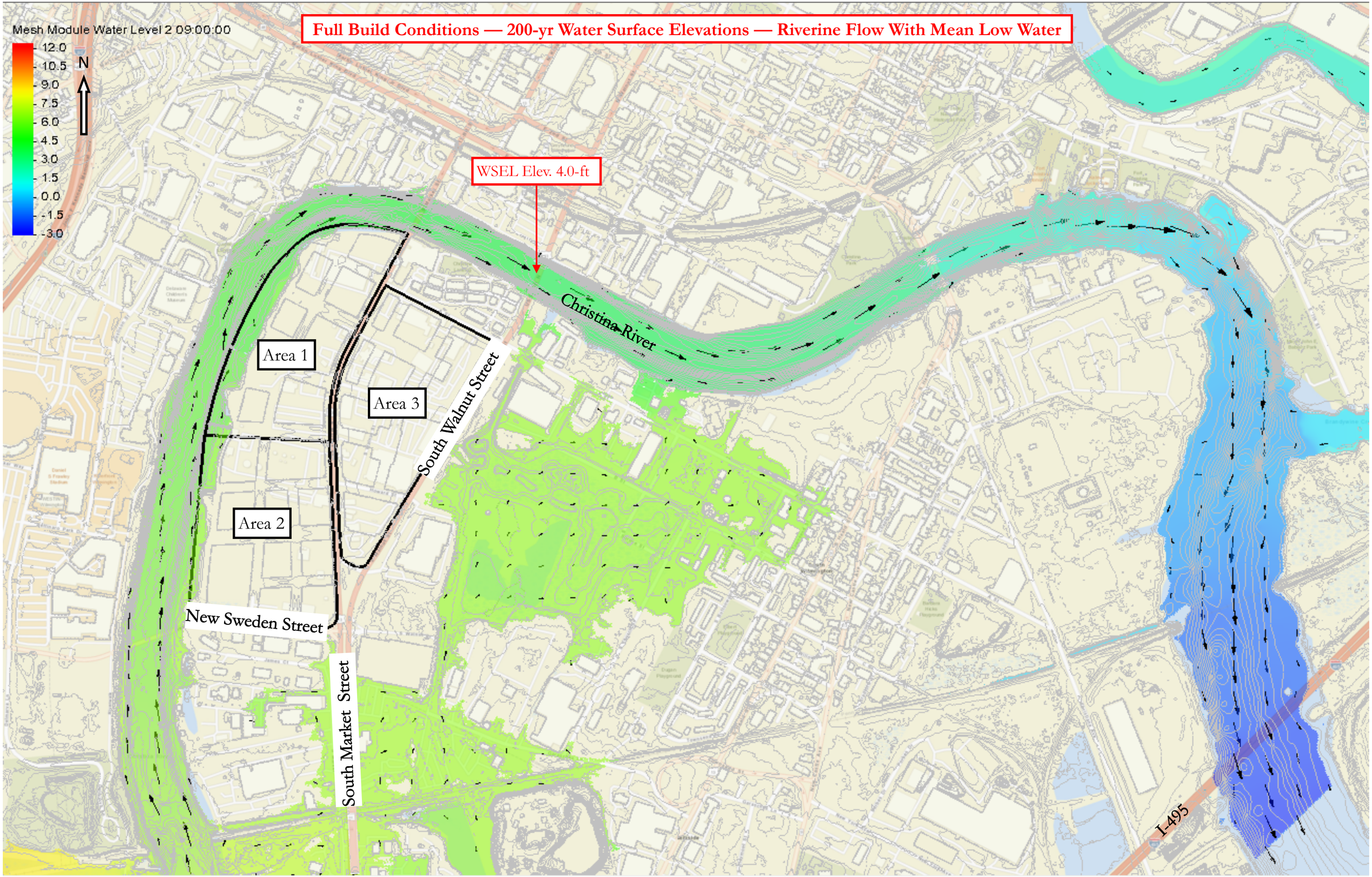
Full Build Conditions — 100-yr Water Surface Elevations — Riverine Flow With Mean Low Water



Existing Conditions — 200-yr Water Surface Elevations — Riverine Flow With Mean Low Water



Full Build Conditions — 200-yr Water Surface Elevations — Riverine Flow With Mean Low Water



Existing Conditions — 10-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)

Mesh Module Water Level 1 23:14:00

12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
-1.5
-3.0

N

Ex. 15” Outfall
to remain

WSEL Elev. 6.9-ft

Christina River

Ex. 24” Outfall
to be removed
Inv. Out = -5.21

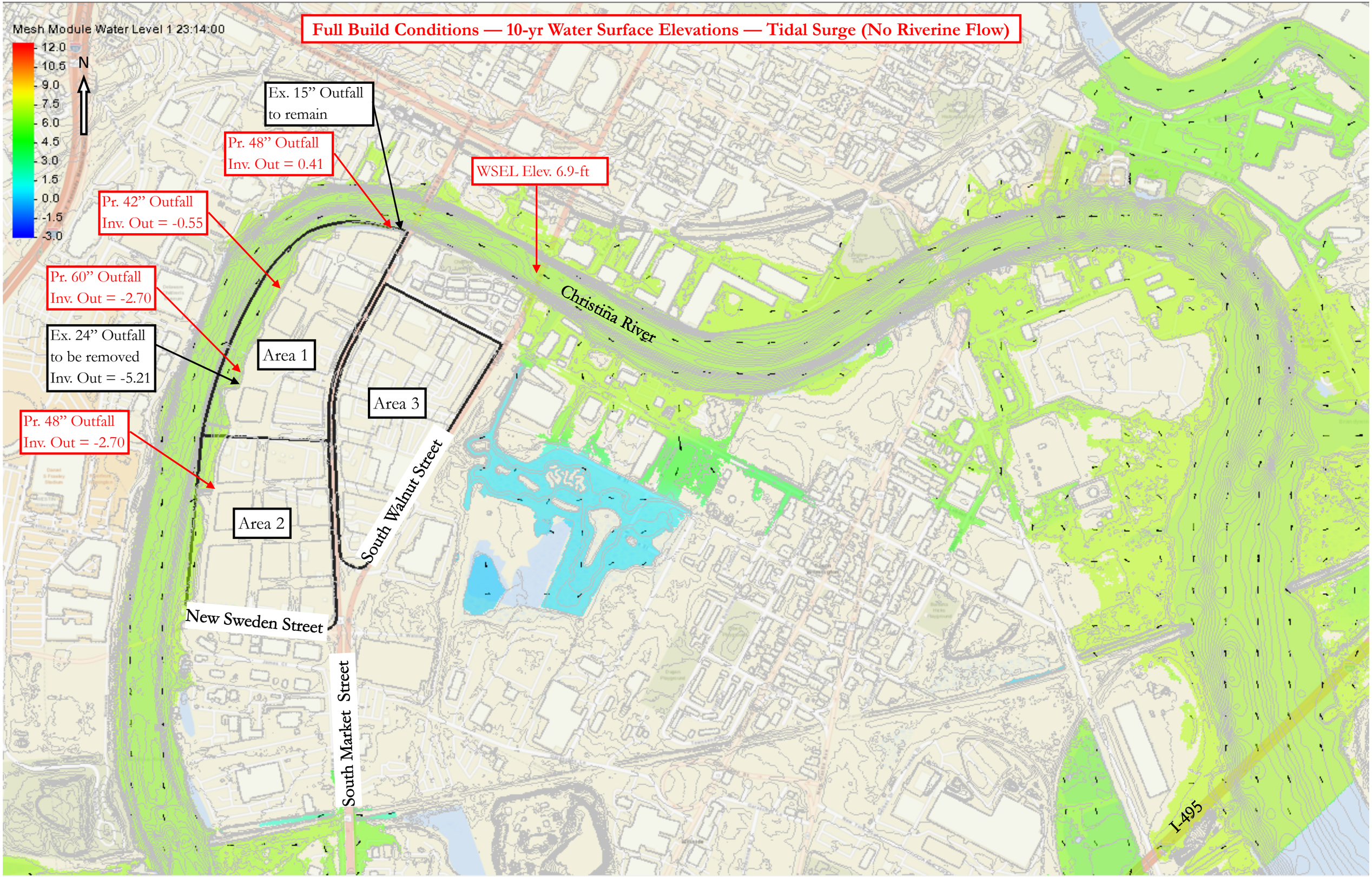
South Walnut Street

New Sweden Street

South Market Street

I-495

Full Build Conditions — 10-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)



Existing Conditions — 50-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)

Mesh Module Water Level 1 23:56:00

12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
-1.5
-3.0

N

Ex. 15” Outfall
to remain

WSEL Elev. 7.8-ft

Christina River

Ex. 24” Outfall
to be removed
Inv. Out = -5.21

South Walnut Street

New Sweden Street

South Market Street

I-495

Full Build Conditions — 50-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)

Mesh Module Water Level 1 23:56:00

12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
-1.5
-3.0

N

Ex. 15” Outfall
to remain

Pr. 48” Outfall
Inv. Out = 0.41

WSEL Elev. 7.8-ft

Pr. 42” Outfall
Inv. Out = -0.55

Pr. 60” Outfall
Inv. Out = -2.70

Ex. 24” Outfall
to be removed
Inv. Out = -5.21

Pr. 48” Outfall
Inv. Out = -2.70

Area 1

Area 3

Area 2

Christina River

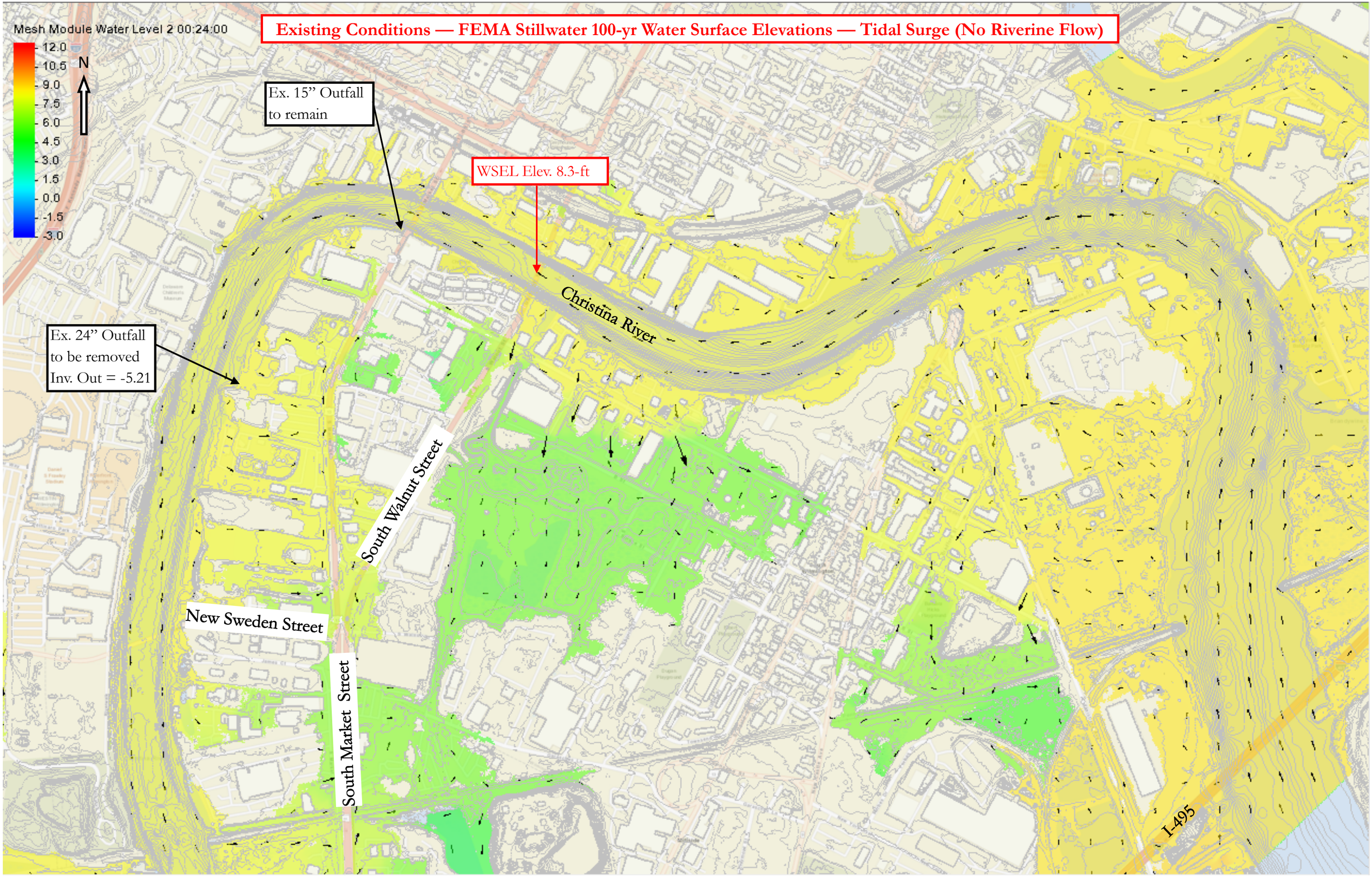
South Walnut Street

New Sweden Street

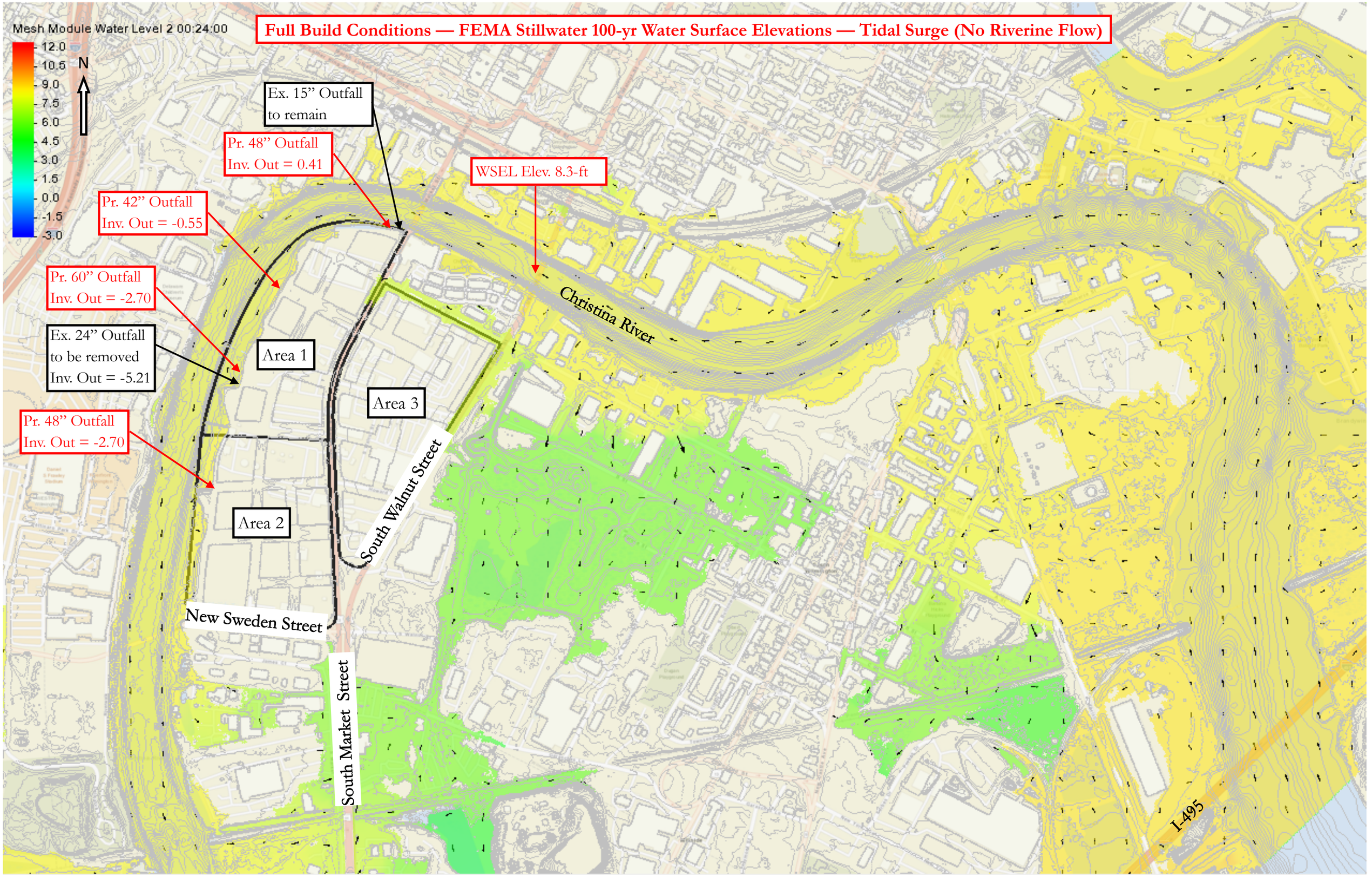
South Market Street

I-495

Existing Conditions — FEMA Stillwater 100-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)



Full Build Conditions — FEMA Stillwater 100-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)



Existing Conditions — FEMA BFE 100-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)

Mesh Module Water Level 2 01:23:00

12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
-1.5
-3.0

N

Ex. 15” Outfall
to remain

WSEL Elev. 9.0-ft

Christina River

Ex. 24” Outfall
to be removed
Inv. Out = -5.21

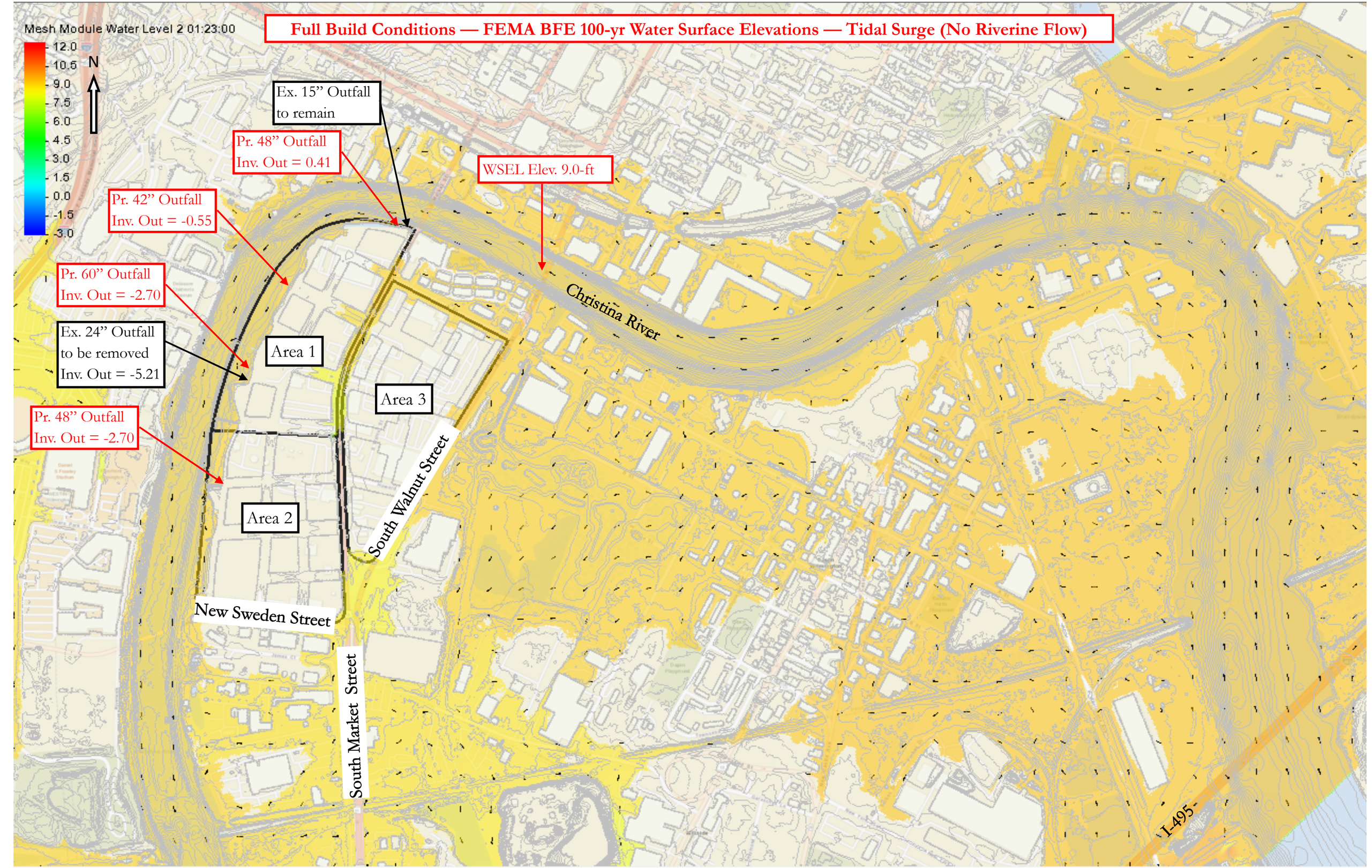
South Walnut Street

New Sweden Street

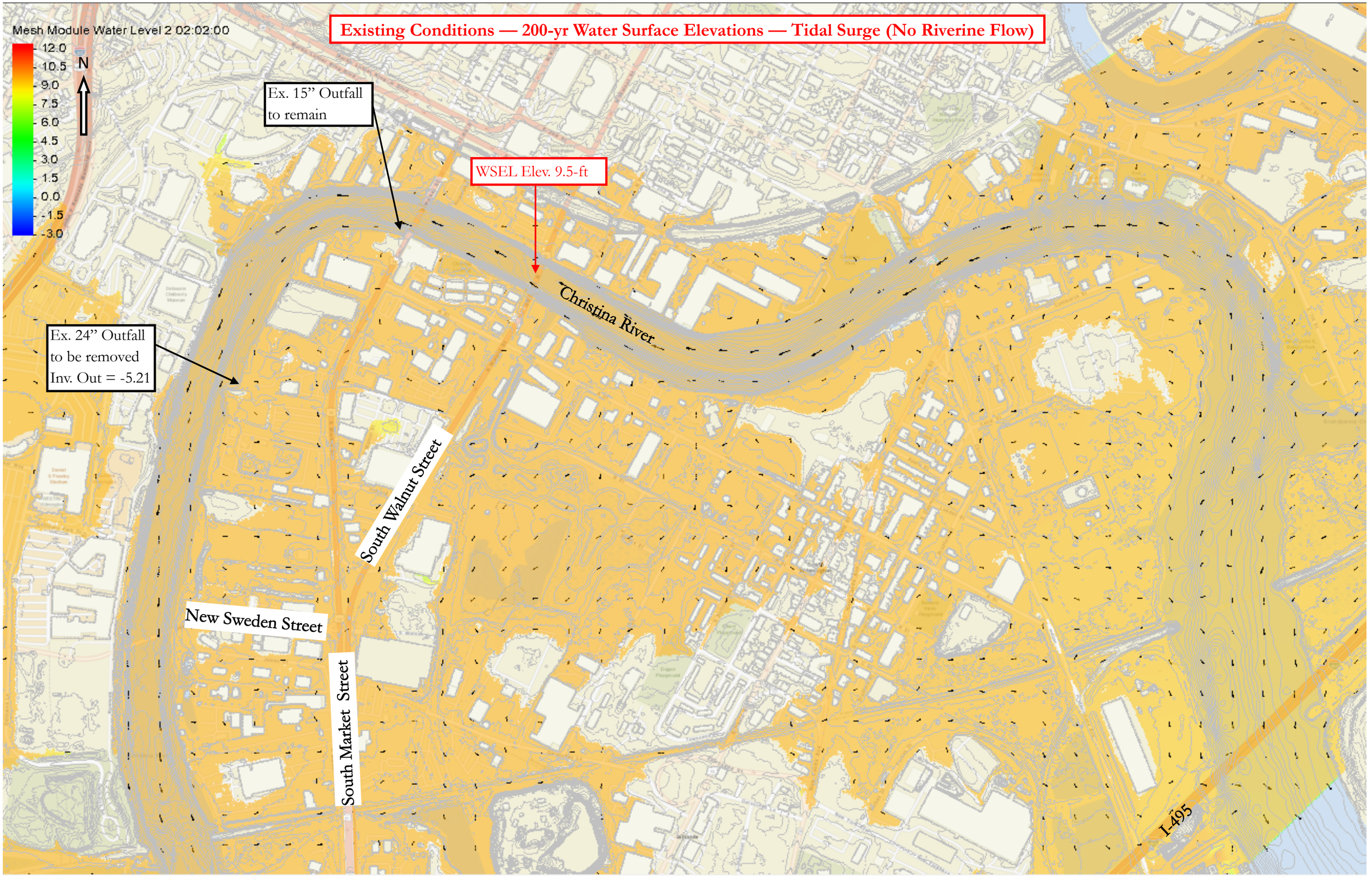
South Market Street

I-495

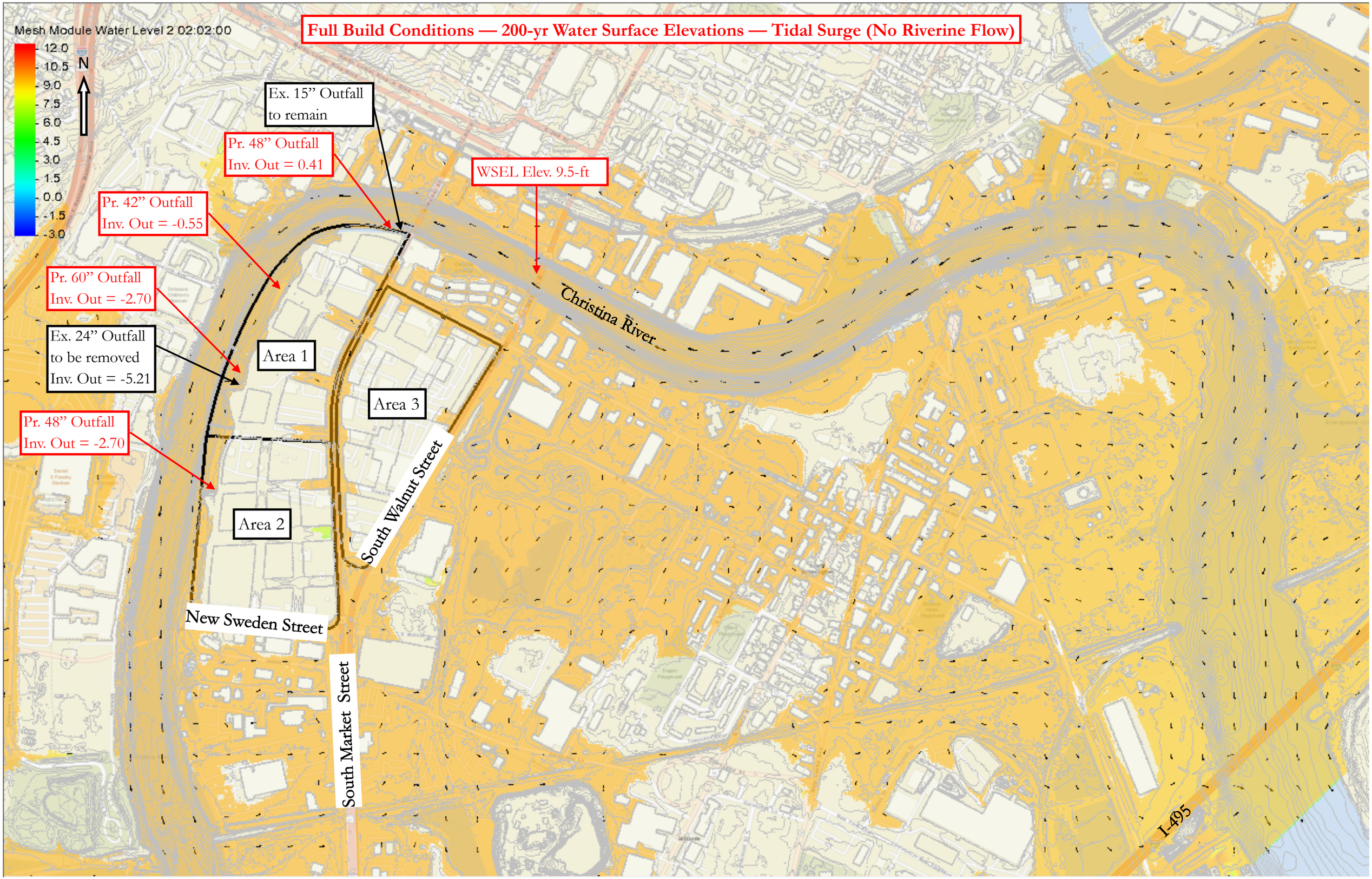
Full Build Conditions — FEMA BFE 100-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)



Existing Conditions — 200-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)



Full Build Conditions — 200-yr Water Surface Elevations — Tidal Surge (No Riverine Flow)



South Wilmington Infrastructure Improvements

Wilmington, DE

2D MODELING, SCOUR, AND DRAINAGE ANALYSIS REPORT

Appendix D

FHWA / SMS Bridge Scour Routine Layouts

South Market Street - Scenarios 1&2 Scour Routine Layout

N

Legend
- Abutment
- Approach Section
- Channel Bank
- Contracted Section
- Thalweg
- 2-ft Contours
- Bridge Geometry

Left Overbank
(LOB)

Flow
Christina River
(main channel)

Existing
Guide Bank

Left Abutment

Right Abutment

To Delaware River

Right Overbank
(ROB)

Existing
Guide Bank

0 25 50 100 150 200
US Feet

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South Market Street - Scenario 3 Scour Routine Layout

N

Legend
- Abutment
- Approach Section
- Channel Bank
- Contracted Section
- Thalweg
- 2-ft Contours
- Bridge Geometry

Existing Guide Bank

Left Abutment

Right Overbank (ROB)

Right Abutment

Existing Guide Bank

Flow

Christina River (main channel)

To Delaware River

Left Overbank (LOB)

0 25 50 100 150 200 US Feet

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South Walnut Street - Scenarios 1&2 Scour Routine Layout

N

Left Overbank
(LOB)

Flow
Christina River
(main channel)

Right Overbank
(ROB)

Left Abutment
Pier 1
Pier 2
Pier 3
Pier 4
Pier 5
Pier 6
Pier 7
Right Abutment

Existing
Guide Bank

Existing
Guide Bank

To Delaware River

Legend
- Abutment
- Approach Section
- Channel Bank
- Contracted Section
- Pier
- Thalweg
- 2-ft Contours
- Bridge Geometry

0 25 50 100 150 200
US Feet

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South Walnut Street - Scenario 3 Scour Routine Layout

N

Legend
- Abutment
- Approach Section
- Channel Bank
- Contracted Section
- Pier
- Thalweg
- 2-ft Contours
- Bridge Geometry

Left Abutment
Pier 1
Pier 2
Pier 3
Pier 4
Pier 5
Pier 6
Pier 7
Right Abutment
Existing Guide Bank
Existing Guide Bank
Right Overbank (ROB)
Left Overbank (LOB)
Flow
Christina River (main channel)
To Delaware River

Christina Landing
Christina Landing Dr
S Walnut St
S Poplar St
S Lombard St
A St
Amtrak
13

0 25 50 100 150 200
US Feet

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South Wilmington Infrastructure Improvements

Wilmington, DE

2D MODELING, SCOUR, AND DRAINAGE ANALYSIS REPORT

Appendix E

Scour Computations

South Market Street

Scenario 1 (Riverine Flow & MHW)
Existing Conditions

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
BRIDGE:	BR 1-688 - South Market Street		**DATE:**	4/4/2023	**PAGE:** 1

Contraction Scour

Approach Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	19.99	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	23.26	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27189.70	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	26566.70	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.84	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000652	0.000652	0.000652	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.65	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	7.59	0.00		
k_1 =	0.59	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.34	--	(ft)	Contraction scour depth

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Contraction Scour

Approach Cross Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.30	21.12	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	24.08	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	1.67	32488.50	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	31723.80	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	25.26	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.86	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000870	0.000870	0.000870	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.09	0.77	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	1.07	9.02	0.00		
k_1 =	0.64	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--*	1.90	--*	(ft)	Contraction scour depth

*No continuous overbank flow at internal bridge cross section

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	26566.70	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.84	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	23.26	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	33.5	--	(ft)	Contraction scour depth

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	31723.80	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.86	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	24.08	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	42.0	--	(ft)	Contraction scour depth

PROJECT:	South Wilmington Infrastructure Improvements	RK&K	**COMPS. BY:**	NSR	**CKD. By:** TJC
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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	23.26	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.45		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	23.26	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.48		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

PROJECT:	South Wilmington Infrastructure Improvements	RK&K	**COMPS. BY:**	NSR	**CKD. By:** TJC
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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	27189.70	(cfs)	Flow at the approach cross section
A_1	=	6221.97	(ft^2)	Flow area at the approach cross section
V_1	=	4.37	(ft/s)	Velocity at the approach cross section
Y_1	=	19.99	(ft)	Hydraulic depth at the approach cross section
q_1	=	87.36	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26566.70	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5211.87	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.10	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	23.26	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	118.56	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	25.97	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	44.15	(ft)	HEC-18 equation 8.3
Y_0	=	23.26	(ft)	
Y_s	=	20.89	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

PROJECT:	South Wilmington Infrastructure Improvements	**COMPS. BY:** NSR	**CKD. By:** TJC
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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	27189.70	(cfs)	Flow at the approach cross section
A_1	=	6221.97	(ft^2)	Flow area at the approach cross section
V_1	=	4.37	(ft/s)	Velocity at the approach cross section
Y_1	=	19.99	(ft)	Hydraulic depth at the approach cross section
q_f	=	87.36	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26566.70	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5211.87	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.10	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	23.26	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	118.56	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	87.36	(ft^2/s)	Upstream unit discharge
q_{2f}	=	118.56	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	61.48	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	153.71	(ft)	HEC-18 equation 8.3
Y_0	=	23.26	(ft)	
Y_s	=	130.45	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	24.08	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.43		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	24.08	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.47		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

PROJECT:	South Wilmington Infrastructure Improvements	RK&K	**COMPS. BY:**	NSR	**CKD. By:** TJC
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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	32488.50	(cfs)	Flow at the approach cross section
A_1	=	6575.7	(ft^2)	Flow area at the approach cross section
V_1	=	4.94	(ft/s)	Velocity at the approach cross section
Y_1	=	21.12	(ft)	Hydraulic depth at the approach cross section
q_1	=	104.35	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	31723.80	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5390.1	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.88	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	24.08	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	141.59	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	27.44	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	46.64	(ft)	HEC-18 equation 8.3
Y_0	=	24.08	(ft)	
Y_s	=	22.56	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

PROJECT:	South Wilmington Infrastructure Improvements	**COMPS. BY:** NSR	**CKD. By:** TJC
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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	32488.50	(cfs)	Flow at the approach cross section
A_1	=	6575.70	(ft^2)	Flow area at the approach cross section
V_1	=	4.94	(ft/s)	Velocity at the approach cross section
Y_1	=	21.12	(ft)	Hydraulic depth at the approach cross section
q_f	=	104.35	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	31723.80	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5390.10	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.88	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	24.08	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	141.59	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	104.35	(ft^2/s)	Upstream unit discharge
q_{2f}	=	141.59	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	71.59	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	178.97	(ft)	HEC-18 equation 8.3
Y_0	=	24.08	(ft)	
Y_s	=	154.89	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 1 (Riverine Flow & MHW)
Proposed Area 1 Build

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
BRIDGE:	BR 1-688 - South Market Street		**DATE:**	4/4/2023	**PAGE:** 1

Contraction Scour

Approach Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	19.93	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	23.26	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27166.10	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	26542.50	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.84	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000651	0.000651	0.000651	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.65	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	7.58	0.00		
k_1 =	0.59	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.27	--	(ft)	Contraction scour depth

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Contraction Scour

Approach Cross Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.30	21.06	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	24.08	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	1.67	32469.50	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	31704.50	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	25.26	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.86	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000868	0.000868	0.000868	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.09	0.77	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	1.07	8.99	0.00		
k_1 =	0.64	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.82	--	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	26542.50	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.84	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	23.26	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	33.5	--	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	31704.50	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.86	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	24.08	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	42.0	--	(ft)	Contraction scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	23.26	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.45		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	23.26	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.48		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	27166.10	(cfs)	Flow at the approach cross section
A_1	=	6203.62	(ft^2)	Flow area at the approach cross section
V_1	=	4.38	(ft/s)	Velocity at the approach cross section
Y_1	=	19.93	(ft)	Hydraulic depth at the approach cross section
q_1	=	87.27	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26542.50	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5206.07	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.09	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	23.26	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	118.47	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	25.90	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	44.03	(ft)	HEC-18 equation 8.3
Y_0	=	23.26	(ft)	
Y_s	=	20.77	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	27166.10	(cfs)	Flow at the approach cross section
A_1	=	6203.62	(ft^2)	Flow area at the approach cross section
V_1	=	4.38	(ft/s)	Velocity at the approach cross section
Y_1	=	19.93	(ft)	Hydraulic depth at the approach cross section
q_f	=	87.27	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26542.50	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5206.07	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.09	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	23.26	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	118.47	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	87.27	(ft^2/s)	Upstream unit discharge
q_{2f}	=	118.47	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	61.44	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	159.75	(ft)	HEC-18 equation 8.3
Y_0	=	23.26	(ft)	
Y_s	=	136.49	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	24.08	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.43		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	24.08	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.47		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	32469.50	(cfs)	Flow at the approach cross section
A_1	=	6557.3	(ft^2)	Flow area at the approach cross section
V_1	=	4.95	(ft/s)	Velocity at the approach cross section
Y_1	=	21.06	(ft)	Hydraulic depth at the approach cross section
q_1	=	104.28	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	31704.50	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5390.06	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.88	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	24.08	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	141.50	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	27.36	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	46.51	(ft)	HEC-18 equation 8.3
Y_0	=	24.08	(ft)	
Y_s	=	22.43	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	32469.50	(cfs)	Flow at the approach cross section
A_1	=	6557.30	(ft^2)	Flow area at the approach cross section
V_1	=	4.95	(ft/s)	Velocity at the approach cross section
Y_1	=	21.06	(ft)	Hydraulic depth at the approach cross section
q_f	=	104.28	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	31704.50	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5390.06	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.88	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	24.08	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	141.50	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	104.28	(ft^2/s)	Upstream unit discharge
q_{2f}	=	141.50	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	71.55	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	178.87	(ft)	HEC-18 equation 8.3
Y_0	=	24.08	(ft)	
Y_s	=	154.79	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 1 (Riverine Flow & MHW)
Proposed Full Build

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Contraction Scour

Approach Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	19.93	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	23.26	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27166.10	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	26542.50	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.84	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000651	0.000651	0.000651	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.65	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	7.58	0.00		
k_1 =	0.59	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.27	--	(ft)	Contraction scour depth

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Contraction Scour

Approach Cross Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.30	21.06	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	24.08	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	1.67	32413.40	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	31649.70	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	25.26	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.86	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000864	0.000864	0.000864	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.09	0.77	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	1.07	8.97	0.00		
k_1 =	0.64	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.82	--	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	26542.50	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.84	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	23.26	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	33.5	--	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	31649.70	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.86	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	24.08	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	41.9	--	(ft)	Contraction scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	23.26	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.45		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	23.26	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.48		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	27166.10	(cfs)	Flow at the approach cross section
A_1	=	6203.64	(ft^2)	Flow area at the approach cross section
V_1	=	4.38	(ft/s)	Velocity at the approach cross section
Y_1	=	19.93	(ft)	Hydraulic depth at the approach cross section
q_1	=	87.27	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26542.50	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5206.08	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.09	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	23.26	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	118.47	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	25.90	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	44.03	(ft)	HEC-18 equation 8.3
Y_0	=	23.26	(ft)	
Y_s	=	20.77	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	27166.10	(cfs)	Flow at the approach cross section
A_1	=	6203.64	(ft^2)	Flow area at the approach cross section
V_1	=	4.38	(ft/s)	Velocity at the approach cross section
Y_1	=	19.93	(ft)	Hydraulic depth at the approach cross section
q_f	=	87.27	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26542.50	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5206.08	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.09	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	23.26	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	118.47	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	87.27	(ft^2/s)	Upstream unit discharge
q_{2f}	=	118.47	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	61.44	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	159.75	(ft)	HEC-18 equation 8.3
Y_0	=	23.26	(ft)	
Y_s	=	136.49	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	21.06	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.49		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	21.06	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.53		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	32413.40	(cfs)	Flow at the approach cross section
A_1	=	6557.32	(ft^2)	Flow area at the approach cross section
V_1	=	4.94	(ft/s)	Velocity at the approach cross section
Y_1	=	21.06	(ft)	Hydraulic depth at the approach cross section
q_1	=	104.10	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	31649.70	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5390.23	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.87	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	24.08	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	141.25	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	27.36	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	46.51	(ft)	HEC-18 equation 8.3
Y_0	=	24.08	(ft)	
Y_s	=	22.43	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	32413.40	(cfs)	Flow at the approach cross section
A_1	=	6557.32	(ft^2)	Flow area at the approach cross section
V_1	=	4.94	(ft/s)	Velocity at the approach cross section
Y_1	=	21.06	(ft)	Hydraulic depth at the approach cross section
q_f	=	104.10	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	31649.70	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5390.23	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.87	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	24.08	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	141.25	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	104.10	(ft^2/s)	Upstream unit discharge
q_{2f}	=	141.25	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	71.44	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	178.60	(ft)	HEC-18 equation 8.3
Y_0	=	24.08	(ft)	
Y_s	=	154.52	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 2 (Riverine Flow & MLW)
Existing Conditions

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Contraction Scour

Approach Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	17.74	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	21.57	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27562.20	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	26939.10	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.80	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000774	0.000774	0.000774	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.66	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.0000	0.2000	0.0000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0000	0.0853	0.0000	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	--	7.80	--		
k_1 =	--	0.69	--		Bed Material Transport Exponent from Section 6.3
y_s =	--	0.27	--	(ft)	Contraction scour depth

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Contraction Scour

Approach Cross Section: 40255.45
Internal Bridge Section: 39450 BRU

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.00	19.26	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	22.62	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	33328.70	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	32551.20	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.84	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001041	0.001041	0.001041	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.80	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.0000	0.2000	0.0000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
T =	0.0000	0.0853	0.0000	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	--	9.42	--		
k_1 =	--	0.69	--		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.08	--	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	26939.10	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.0000	0.2000	0.0000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.0000	0.2500	0.0000	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.80	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	21.57	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	35.9	--	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	32551.20	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.0000	0.2000	0.0000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
D_m =	0.0000	0.2500	0.0000	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.84	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	22.62	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	44.9	--	(ft)	Contraction scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	21.57	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.48		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	21.57	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.52		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	27562.20	(cfs)	Flow at the approach cross section
A_1	=	5524.01	(ft^2)	Flow area at the approach cross section
V_1	=	4.99	(ft/s)	Velocity at the approach cross section
Y_1	=	17.74	(ft)	Hydraulic depth at the approach cross section
q_1	=	88.53	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26939.10	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	4826.58	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.57	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	21.57	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	120.24	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	23.06	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	39.21	(ft)	HEC-18 equation 8.3
Y_0	=	21.57	(ft)	
Y_s	=	17.64	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	27562.20	(cfs)	Flow at the approach cross section
A_1	=	5524.01	(ft^2)	Flow area at the approach cross section
V_1	=	4.99	(ft/s)	Velocity at the approach cross section
Y_1	=	17.74	(ft)	Hydraulic depth at the approach cross section
q_f	=	88.53	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26939.10	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	4826.58	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.57	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	21.57	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	120.24	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	88.53	(ft^2/s)	Upstream unit discharge
q_{2f}	=	120.24	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	62.23	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	155.58	(ft)	HEC-18 equation 8.3
Y_0	=	21.57	(ft)	
Y_s	=	134.01	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	22.62	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.46		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	22.62	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.50		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left Abutment

Q_1	=	33328.70	(cfs)	Flow at the approach cross section
A_1	=	5995.99	(ft^2)	Flow area at the approach cross section
V_1	=	5.56	(ft/s)	Velocity at the approach cross section
Y_1	=	19.26	(ft)	Hydraulic depth at the approach cross section
q_1	=	107.06	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	32551.20	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5063.24	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	6.42	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	22.62	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	145.27	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	25.02	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	42.53	(ft)	HEC-18 equation 8.3
Y_0	=	22.62	(ft)	
Y_s	=	19.91	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left Abutment

Q_1	=	33328.70	(cfs)	Flow at the approach cross section
A_1	=	5995.99	(ft^2)	Flow area at the approach cross section
V_1	=	5.56	(ft/s)	Velocity at the approach cross section
Y_1	=	19.26	(ft)	Hydraulic depth at the approach cross section
q_f	=	107.06	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	32551.20	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5063.24	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	6.42	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	22.62	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	145.27	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	107.06	(ft^2/s)	Upstream unit discharge
q_{2f}	=	145.27	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	73.18	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	182.95	(ft)	HEC-18 equation 8.3
Y_0	=	22.62	(ft)	
Y_s	=	160.33	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 2 (Riverine Flow & MLW)
Proposed Area 1 Build

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Contraction Scour

Approach Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	17.72	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	21.57	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27562.50	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	26939.30	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.80	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000776	0.000776	0.000776	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.67	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.0000	0.2000	0.0000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0000	0.0853	0.0000	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	--	7.80	--		
k_1 =	--	0.69	--		Bed Material Transport Exponent from Section 6.3
y_s =	--	0.25	--	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.00	19.21	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	22.62	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	33283.10	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	32505.40	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.84	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001040	0.001040	0.001040	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.80	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.0000	0.2000	0.0000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
T =	0.0000	0.0853	0.0000	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	--	9.40	--		
k_1 =	--	0.69	--		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.01	--	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	26939.30	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.0000	0.2000	0.0000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.0000	0.2500	0.0000	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.80	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	21.57	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	35.9	--	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	32505.40	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.0000	0.2000	0.0000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
D_m =	0.0000	0.2500	0.0000	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.84	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	22.62	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	44.8	--	(ft)	Contraction scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	21.57	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.48		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	21.57	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.52		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	27562.50	(cfs)	Flow at the approach cross section
A_1	=	5514.62	(ft^2)	Flow area at the approach cross section
V_1	=	5.00	(ft/s)	Velocity at the approach cross section
Y_1	=	17.72	(ft)	Hydraulic depth at the approach cross section
q_1	=	88.57	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26939.30	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	4826.55	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.57	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	21.57	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	120.25	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	23.03	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	39.15	(ft)	HEC-18 equation 8.3
Y_0	=	21.57	(ft)	
Y_s	=	17.58	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	27562.50	(cfs)	Flow at the approach cross section
A_1	=	5514.62	(ft^2)	Flow area at the approach cross section
V_1	=	5.00	(ft/s)	Velocity at the approach cross section
Y_1	=	17.72	(ft)	Hydraulic depth at the approach cross section
q_f	=	88.57	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26939.30	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	4826.55	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.57	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	21.57	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	120.25	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	88.57	(ft^2/s)	Upstream unit discharge
q_{2f}	=	120.25	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	62.23	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	155.58	(ft)	HEC-18 equation 8.3
Y_0	=	21.57	(ft)	
Y_s	=	134.01	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	19.21	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.54		Left Set Back Ratio

Right Abutment

D	=	10.40	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	22.62	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.46		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	33283.10	(cfs)	Flow at the approach cross section
A_1	=	5980.3	(ft^2)	Flow area at the approach cross section
V_1	=	5.57	(ft/s)	Velocity at the approach cross section
Y_1	=	19.21	(ft)	Hydraulic depth at the approach cross section
q_1	=	106.91	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	32505.40	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5063.48	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	6.41	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	22.62	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	145.06	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	24.95	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	42.42	(ft)	HEC-18 equation 8.3
Y_0	=	22.62	(ft)	
Y_s	=	19.80	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	33283.10	(cfs)	Flow at the approach cross section
A_1	=	5980.30	(ft^2)	Flow area at the approach cross section
V_1	=	5.57	(ft/s)	Velocity at the approach cross section
Y_1	=	19.21	(ft)	Hydraulic depth at the approach cross section
q_f	=	106.91	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	32505.40	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5063.48	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	6.41	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	22.62	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	145.06	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	106.91	(ft^2/s)	Upstream unit discharge
q_{2f}	=	145.06	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	73.09	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	182.72	(ft)	HEC-18 equation 8.3
Y_0	=	22.62	(ft)	
Y_s	=	160.10	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 2 (Riverine Flow & MLW)
Proposed Full Build

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Contraction Scour

Approach Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	17.72	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	21.57	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27562.60	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	26939.30	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.80	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000776	0.000776	0.000776	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.67	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	7.80	0.00		
k_1 =	0.59	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	0.25	--	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 223-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.00	19.21	0.00	(ft)	Average depth in the approach cross section
y_o =	0.00	22.62	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	33283.00	0.00	(cfs)	Flow in the approach cross section
Q_2 =	0.00	32505.40	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	311.29	0.00	(ft)	Top width in the approach cross section
W_2 =	0.00	223.84	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001040	0.001040	0.001040	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.80	0.00	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	9.40	0.00		
k_1 =	0.59	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--*	1.01	--*	(ft)	Contraction scour depth

*No continuous overbank flow at internal bridge cross section

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	26939.30	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.80	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	21.57	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	35.9	--	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	32505.40	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.84	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	22.62	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	44.8	--	(ft)	Contraction scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	21.57	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.48		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	21.57	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.52		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	27562.60	(cfs)	Flow at the approach cross section
A_1	=	5514.63	(ft^2)	Flow area at the approach cross section
V_1	=	5.00	(ft/s)	Velocity at the approach cross section
Y_1	=	17.72	(ft)	Hydraulic depth at the approach cross section
q_1	=	88.57	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26939.30	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	4826.56	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.57	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	21.57	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	120.25	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	23.03	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	39.15	(ft)	HEC-18 equation 8.3
Y_0	=	21.57	(ft)	
Y_s	=	17.58	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 223-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	27562.60	(cfs)	Flow at the approach cross section
A_1	=	5514.63	(ft^2)	Flow area at the approach cross section
V_1	=	5.00	(ft/s)	Velocity at the approach cross section
Y_1	=	17.72	(ft)	Hydraulic depth at the approach cross section
q_f	=	88.60	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	26939.30	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	4826.56	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	5.57	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	21.57	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	120.14	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	88.60	(ft^2/s)	Upstream unit discharge
q_{2f}	=	120.14	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	62.19	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	155.47	(ft)	HEC-18 equation 8.3
Y_0	=	21.57	(ft)	
Y_s	=	133.90	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	22.62	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.46		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	22.62	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.50		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5)

Approach Cross Section: 223-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	33283.00	(cfs)	Flow at the approach cross section
A_1	=	5980.53	(ft^2)	Flow area at the approach cross section
V_1	=	5.57	(ft/s)	Velocity at the approach cross section
Y_1	=	19.21	(ft)	Hydraulic depth at the approach cross section
q_1	=	106.91	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	32505.40	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5063.59	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	6.41	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	22.62	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	145.06	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	24.95	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	42.42	(ft)	HEC-18 equation 8.3
Y_0	=	22.62	(ft)	
Y_s	=	19.80	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Approach Cross Section: 223-ft Upstream of Contracted Section

Left and Right Abutment

Q_1	=	33283.00	(cfs)	Flow at the approach cross section
A_1	=	5980.53	(ft^2)	Flow area at the approach cross section
V_1	=	5.57	(ft/s)	Velocity at the approach cross section
Y_1	=	19.21	(ft)	Hydraulic depth at the approach cross section
q_f	=	106.91	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	32505.40	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5063.59	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	6.41	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	22.62	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	145.06	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	106.91	(ft^2/s)	Upstream unit discharge
q_{2f}	=	145.06	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.36		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	73.09	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	182.72	(ft)	HEC-18 equation 8.3
Y_0	=	22.62	(ft)	
Y_s	=	160.10	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 3 (Tidal Surge Only)
Existing Conditions

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Contraction Scour

Approach Section: 233-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.87	25.17	0.60	(ft)	Average depth in the approach cross section
y_o =	0.00	25.50	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	5.95	9538.06	15.78	(cfs)	Flow in the approach cross section
Q_2 =	0.00	9340.46	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	37.49	298.24	226.45	(ft)	Top width in the approach cross section
W_2 =	0.00	223.05	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000074	0.000071	0.000074	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.05	0.24	0.04	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.53	2.81	0.44		
k_1 =	0.64	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	4.71	--	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 233-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	8.98	26.35	1.60	(ft)	Average depth in the approach cross section
y_o =	0.00	26.55	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	11.50	6079.56	40.62	(cfs)	Flow in the approach cross section
Q_2 =	0.00	5937.50	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	232.47	298.24	236.49	(ft)	Top width in the approach cross section
W_2 =	0.00	223.06	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000015	0.000015	0.000015	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.07	0.11	0.03	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.77	1.32	0.33		
k_1 =	0.64	0.64	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	4.55	--	(ft)	

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	9340.46	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.05	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	25.50	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	0.0	--	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	5937.50	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.06	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	26.55	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	0.0	--	(ft)	Contraction scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	25.50	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.41		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	25.50	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.44		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	9538.06	(cfs)	Flow at the approach cross section
A_1	=	7507.61	(ft^2)	Flow area at the approach cross section
V_1	=	1.27	(ft/s)	Velocity at the approach cross section
Y_1	=	25.17	(ft)	Hydraulic depth at the approach cross section
q_1	=	31.98	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	9340.46	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5688.28	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.63	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	25.50	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	41.68	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	31.59	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	53.70	(ft)	HEC-18 equation 8.3
Y_0	=	25.50	(ft)	
Y_s	=	28.20	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	9538.06	(cfs)	Flow at the approach cross section
A_1	=	7507.61	(ft^2)	Flow area at the approach cross section
V_1	=	1.27	(ft/s)	Velocity at the approach cross section
Y_1	=	25.17	(ft)	Hydraulic depth at the approach cross section
q_f	=	31.98	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	9340.46	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5688.28	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.63	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	25.50	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	41.68	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	31.98	(ft^2/s)	Upstream unit discharge
q_{2f}	=	41.68	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	25.10	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	65.25	(ft)	HEC-18 equation 8.3
Y_0	=	25.50	(ft)	
Y_s	=	39.75	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	26.55	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.39		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	26.55	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.42		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 233-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	6079.56	(cfs)	Flow at the approach cross section
A_1	=	7859.21	(ft^2)	Flow area at the approach cross section
V_1	=	0.77	(ft/s)	Velocity at the approach cross section
Y_1	=	26.35	(ft)	Hydraulic depth at the approach cross section
q_1	=	20.38	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	5937.50	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5922.75	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.00	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	26.55	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	26.50	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	32.99	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	56.09	(ft)	HEC-18 equation 8.3
Y_0	=	26.55	(ft)	
Y_s	=	29.54	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 233-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	6079.56	(cfs)	Flow at the approach cross section
A_1	=	7859.21	(ft^2)	Flow area at the approach cross section
V_1	=	0.77	(ft/s)	Velocity at the approach cross section
Y_1	=	26.35	(ft)	Hydraulic depth at the approach cross section
q_f	=	20.38	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	5937.50	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5922.75	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.00	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	26.55	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	26.50	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	20.38	(ft^2/s)	Upstream unit discharge
q_{2f}	=	26.50	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	17.02	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	44.25	(ft)	HEC-18 equation 8.3
Y_0	=	26.55	(ft)	
Y_s	=	17.70	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 3 (Tidal Surge Only)
Proposed Area 1 Build

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Contraction Scour

Approach Section: 233-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.89	25.19	0.60	(ft)	Average depth in the approach cross section
y_o =	0.00	25.52	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	5.96	9286.11	16.15	(cfs)	Flow in the approach cross section
Q_2 =	0.00	9092.70	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	37.49	298.24	236.49	(ft)	Top width in the approach cross section
W_2 =	0.00	223.05	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000067	0.000067	0.000067	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.04	0.23	0.04	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.51	2.73	0.42		
k_1 =	0.64	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	4.71	--	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 233-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	8.98	26.35	1.60	(ft)	Average depth in the approach cross section
y_o =	0.00	26.55	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	11.60	6054.78	40.68	(cfs)	Flow in the approach cross section
Q_2 =	0.00	5913.27	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	232.47	298.24	236.49	(ft)	Top width in the approach cross section
W_2 =	0.00	223.08	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000015	0.000015	0.000015	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.07	0.11	0.03	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.77	1.32	0.33		
k_1 =	0.64	0.64	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	4.54	--	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	9092.70	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.05	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	25.52	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	0.0	--	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	5913.27	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.08	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	26.55	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	0.0	--	(ft)	Contraction scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	25.52	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.41		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	25.52	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.44		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	9286.11	(cfs)	Flow at the approach cross section
A_1	=	7512.47	(ft^2)	Flow area at the approach cross section
V_1	=	1.24	(ft/s)	Velocity at the approach cross section
Y_1	=	25.19	(ft)	Hydraulic depth at the approach cross section
q_1	=	31.14	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	9092.70	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5691.81	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.59	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	25.52	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	40.58	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	31.61	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	53.74	(ft)	HEC-18 equation 8.3
Y_0	=	25.52	(ft)	
Y_s	=	28.22	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	9286.11	(cfs)	Flow at the approach cross section
A_1	=	7507.72	(ft^2)	Flow area at the approach cross section
V_1	=	1.26	(ft/s)	Velocity at the approach cross section
Y_1	=	25.19	(ft)	Hydraulic depth at the approach cross section
q_f	=	31.74	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	9092.70	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5688.55	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.62	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	25.52	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	41.34	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	31.74	(ft^2/s)	Upstream unit discharge
q_{2f}	=	41.34	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	24.92	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	64.80	(ft)	HEC-18 equation 8.3
Y_0	=	25.52	(ft)	
Y_s	=	39.28	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	26.55	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.4		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	26.55	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.4		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 233-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	6054.78	(cfs)	Flow at the approach cross section
A_1	=	7858.86	(ft^2)	Flow area at the approach cross section
V_1	=	0.77	(ft/s)	Velocity at the approach cross section
Y_1	=	26.35	(ft)	Hydraulic depth at the approach cross section
q_1	=	20.30	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	5913.27	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5923.02	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.99	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	26.55	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	26.39	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	32.99	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	56.09	(ft)	HEC-18 equation 8.3
Y_0	=	26.55	(ft)	
Y_s	=	29.54	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 233-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	6054.78	(cfs)	Flow at the approach cross section
A_1	=	7858.86	(ft^2)	Flow area at the approach cross section
V_1	=	0.77	(ft/s)	Velocity at the approach cross section
Y_1	=	26.35	(ft)	Hydraulic depth at the approach cross section
q_f	=	20.30	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	5913.27	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5923.02	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.99	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	26.55	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	26.39	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	20.30	(ft^2/s)	Upstream unit discharge
q_{2f}	=	26.39	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	16.96	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	44.10	(ft)	HEC-18 equation 8.3
Y_0	=	26.55	(ft)	
Y_s	=	17.55	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 3 (Tidal Surge Only)
Proposed Full Build

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Contraction Scour

Approach Section: 233-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.89	25.19	0.60	(ft)	Average depth in the approach cross section
y_o =	0.00	25.52	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	5.96	9286.11	16.15	(cfs)	Flow in the approach cross section
Q_2 =	0.00	9092.70	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	37.49	298.24	236.49	(ft)	Top width in the approach cross section
W_2 =	0.00	223.05	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000067	0.000067	0.000067	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.04	0.23	0.04	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.51	2.73	0.42		
k_1 =	0.64	0.69	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	4.71	--	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 233-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	8.98	26.35	1.60	(ft)	Average depth in the approach cross section
y_o =	0.00	26.55	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	11.60	6054.78	40.68	(cfs)	Flow in the approach cross section
Q_2 =	0.00	5913.27	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	232.47	298.24	236.49	(ft)	Top width in the approach cross section
W_2 =	0.00	223.08	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000015	0.000015	0.000015	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.07	0.11	0.03	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.77	1.32	0.33		
k_1 =	0.64	0.64	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	--	4.54	--	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	9092.70	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.05	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	25.52	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	0.0	--	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	5913.27	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.08	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	26.55	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	0.0	--	(ft)	Contraction scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	25.52	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.41		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	25.52	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.44		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	9286.11	(cfs)	Flow at the approach cross section
A_1	=	7512.47	(ft^2)	Flow area at the approach cross section
V_1	=	1.24	(ft/s)	Velocity at the approach cross section
Y_1	=	25.19	(ft)	Hydraulic depth at the approach cross section
q_1	=	31.14	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	9092.70	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5691.81	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.59	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	25.52	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	40.58	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	31.61	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	53.74	(ft)	HEC-18 equation 8.3
Y_0	=	25.52	(ft)	
Y_s	=	28.22	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	9286.11	(cfs)	Flow at the approach cross section
A_1	=	7507.72	(ft^2)	Flow area at the approach cross section
V_1	=	1.26	(ft/s)	Velocity at the approach cross section
Y_1	=	25.19	(ft)	Hydraulic depth at the approach cross section
q_f	=	31.74	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	9092.70	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5688.55	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.62	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	25.52	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	41.34	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	31.74	(ft^2/s)	Upstream unit discharge
q_{2f}	=	41.34	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	24.92	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	64.80	(ft)	HEC-18 equation 8.3
Y_0	=	25.52	(ft)	
Y_s	=	39.28	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	26.55	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.4		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	26.55	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.4		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 233-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	6054.78	(cfs)	Flow at the approach cross section
A_1	=	7858.86	(ft^2)	Flow area at the approach cross section
V_1	=	0.77	(ft/s)	Velocity at the approach cross section
Y_1	=	26.35	(ft)	Hydraulic depth at the approach cross section
q_1	=	20.30	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	5913.27	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5923.02	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.99	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	26.55	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	26.39	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	32.99	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	56.09	(ft)	HEC-18 equation 8.3
Y_0	=	26.55	(ft)	
Y_s	=	29.54	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 233-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	6054.78	(cfs)	Flow at the approach cross section
A_1	=	7858.86	(ft^2)	Flow area at the approach cross section
V_1	=	0.77	(ft/s)	Velocity at the approach cross section
Y_1	=	26.35	(ft)	Hydraulic depth at the approach cross section
q_f	=	20.30	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	5913.27	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	5923.02	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.99	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	26.55	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	26.39	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	20.30	(ft^2/s)	Upstream unit discharge
q_{2f}	=	26.39	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.30		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	16.96	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	44.10	(ft)	HEC-18 equation 8.3
Y_0	=	26.55	(ft)	
Y_s	=	17.55	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Sea Level Rise
Proposed Conditions Full Build

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Contraction Scour

Approach Section: 233-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	3.40	27.68	2.96	(ft)	Average depth in the approach cross section
y_o =	0.00	27.73	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	178.10	13283.80	82.92	(cfs)	Flow in the approach cross section
Q_2 =	0.00	12862.40	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	232.47	298.24	236.49	(ft)	Top width in the approach cross section
W_2 =	0.00	223.09	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000118	0.000118	0.000118	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.11	0.32	0.11	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	1.33	3.79	1.24		
k_1 =	0.64	0.69	0.64		Bed Material Transport Exponent from Section 6.3
y_s =	--*	5.17	--*	(ft)	Contraction scour depth

*No overbank flow at internal bridge cross section

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Contraction Scour

Approach Section: 233-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

y_1 =	5.00	28.82	4.12	(ft)	Average depth in the approach cross section
y_o =	0.00	28.82	0.00	(ft)	Average depth in the internal bridge cross section
Q_1 =	165.13	9205.01	70.90	(cfs)	Flow in the approach cross section
Q_2 =	0.00	8876.49	0.00	(cfs)	Flow in the internal bridge cross section
W_1 =	232.47	298.24	236.49	(ft)	Top width in the approach cross section
W_2 =	0.00	223.03	0.00	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000032	0.000032	0.000032	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.07	0.17	0.07	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.84	2.02	0.76		
k_1 =	0.64	0.69	0.64		Bed Material Transport Exponent from Section 6.3
y_s =	--*	5.32	--*	(ft)	*No overbank flow at internal bridge cross section

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	12862.40	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.09	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	27.73	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	2.8	--	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	8876.49	0.00	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	223.03	0.00	(ft)	Top width of internal bridge cross section
y_o =	0.00	28.82	0.00	(ft)	Average depth in internal bridge cross section
y_s =	--	0.0	--	(ft)	Contraction scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	27.73	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.38		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	27.73	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.40		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	13283.80	(cfs)	Flow at the approach cross section
A_1	=	8254.97	(ft^2)	Flow area at the approach cross section
V_1	=	1.61	(ft/s)	Velocity at the approach cross section
Y_1	=	27.68	(ft)	Hydraulic depth at the approach cross section
q_1	=	44.56	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	12862.40	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	6185.41	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	2.07	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	27.73	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	57.40	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.29		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	34.39	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	58.46	(ft)	HEC-18 equation 8.3
Y_0	=	27.73	(ft)	
Y_s	=	30.73	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 233-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	13283.80	(cfs)	Flow at the approach cross section
A_1	=	8254.97	(ft^2)	Flow area at the approach cross section
V_1	=	1.61	(ft/s)	Velocity at the approach cross section
Y_1	=	27.68	(ft)	Hydraulic depth at the approach cross section
q_f	=	44.56	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	12862.40	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	6185.41	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	2.07	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	27.73	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	57.40	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	44.56	(ft^2/s)	Upstream unit discharge
q_{2f}	=	57.40	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.29		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	33.02	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	85.84	(ft)	HEC-18 equation 8.3
Y_0	=	27.73	(ft)	
Y_s	=	58.11	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment

D	=	10.4	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	28.82	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.4		Left Set Back Ratio

Right Abutment

D	=	11.20	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	28.82	(ft)	Average channel flow depth at internal bridge section
SBR	=	0.4		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 233-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Left and Right Abutment

Q_1	=	9205.01	(cfs)	Flow at the approach cross section
A_1	=	8596.48	(ft^2)	Flow area at the approach cross section
V_1	=	1.07	(ft/s)	Velocity at the approach cross section
Y_1	=	28.82	(ft)	Hydraulic depth at the approach cross section
q_1	=	30.84	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	8876.49	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	6428.78	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.37	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	28.82	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	39.48	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.28		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	35.62	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	60.55	(ft)	HEC-18 equation 8.3
Y_0	=	28.82	(ft)	
Y_s	=	31.73	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 233-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Left and Right Abutment

Q_1	=	9205.01	(cfs)	Flow at the approach cross section
A_1	=	8596.48	(ft^2)	Flow area at the approach cross section
V_1	=	1.07	(ft/s)	Velocity at the approach cross section
Y_1	=	28.82	(ft)	Hydraulic depth at the approach cross section
q_f	=	30.84	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	8876.49	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	6428.78	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	1.37	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	28.82	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	39.48	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	30.84	(ft^2/s)	Upstream unit discharge
q_{2f}	=	39.48	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.28		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	23.96	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	62.29	(ft)	HEC-18 equation 8.3
Y_0	=	28.82	(ft)	
Y_s	=	33.47	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

South Walnut Street

Scenario 1 (Riverine Flow & MHW)
Existing Conditions

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Contraction Scour

Approach Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	23.89	2.00	(ft)	Average depth in the approach cross section
y_o =	0.20	28.58	0.75	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27114.40	30.84	(cfs)	Flow in the approach cross section
Q_2 =	0.04	26571.60	156.33	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	275.97	5.06	(ft)	Top width in the approach cross section
W_2 =	98.30	193.40	87.39	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000858	0.000858	0.000858	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.81	0.24	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	9.52	2.76		
k_1 =	0.59	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.43	0.38	(ft)	Contraction scour depth

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Contraction Scour

Approach Cross Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.10	24.96	3.95	(ft)	Average depth in the approach cross section
y_o =	1.05	29.51	0.90	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.09	32371.70	86.73	(cfs)	Flow in the approach cross section
Q_2 =	2.25	31649.10	287.92	(cfs)	Flow in the internal bridge cross section
W_1 =	178.98	275.97	15.06	(ft)	Top width in the approach cross section
W_2 =	171.53	193.45	197.54	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001133	0.001133	0.001133	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.06	0.95	0.38	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.71	11.19	4.45		
k_1 =	0.64	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--*	1.77	0.97	(ft)	Contraction scour depth

*Non-erosive velocity

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 254-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.04	26571.60	156.33	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	98.30	193.40	87.39	(ft)	Top width of internal bridge cross section
y_o =	0.20	28.58	0.75	(ft)	Average depth in internal bridge cross section
y_s =	--	35.8	0.8	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 254-ft Upstream of Contracted Section

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	2.25	31649.10	603.29	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	171.53	193.45	217.56	(ft)	Top width of internal bridge cross section
y_o =	1.05	29.51	1.76	(ft)	Average depth in internal bridge cross section
y_s =	--*	45.2	0.5	(ft)	Contraction scour depth

*Non-erosive velocity

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00	53.44	5.25	0.00	(˚)	Angle of attack
K_2 =	1.00	1.00	2.23	1.20	1.00		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00	18.41	12.71	0.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00	0.80	1.38	0.00	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--	0.03	0.07	--		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--	30.2	19.5	--	(ft)	Pier scour depth
	--	--	--	--	--		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--	30.2	19.5	--	(ft)	Pier scour depth

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	9.38	9.38					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				(˚)	Angle of attack
K_2 =	1.00	1.00					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--				(ft)	Pier scour depth
	--	--					Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8
$y_s \leq 3.0$ times the pier width (a) for Fr > 0.8

y_s =	--	--				(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	68.50	71.40	53.19	7.22	7.82	(˚)	Angle of attack
K_2 =	4.20	4.23	2.23	1.27	1.70		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	1.10	1.50	19.65	13.68	1.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.01	0.01	0.92	1.61	0.10	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.00	0.00	0.04	0.08	0.02		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	2.0	2.1	32.4	22.3	2.1	**(ft)**	Pier scour depth
	14.4	14.4	67.8	67.8	14.4		Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8 $y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	--*	--*	32.4	22.3	2.1	(ft)	Pier scour depth
							*Non-erosive velocity

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	9.38	9.38				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				Angle of attack
K_2 =	1.00	1.00				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--			(ft)	Pier scour depth
	--	--				Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--			**(ft)**	Pier scour depth

Scenario 1 (Riverine Flow & MHW)
Proposed Area 1 Build

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Contraction Scour

Approach Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	23.88	2.00	(ft)	Average depth in the approach cross section
y_o =	0.75	28.57	0.75	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27089.30	30.74	(cfs)	Flow in the approach cross section
Q_2 =	155.73	26547.20	155.73	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	275.97	5.06	(ft)	Top width in the approach cross section
W_2 =	87.39	193.40	87.39	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000854	0.000854	0.000854	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.81	0.23	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	9.50	2.75		
k_1 =	0.59	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.43	0.38	(ft)	Contraction scour depth

PROJECT:	Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Contraction Scour

Approach Cross Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.10	24.96	3.95	(ft)	Average depth in the approach cross section
y_o =	1.05	29.51	0.90	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.10	32351.40	86.68	(cfs)	Flow in the approach cross section
Q_2 =	2.22	31631.50	285.68	(cfs)	Flow in the internal bridge cross section
W_1 =	178.98	275.97	15.06	(ft)	Top width in the approach cross section
W_2 =	171.53	193.46	197.54	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001131	0.001131	0.001131	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.06	0.95	0.38	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.71	11.18	4.45		
k_1 =	0.64	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--*	1.77	0.96	(ft)	Contraction scour depth

*Non-erosive velocity

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 254-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	155.73	26547.20	155.73	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	87.39	193.40	87.39	(ft)	Top width of internal bridge cross section
y_o =	0.75	28.57	0.75	(ft)	Average depth in internal bridge cross section
y_s =	--	35.7	0.8	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 254-ft Upstream of Contracted Section

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	2.22	31631.50	605.59	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	171.53	193.46	217.56	(ft)	Top width of internal bridge cross section
y_o =	1.05	29.51	1.76	(ft)	Average depth in internal bridge cross section
y_s =	--*	45.2	0.5	(ft)	Contraction scour depth

*Non-erosive velocity

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	59.20	49.88	53.45	5.20	0.00	(˚)	Angle of attack
K_2 =	4.04	3.81	2.23	1.20	1.00		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00	18.40	12.71	0.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00	0.80	1.38	0.00	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--	0.03	0.07	--		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--	30.2	19.5	--	(ft)	Pier scour depth
	--	--	--	--	--		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--	30.2	19.5	--	(ft)	Pier scour depth

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	12.00	12.00					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				(°)	Angle of attack
K_2 =	1.00	1.00					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--				(ft)	Pier scour depth
	--	--					Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8 $y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	--	--				(ft)	Pier scour depth

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	68.50	71.40	53.19	7.13	7.82	(˚)	Angle of attack
K_2 =	4.20	4.23	2.23	1.26	1.70		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	1.10	1.50	19.66	13.68	1.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.01	0.01	0.91	1.61	0.10	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.00	0.00	0.04	0.08	0.02		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	2.0	2.1	32.2	22.2	2.1	**(ft)**	Pier scour depth
	14.4	14.4	67.8	67.8	14.4		Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8 $y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	--*	--*	32.2	22.2	2.1	(ft)	Pier scour depth
							*Non-erosive velocity

PROJECT:	South Wilmington Infrastructure Improvements	**COMPS. BY:** NSR	**CKD. By:** TJC
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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	12.00	12.00				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				Angle of attack
K_2 =	1.00	1.00				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--			(ft)	Pier scour depth
	--	--				Maximum Scour Depth check from HEC-18 7.2
						For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8 $y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	--	--			**(ft)**	Pier scour depth

Scenario 1 (Riverine Flow & MHW)
Proposed Full Build

PROJECT:	South Wilmington Infrastructure Improvements		**COMPS. BY:**	NSR	**CKD. By:** TJC
BRIDGE:	BR 1-687 - South Walnut Street		**DATE:**	4/4/2023	**PAGE:** 1

Contraction Scour

Approach Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	23.88	2.00	(ft)	Average depth in the approach cross section
y_o =	0.20	28.57	0.75	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27089.30	30.75	(cfs)	Flow in the approach cross section
Q_2 =	0.00	26547.20	155.72	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	275.97	5.06	(ft)	Top width in the approach cross section
W_2 =	98.30	193.40	87.39	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000854	0.000854	0.000854	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.81	0.23	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	9.50	2.75		
k_1 =	0.59	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.43	0.37	(ft)	Contraction scour depth

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Contraction Scour

Approach Cross Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.10	24.96	3.95	(ft)	Average depth in the approach cross section
y_o =	1.05	29.51	0.91	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.09	32295.50	86.61	(cfs)	Flow in the approach cross section
Q_2 =	2.23	31577.40	284.81	(cfs)	Flow in the internal bridge cross section
W_1 =	178.98	275.97	15.06	(ft)	Top width in the approach cross section
W_2 =	171.53	193.46	197.54	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001127	0.001127	0.001127	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.06	0.95	0.38	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.71	11.16	4.44		
k_1 =	0.64	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--*	1.77	0.95	(ft)	Contraction scour depth

*Non-erosive velocity

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 254-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	26547.20	155.72	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	98.30	193.40	87.39	(ft)	Top width of internal bridge cross section
y_o =	0.20	28.57	0.75	(ft)	Average depth in internal bridge cross section
y_s =	--	35.7	0.8	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 254-ft Upstream of Contracted Section

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	2.23	31577.40	609.56	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	171.53	193.46	217.56	(ft)	Top width of internal bridge cross section
y_o =	1.05	29.51	1.74	(ft)	Average depth in internal bridge cross section
y_s =	--*	45.1	0.5	(ft)	Contraction scour depth

*Non-erosive velocity

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00	53.45	5.23	0.00	(°)	Angle of attack
K_2 =	1.00	1.00	2.23	1.20	1.00		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00	18.40	12.71	0.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00	0.80	1.38	0.00	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--	0.03	0.07	--		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--	30.2	19.5	--	(ft)	Pier scour depth
	--	--	--	--	--		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--	30.2	19.5	--	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	12.00	12.00					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				(˚)	Angle of attack
K_2 =	1.00	1.00					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--				(ft)	Pier scour depth
	--	--					Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8
$y_s \leq 3.0$ times the pier width (a) for Fr > 0.8

y_s =	--	--				(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	68.50	71.40	53.19	7.11	7.82	(˚)	Angle of attack
K_2 =	4.20	4.23	2.23	1.26	1.70		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	1.10	1.50	19.66	13.68	1.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.01	0.01	0.91	1.61	0.09	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.00	0.00	0.04	0.08	0.02		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	2.0	2.1	32.2	22.2	2.0	**(ft)**	Pier scour depth
	14.4	14.4	67.8	67.8	14.4		Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$ $y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$
y_s =	--*	--*	32.2	22.2	2.0	(ft)	Pier scour depth
							*Non-erosive velocity

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	9.38	9.38				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				Angle of attack
K_2 =	1.00	1.00				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--			(ft)	Pier scour depth
	--	--				Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--			**(ft)**	Pier scour depth

Scenario 2 (Riverine Flow & MLW)
Existing Conditions

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Contraction Scour

Approach Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	21.52	3.48	(ft)	Average depth in the approach cross section
y_o =	0.00	26.33	0.14	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27501.50	6.73	(cfs)	Flow in the approach cross section
Q_2 =	0.00	27103.70	4.40	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	275.97	5.06	(ft)	Top width in the approach cross section
W_2 =	0.00	193.32	67.37	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001055	0.001055	0.001055	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.86	0.34	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	--	10.02	4.03		
k_1 =	--	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--	0.84	0.27	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.00	23.00	3.90	(ft)	Average depth in the approach cross section
y_o =	0.00	27.63	0.43	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	33231.30	25.98	(cfs)	Flow in the approach cross section
Q_2 =	0.00	32659.90	83.43	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	275.97	5.06	(ft)	Top width in the approach cross section
W_2 =	0.00	193.39	77.38	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001387	0.001387	0.001387	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	1.01	0.42	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	--	11.88	4.89		
k_1 =	--	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.33	1.18	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 254-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	27103.70	4.40	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	193.32	67.37	(ft)	Top width of internal bridge cross section
y_o =	0.00	26.33	0.14	(ft)	Average depth in internal bridge cross section
y_s =	--	39.1	0.0	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	32659.90	83.43	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	193.39	77.38	(ft)	Top width of internal bridge cross section
y_o =	0.00	27.63	0.43	(ft)	Average depth in internal bridge cross section
y_s =	--	49.2	0.6	(ft)	Contraction scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00	52.46	4.39	0.00	(°)	Angle of attack
K_2 =	1.00	1.00	2.22	1.17	1.00		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00	15.85	10.48	0.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00	0.86	1.31	0.00	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--	0.04	0.07	--		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--	30.4	18.1	--	(ft)	Pier scour depth
	--	--	--	--	--		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--	30.4	18.1	--	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	9.38	9.38					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				(˚)	Angle of attack
K_2 =	1.00	1.00					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--				(ft)	Pier scour depth
	--	--					Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8
$y_s \leq 3.0$ times the pier width (a) for Fr > 0.8

y_s =	--	--				(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00	53.17	0.00	0.00	(°)	Angle of attack
K_2 =	1.00	1.00	2.23	1.00	1.00		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00	17.56	11.84	0.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00	0.98	1.59	0.00	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--	0.04	0.08	--		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--	32.7	17.2	--	**(ft)**	Pier scour depth
	--	--	--	--	--		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--	32.7	17.2	--	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	9.38	9.38				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				Angle of attack
K_2 =	1.00	1.00				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--			(ft)	Pier scour depth
	--	--				Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--			**(ft)**	Pier scour depth

Scenario 2 (Riverine Flow & MLW)
Proposed Area 1 Build

PROJECT:	South Wilmington Infrastructure Improvements - Area 1 Build		**COMPS. BY:**	NSR	**CKD. By:** TJC
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Contraction Scour

Approach Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	21.52	3.48	(ft)	Average depth in the approach cross section
y_o =	0.00	26.33	0.14	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27501.40	6.72	(cfs)	Flow in the approach cross section
Q_2 =	0.00	27103.60	4.39	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	275.97	5.06	(ft)	Top width in the approach cross section
W_2 =	0.00	193.32	67.37	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000000	0.001056	0.001056	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.86	0.34	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	--	10.03	4.03		
k_1 =	--	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--	0.84	0.26	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.00	23.01	3.90	(ft)	Average depth in the approach cross section
y_o =	0.00	27.64	0.43	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	33183.60	25.96	(cfs)	Flow in the approach cross section
Q_2 =	0.00	32612.60	83.54	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	275.97	5.06	(ft)	Top width in the approach cross section
W_2 =	0.00	193.39	77.38	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001382	0.001382	0.001382	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	1.01	0.42	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	11.86	4.88		
k_1 =	0.59	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.33	1.19	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 254-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	27103.60	4.39	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	193.32	67.37	(ft)	Top width of internal bridge cross section
y_o =	0.00	26.33	0.14	(ft)	Average depth in internal bridge cross section
y_s =	--	39.1	0.0	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	32612.60	83.54	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	193.39	77.38	(ft)	Top width of internal bridge cross section
y_o =	0.00	27.64	0.43	(ft)	Average depth in internal bridge cross section
y_s =	--	49.1	0.6	(ft)	Contraction scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00	52.45	4.38	0.00	(°)	Angle of attack
K_2 =	1.00	1.00	2.22	1.17	1.00		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00	15.85	10.48	0.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00	0.86	1.31	0.00	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--	0.04	0.07	--		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--	30.4	18.1	--	(ft)	Pier scour depth
	--	--	67.8	67.8	--		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--	30.4	18.1	--	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	9.38	9.38					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				(˚)	Angle of attack
K_2 =	1.00	1.00					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--				(ft)	Pier scour depth
	--	--					Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq$ 2.4 times the pier width (a) for Fr ≤ 0.8
							$y_s \leq$ 3.0 times the pier width (a) for Fr > 0.8
y_s =	--	--				(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00	53.17	0.00	0.00	(˚)	Angle of attack
K_2 =	1.00	1.00	2.23	1.00	1.00		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00	17.56	11.84	0.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00	0.97	1.58	0.00	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--	0.04	0.08	--		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--	32.6	17.1	--	**(ft)**	Pier scour depth
	--	--	67.8	67.8	--		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--	32.6	17.1	--	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	9.38	9.38				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				Angle of attack
K_2 =	1.00	1.00				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--			(ft)	Pier scour depth
	--	--				Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--			**(ft)**	Pier scour depth

Scenario 2 (Riverine Flow & MLW)
Proposed Full Build

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Contraction Scour

Approach Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	0.00	21.52	3.48	(ft)	Average depth in the approach cross section
y_o =	0.00	26.33	0.14	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	27501.50	6.70	(cfs)	Flow in the approach cross section
Q_2 =	0.00	27103.60	4.33	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	275.97	5.06	(ft)	Top width in the approach cross section
W_2 =	0.00	193.32	67.37	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000000	0.001055	0.001055	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	0.86	0.34	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	10.02	4.03		
k_1 =	0.59	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--	0.84	0.26	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 254-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	0.00	23.01	3.90	(ft)	Average depth in the approach cross section
y_o =	0.00	27.64	0.43	(ft)	Average depth in the internal bridge cross section
Q_1 =	0.00	33183.40	25.97	(cfs)	Flow in the approach cross section
Q_2 =	0.00	32612.40	83.60	(cfs)	Flow in the internal bridge cross section
W_1 =	0.00	275.97	5.06	(ft)	Top width in the approach cross section
W_2 =	0.00	195.43	77.38	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.001382	0.001382	0.001382	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.00	1.01	0.42	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.00	11.86	4.88		
k_1 =	0.59	0.69	0.69		Bed Material Transport Exponent from Section 6.3
y_s =	--	1.13	1.19	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 254-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	27103.60	4.33	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	193.32	67.37	(ft)	Top width of internal bridge cross section
y_o =	0.00	26.33	0.14	(ft)	Average depth in internal bridge cross section
y_s =	--	39.1	0.0	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	0.00	32612.40	83.60	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Particle size from 2/10/2022 Terracon Geotechnical Report
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	0.00	195.43	77.38	(ft)	Top width of internal bridge cross section
y_o =	0.00	27.64	0.43	(ft)	Average depth in internal bridge cross section
y_s =	--	48.4	0.6	(ft)	Contraction scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00	52.46	4.38	0.00	(°)	Angle of attack
K_2 =	1.00	1.00	2.22	1.17	1.00		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00	15.85	10.48	0.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00	0.86	1.31	0.00	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--	0.04	0.07	--		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--	30.4	18.1	--	(ft)	Pier scour depth
	--	--	--	--	--		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--	30.4	18.1	--	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	9.38	9.38					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				(˚)	Angle of attack
K_2 =	1.00	1.00					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--				(ft)	Pier scour depth
	--	--					Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8 $y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	--	--				(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00	53.17	0.00	0.00	(°)	Angle of attack
K_2 =	1.00	1.00	2.23	1.00	1.00		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00	17.56	11.84	0.00	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00	0.97	1.58	0.00	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--	0.04	0.08	--		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--	32.6	17.1	--	(ft)	Pier scour depth
	--	--	--	--	--		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	--	--	32.6	17.1	--	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	9.38	9.38				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	0.00	0.00				Angle of attack
K_2 =	1.00	1.00				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	0.00	0.00			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.00	0.00			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	--	--				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	--	--			(ft)	Pier scour depth
	--	--				Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8
$y_s \leq 3.0$ times the pier width (a) for Fr > 0.8

y_s =	--	--			(ft)	Pier scour depth

Scenario 3 (Tidal Surge Only)
Existing Conditions

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Contraction Scour

Approach Section: 195-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	2.06	27.21	2.27	(ft)	Average depth in the approach cross section
y_o =	2.31	31.63	1.01	(ft)	Average depth in the internal bridge cross section
Q_1 =	680.57	9987.72	87.48	(cfs)	Flow in the approach cross section
Q_2 =	282.39	9271.78	122.26	(cfs)	Flow in the internal bridge cross section
W_1 =	252.33	317.28	362.01	(ft)	Top width in the approach cross section
W_2 =	227.57	191.17	423.26	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000073	0.000073	0.000073	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.07	0.25	0.07	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.82	2.96	0.86		
k_1 =	0.64	0.69	0.64		Bed Material Transport Exponent from Section 6.3
y_s =	0.00	4.58	1.73	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 195-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	3.25	28.39	2.90	(ft)	Average depth in the approach cross section
y_o =	3.15	32.74	2.22	(ft)	Average depth in the internal bridge cross section
Q_1 =	250.41	6255.05	108.15	(cfs)	Flow in the approach cross section
Q_2 =	198.41	5847.67	143.80	(cfs)	Flow in the internal bridge cross section
W_1 =	252.33	317.28	372.02	(ft)	Top width in the approach cross section
W_2 =	237.59	191.21	423.26	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000019	0.000019	0.000019	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.04	0.13	0.04	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.52	1.55	0.49		
k_1 =	0.64	0.64	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	0.00	4.32	1.21	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	282.39	9271.78	122.26	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	227.57	191.17	423.26	(ft)	Top width of internal bridge cross section
y_o =	2.31	31.63	1.01	(ft)	Average depth in internal bridge cross section
y_s =	0.0	0.0	0.0	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	198.41	5847.67	143.80	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	237.59	191.21	423.26	(ft)	Top width of internal bridge cross section
y_o =	3.15	32.74	2.22	(ft)	Average depth in internal bridge cross section
y_s =	0.0	0.0	0.0	(ft)	Contraction scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	86.86	86.86	15.81	7.31	65.07	(˚)	Angle of attack
K_2 =	4.30	4.30	1.53	1.27	4.15		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	2.91	3.50	19.78	18.66	0.86	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.30	0.70	0.37	0.87	1.23	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.03	0.07	0.01	0.04	0.23		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	9.9	14.6	15.0	17.9	14.9	(ft)	Pier scour depth
	14.4	14.4	--	--	14.4		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	9.9	14.4	15.0	17.9	14.4	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	9.38	9.38					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	82.40	85.80				(˚)	Angle of attack
K_2 =	4.30	4.30					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	1.92	2.49				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.99	1.04				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	0.13	0.12					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	15.6	16.5				(ft)	Pier scour depth
	14.4	14.4					Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8
							$y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	14.4	14.4				(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	88.41	88.41	13.33	8.54	43.15	(˚)	Angle of attack
K_2 =	4.29	4.29	1.46	1.31	3.59		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	4.14	4.70	20.90	19.87	2.06	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.20	0.40	0.24	0.47	0.41	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.02	0.03	0.01	0.02	0.05		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	8.7	11.9	12.0	14.3	9.0	**(ft)**	Pier scour depth
	14.4	14.4	--	--	14.4		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	8.7	11.9	12.0	14.3	9.0	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	9.38	9.38				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	66.04	83.83				Angle of attack
K_2 =	4.16	4.30				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	3.14	3.72			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.30	0.28			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	0.03	0.03				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	9.7	9.9			(ft)	Pier scour depth
	14.4	14.4				Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	9.7	9.9			**(ft)**	Pier scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment Flow does not hit left abutment**

D	=	211	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	31.63	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.67		Left Set Back Ratio

Right Abutment

D	=	224.00	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	31.63	(ft)	Average channel flow depth at internal bridge section
SBR	=	7.08		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Right Abutment

Q_1	=	87.48	(cfs)	Flow at the approach cross section
A_1	=	795.27	(ft^2)	Flow area at the approach cross section
V_1	=	0.11	(ft/s)	Velocity at the approach cross section
Y_1	=	2.27	(ft)	Hydraulic depth at the approach cross section
q_1	=	0.25	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	122.26	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	421.59	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.29	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	1.01	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	0.29	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.17		(Use minimum value of 1.0 in finding α)
α	=	1.40		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	2.60	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	3.64	(ft)	HEC-18 equation 8.3
Y_0	=	1.01	(ft)	
Y_s	=	2.63	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Right Abutment

Q_1	=	87.48	(cfs)	Flow at the approach cross section
A_1	=	795.27	(ft^2)	Flow area at the approach cross section
V_1	=	0.11	(ft/s)	Velocity at the approach cross section
Y_1	=	2.27	(ft)	Hydraulic depth at the approach cross section
q_f	=	0.25	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	122.26	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	421.59	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.29	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	1.01	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	0.29	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	0.25	(ft^2/s)	Upstream unit discharge
q_{2f}	=	0.29	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.17		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	0.36	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	0.90	(ft)	HEC-18 equation 8.3
Y_0	=	1.01	(ft)	
Y_s	=	0.00	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment Flow does not hit left abutment**

D	=	211	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	32.74	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.4		Left Set Back Ratio

Right Abutment

D	=	224.00	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	32.74	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.8		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 195-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Right Abutment

Q_1	=	108.15	(cfs)	Flow at the approach cross section
A_1	=	1081.5	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.90	(ft)	Hydraulic depth at the approach cross section
q_1	=	0.29	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	143.80	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	958.67	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.15	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	2.22	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	0.33	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.15		(Use minimum value of 1.0 in finding α)
α	=	1.40		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	3.26	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	4.57	(ft)	HEC-18 equation 8.3
Y_0	=	2.22	(ft)	
Y_s	=	2.35	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 195-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Right Abutment

Q_1	=	108.15	(cfs)	Flow at the approach cross section
A_1	=	1081.5	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.90	(ft)	Hydraulic depth at the approach cross section
q_f	=	0.29	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	143.80	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	958.6667	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.15	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	2.22	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	0.33	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	0.29	(ft^2/s)	Upstream unit discharge
q_{2f}	=	0.33	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.15		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	0.40	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	1.00	(ft)	HEC-18 equation 8.3
Y_0	=	2.22	(ft)	
Y_s	=	0.00	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 3 (Tidal Surge Only)
Proposed Area 1 Build

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Contraction Scour

Approach Section: 195-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	2.05	27.23	2.27	(ft)	Average depth in the approach cross section
y_o =	2.31	31.65	1.01	(ft)	Average depth in the internal bridge cross section
Q_1 =	686.51	9749.51	86.83	(cfs)	Flow in the approach cross section
Q_2 =	280.58	9040.41	121.06	(cfs)	Flow in the internal bridge cross section
W_1 =	252.33	317.28	362.01	(ft)	Top width in the approach cross section
W_2 =	227.57	191.15	423.26	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000069	0.000069	0.000069	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.07	0.25	0.07	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.79	2.88	0.83		
k_1 =	0.64	0.69	0.64		Bed Material Transport Exponent from Section 6.3
y_s =	0.00	4.56	1.72	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 195-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	3.24	28.38	2.90	(ft)	Average depth in the approach cross section
y_o =	3.15	32.74	2.22	(ft)	Average depth in the internal bridge cross section
Q_1 =	261.44	6236.34	106.83	(cfs)	Flow in the approach cross section
Q_2 =	198.24	5825.78	141.95	(cfs)	Flow in the internal bridge cross section
W_1 =	252.33	317.28	372.02	(ft)	Top width in the approach cross section
W_2 =	237.59	191.20	423.26	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000019	0.000019	0.000019	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.04	0.13	0.04	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.52	1.54	0.49		
k_1 =	0.64	0.64	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	0.00	4.28	1.21	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	280.58	9040.41	121.06	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	227.57	191.15	423.26	(ft)	Top width of internal bridge cross section
y_o =	2.31	31.65	1.01	(ft)	Average depth in internal bridge cross section
y_s =	0.0	0.0	0.0	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	198.24	5825.78	141.95	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	237.59	191.20	423.26	(ft)	Top width of internal bridge cross section
y_o =	3.15	32.74	2.22	(ft)	Average depth in internal bridge cross section
y_s =	0.0	0.0	0.0	(ft)	Contraction scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	86.71	86.71	15.80	7.05	65.38	(˚)	Angle of attack
K_2 =	4.30	4.30	1.53	1.26	4.15		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	2.92	3.50	19.81	18.64	0.87	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.30	0.70	0.36	0.85	1.24	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.03	0.07	0.01	0.03	0.23		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	9.9	14.6	14.9	17.6	14.9	(ft)	Pier scour depth
	14.4	14.4	--	--	14.4		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	9.9	14.4	14.9	17.6	14.4	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	9.38	9.38					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	82.49	85.78				(˚)	Angle of attack
K_2 =	4.30	4.30					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	1.93	2.51				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	1.00	1.06				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	0.13	0.12					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	15.7	16.7				(ft)	Pier scour depth
	14.4	14.4					Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8
							$y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	14.4	14.4				(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	88.98	88.98	13.39	8.39	43.86	(˚)	Angle of attack
K_2 =	4.29	4.29	1.46	1.30	3.61		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	4.14	4.70	20.91	19.86	2.06	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.20	0.40	0.24	0.47	0.42	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.02	0.03	0.01	0.02	0.05		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	8.7	11.9	12.0	14.2	9.2	**(ft)**	Pier scour depth
	14.4	14.4	--	--	14.4		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	8.7	11.9	12.0	14.2	9.2	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	9.38	9.38				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	66.45	83.73				Angle of attack
K_2 =	4.17	4.30				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	3.14	3.72			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.31	0.29			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	0.03	0.03				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	9.8	10.1			(ft)	Pier scour depth
	14.4	14.4				Maximum Scour Depth check from HEC-18 7.2
						For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8
						$y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	9.8	10.1			**(ft)**	Pier scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment Flow does not hit left abutment**

D	=	211	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	31.65	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.67		Left Set Back Ratio

Right Abutment

D	=	224.00	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	31.65	(ft)	Average channel flow depth at internal bridge section
SBR	=	7.08		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Right Abutment

Q_1	=	86.83	(cfs)	Flow at the approach cross section
A_1	=	789.36	(ft^2)	Flow area at the approach cross section
V_1	=	0.11	(ft/s)	Velocity at the approach cross section
Y_1	=	2.27	(ft)	Hydraulic depth at the approach cross section
q_1	=	0.25	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	121.06	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	432.36	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.28	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	1.01	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	0.28	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.13		(Use minimum value of 1.0 in finding α)
α	=	1.40		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	2.53	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	3.54	(ft)	HEC-18 equation 8.3
Y_0	=	1.01	(ft)	
Y_s	=	2.53	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Right Abutment

Q_1	=	86.83	(cfs)	Flow at the approach cross section
A_1	=	789.36	(ft^2)	Flow area at the approach cross section
V_1	=	0.11	(ft/s)	Velocity at the approach cross section
Y_1	=	2.27	(ft)	Hydraulic depth at the approach cross section
q_f	=	0.25	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	121.06	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	432.36	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.28	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	1.01	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	0.28	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	0.25	(ft^2/s)	Upstream unit discharge
q_{2f}	=	0.28	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.13		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	0.35	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	0.87	(ft)	HEC-18 equation 8.3
Y_0	=	1.01	(ft)	
Y_s	=	0.00	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment Flow does not hit left abutment**

D	=	211	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	32.74	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.4		Left Set Back Ratio

Right Abutment

D	=	224.00	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	32.74	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.8		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 195-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Right Abutment

Q_1	=	106.83	(cfs)	Flow at the approach cross section
A_1	=	1068.3	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.90	(ft)	Hydraulic depth at the approach cross section
q_1	=	0.29	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	141.95	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	946.33	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.15	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	2.22	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	0.33	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.15		(Use minimum value of 1.0 in finding α)
α	=	1.40		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	3.26	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	4.57	(ft)	HEC-18 equation 8.3
Y_0	=	2.22	(ft)	
Y_s	=	2.35	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 195-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Right Abutment

Q_1	=	106.83	(cfs)	Flow at the approach cross section
A_1	=	1068.3	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.90	(ft)	Hydraulic depth at the approach cross section
q_f	=	0.29	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	141.95	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	946.3333	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.15	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	2.22	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	0.33	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	0.29	(ft^2/s)	Upstream unit discharge
q_{2f}	=	0.33	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.15		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	0.40	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	1.00	(ft)	HEC-18 equation 8.3
Y_0	=	2.22	(ft)	
Y_s	=	0.00	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Scenario 3 (Tidal Surge Only)
Proposed Full Build

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Contraction Scour

Approach Section: 195-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	2.09	27.25	2.29	(ft)	Average depth in the approach cross section
y_o =	2.34	31.67	1.05	(ft)	Average depth in the internal bridge cross section
Q_1 =	700.02	9244.68	80.15	(cfs)	Flow in the approach cross section
Q_2 =	270.46	8553.95	110.81	(cfs)	Flow in the internal bridge cross section
W_1 =	252.33	317.28	362.01	(ft)	Top width in the approach cross section
W_2 =	227.57	191.08	423.26	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000059	0.000059	0.000059	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.06	0.23	0.07	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.74	2.67	0.78		
k_1 =	0.64	0.69	0.64		Bed Material Transport Exponent from Section 6.3
y_s =	0.00	4.51	1.69	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 195-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	3.25	28.39	2.90	(ft)	Average depth in the approach cross section
y_o =	3.15	32.74	2.23	(ft)	Average depth in the internal bridge cross section
Q_1 =	244.94	5851.67	101.99	(cfs)	Flow in the approach cross section
Q_2 =	188.06	5468.25	133.64	(cfs)	Flow in the internal bridge cross section
W_1 =	252.33	317.28	372.02	(ft)	Top width in the approach cross section
W_2 =	237.59	191.19	423.26	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000016	0.000016	0.000016	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.04	0.12	0.04	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	0.48	1.42	0.45		
k_1 =	0.59	0.64	0.59		Bed Material Transport Exponent from Section 6.3
y_s =	0.00	4.30	1.16	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	270.46	8553.95	110.81	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	227.57	191.08	423.26	(ft)	Top width of internal bridge cross section
y_o =	2.34	31.67	1.05	(ft)	Average depth in internal bridge cross section
y_s =	0.0	0.0	0.0	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	188.06	5468.25	133.64	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	237.59	191.19	423.26	(ft)	Top width of internal bridge cross section
y_o =	3.15	32.74	2.23	(ft)	Average depth in internal bridge cross section
y_s =	0.0	0.0	0.0	(ft)	Contraction scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	86.11	86.11	15.82	6.73	65.88	(˚)	Angle of attack
K_2 =	4.30	4.30	1.53	1.25	4.16		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	2.94	3.50	19.93	18.62	0.89	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.30	0.70	0.33	0.82	1.25	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.03	0.07	0.01	0.03	0.23		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	9.9	14.6	14.3	17.1	15.1	(ft)	Pier scour depth
	14.4	14.4	--	--	14.4		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	9.9	14.4	14.3	17.1	14.4	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	9.38	9.38					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	82.55	86.21				(˚)	Angle of attack
K_2 =	4.30	4.30					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	1.96	2.53				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	1.01	1.06				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	0.13	0.12					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	15.8	16.7				(ft)	Pier scour depth
	14.4	14.4					Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8 $y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	14.4	14.4				(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	89.10	89.10	13.72	9.14	42.23	(˚)	Angle of attack
K_2 =	4.29	4.29	1.47	1.33	3.56		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	4.15	4.70	20.93	19.85	2.06	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.20	0.40	0.23	0.45	0.39	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.02	0.03	0.01	0.02	0.05		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	8.7	11.9	11.9	14.2	8.7	**(ft)**	Pier scour depth
	14.4	14.4	--	--	14.4		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	8.7	11.9	11.9	14.2	8.7	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	9.38	9.38				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	65.45	83.07				Angle of attack
K_2 =	4.16	4.30				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	3.14	3.72			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.29	0.27			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	0.03	0.02				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	9.5	9.8			(ft)	Pier scour depth
	14.4	14.4				Maximum Scour Depth check from HEC-18 7.2
						For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8 $y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	9.5	9.8			**(ft)**	Pier scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment Flow does not hit left abutment**

D	=	211	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	31.67	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.66		Left Set Back Ratio

Right Abutment

D	=	224.00	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	31.67	(ft)	Average channel flow depth at internal bridge section
SBR	=	7.07		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Right Abutment

Q_1	=	80.15	(cfs)	Flow at the approach cross section
A_1	=	801.50	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.29	(ft)	Hydraulic depth at the approach cross section
q_1	=	0.23	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	110.81	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	443.24	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.25	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	1.05	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	0.26	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.15		(Use minimum value of 1.0 in finding α)
α	=	1.55		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	2.57	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	3.99	(ft)	HEC-18 equation 8.3
Y_0	=	1.05	(ft)	
Y_s	=	2.94	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Right Abutment

Q_1	=	80.15	(cfs)	Flow at the approach cross section
A_1	=	801.50	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.29	(ft)	Hydraulic depth at the approach cross section
q_f	=	0.23	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	110.81	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	443.24	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.25	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	1.05	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	0.26	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	0.23	(ft^2/s)	Upstream unit discharge
q_{2f}	=	0.26	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.15		(Use minimum value of 1.0 in finding α)
α	=	2.55		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	0.33	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	0.83	(ft)	HEC-18 equation 8.3
Y_0	=	1.05	(ft)	
Y_s	=	0.00	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment Flow does not hit left abutment**

D	=	211	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	32.74	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.4		Left Set Back Ratio

Right Abutment

D	=	224.00	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	32.74	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.8		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 195-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Right Abutment

Q_1	=	101.99	(cfs)	Flow at the approach cross section
A_1	=	1019.9	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.90	(ft)	Hydraulic depth at the approach cross section
q_1	=	0.29	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	133.64	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	954.57	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.14	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	2.23	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	0.31	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.08		(Use minimum value of 1.0 in finding α)
α	=	1.20		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	3.09	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	3.71	(ft)	HEC-18 equation 8.3
Y_0	=	2.23	(ft)	
Y_s	=	1.48	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 195-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Right Abutment

Q_1	=	101.99	(cfs)	Flow at the approach cross section
A_1	=	1019.9	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.90	(ft)	Hydraulic depth at the approach cross section
q_f	=	0.29	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	133.64	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	954.5714	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.14	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	2.23	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	0.31	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	0.29	(ft^2/s)	Upstream unit discharge
q_{2f}	=	0.31	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.08		(Use minimum value of 1.0 in finding α)
α	=	1.00		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	0.38	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	0.38	(ft)	HEC-18 equation 8.3
Y_0	=	2.23	(ft)	
Y_s	=	0.00	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

Sea Level Rise
Proposed Conditions Full Build

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Contraction Scour

Approach Section: 195-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

100-year

	LOB	Channel	ROB		
y_1 =	4.52	29.71	3.68	(ft)	Average depth in the approach cross section
y_o =	4.08	34.20	3.28	(ft)	Average depth in the internal bridge cross section
Q_1 =	529.32	13576.60	412.60	(cfs)	Flow in the approach cross section
Q_2 =	645.17	12545.10	531.17	(cfs)	Flow in the internal bridge cross section
W_1 =	252.33	317.28	372.02	(ft)	Top width in the approach cross section
W_2 =	267.73	191.41	423.26	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000134	0.000134	0.000134	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.14	0.36	0.13	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D_{50} from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	1.64	4.20	1.48		
k_1 =	0.64	0.69	0.64		Bed Material Transport Exponent from Section 6.3
y_s =	1.08	5.15	0.93	(ft)	Contraction scour depth

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Contraction Scour

Approach Section: 195-ft Upstream of Contracted Section

Live-Bed

$$y_s = y_1 \left[\left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1} \right] - y_o$$

200-year

	LOB	Channel	ROB		
y_1 =	5.64	30.86	4.38	(ft)	Average depth in the approach cross section
y_o =	4.69	35.36	4.27	(ft)	Average depth in the internal bridge cross section
Q_1 =	416.47	9512.24	328.91	(cfs)	Flow in the approach cross section
Q_2 =	565.69	8714.15	434.37	(cfs)	Flow in the internal bridge cross section
W_1 =	252.33	317.28	372.02	(ft)	Top width in the approach cross section
W_2 =	267.73	191.49	423.26	(ft)	Top width in the internal bridge cross section
g =	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
S_1 =	0.000041	0.000041	0.000041	(ft/ft)	Slope of energy grade line from approach cross section
V_* =	0.09	0.20	0.08	(ft/s)	Shear velocity in approach cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
T =	0.0853	0.0853	0.0853	(ft/s)	Fall velocity of bed material, From Figure 6.8 multiply by 3.28 for Eng. Units
V_*/T =	1.01	2.37	0.89		
k_1 =	0.64	0.69	0.64		Bed Material Transport Exponent from Section 6.3
y_s =	2.37	5.20	0.85	(ft)	Contraction scour depth

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Clear-Water

$$y_s = \left[\frac{K_u Q^2}{D_m^{\frac{2}{3}} W^2}\right]^{\frac{3}{7}} - y_o$$

Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

	LOB	Channel	ROB		
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	645.17	12545.10	531.17	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	267.73	191.41	423.26	(ft)	Top width of internal bridge cross section
y_o =	4.08	34.20	3.28	(ft)	Average depth in internal bridge cross section
y_s =	0.0	0.0	0.0	(ft)	Contraction scour depth

200-year

	Bridge Opening				
K_u =	0.0077	0.0077	0.0077		Coefficient for English units
Q =	565.69	8714.15	434.37	(cfs)	Flow in the internal bridge cross section
D_{50} =	0.2000	0.2000	0.2000	(mm)	Reasonable lower limit of D50 from HEC-18
D_m =	0.2500	0.2500	0.2500	(mm)	Diameter of smallest nontransportable particle (1.25*D50)
W =	267.73	191.49	423.26	(ft)	Top width of internal bridge cross section
y_o =	4.69	35.36	4.27	(ft)	Average depth in internal bridge cross section
y_s =	0.0	0.0	0.0	(ft)	Contraction scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	84.64	84.64	4.98	6.54	37.01	(˚)	Angle of attack
K_2 =	4.30	4.30	1.19	1.24	3.36		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	5.45	5.90	21.93	21.41	3.39	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.70	1.30	0.61	0.99	0.84	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.05	0.09	0.02	0.04	0.08		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	15.5	20.4	14.7	18.8	12.3	(ft)	Pier scour depth
	14.4	14.4	--	--	14.4		Maximum Scour Depth check from HEC-18 7.2
							For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8 $y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	14.4	14.4	14.7	18.8	12.3	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

100-year

	Pier 6	Pier 7					
K_1 =	1.00	1.00					Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00				(ft)	Pier width
L =	56.25	56.25				(ft)	Length of pier
L/a =	9.38	9.38					If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	53.99	71.51				(˚)	Angle of attack
K_2 =	3.92	4.24					Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10					Bed condition correction factor from HEC-18 Table 7.3
y_1 =	4.45	5.03				(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.58	0.48				(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20				(ft/s^2)	Acceleration of gravity
Fr_1 =	0.05	0.04					Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	12.7	12.8				(ft)	Pier scour depth
	14.4	14.4					Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8
$y_s \leq 3.0$ times the pier width (a) for Fr > 0.8

y_s =	12.7	12.8				(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5		
K_1 =	1.00	1.00	1.10	1.10	1.00		Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00	28.25	28.25	6.00	(ft)	Pier width
L =	56.25	56.25	100.00	100.00	56.25	(ft)	Length of pier
L/a =	9.38	9.38	3.54	3.54	9.38		If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	80.53	80.53	0.52	5.03	35.95	(°)	Angle of attack
K_2 =	4.30	4.30	1.02	1.19	3.31		Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10	1.10	1.10	1.10		Bed condition correction factor from HEC-18 Table 7.3
y_1 =	6.61	7.20	22.98	22.64	4.56	(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.35	0.80	0.44	0.69	0.62	(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20	32.20	32.20	32.20	(ft/s^2)	Acceleration of gravity
Fr_1 =	0.02	0.05	0.02	0.03	0.05		Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	11.8	17.0	11.0	15.6	11.1	**(ft)**	Pier scour depth
	14.4	14.4	67.8	67.8	14.4		Maximum Scour Depth check from HEC-18 7.2

For round nose piers: $y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

y_s =	11.8	14.4	11.0	15.6	11.1	(ft)	Pier scour depth

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Pier Scour

$$y_s = 2.0\,K_1\,K_2\,K_3\,y_1^{0.35}\,a^{0.65}\,Fr_1^{0.43}$$

200-year

	Pier 6	Pier 7				
K_1 =	1.00	1.00				Pier nose shape correction factor from HEC-18 Table 7.1
a =	6.00	6.00			(ft)	Pier width
L =	56.25	56.25			(ft)	Length of pier
L/a =	9.38	9.38				If L/a > 12, then use L/a = 12 (HEC-18 page 7.4)
Θ =	51.98	67.28				Angle of attack
K_2 =	3.87	4.18				Angle of attack correction factor from HEC-18 Equation 7.4 or Table 7.2
K_3 =	1.10	1.10				Bed condition correction factor from HEC-18 Table 7.3
y_1 =	5.60	6.19			(ft)	Flow depth directly upstream of pier, from contracted cross section
V_1 =	0.43	0.35			(ft/s)	Velocity of flow directly upstream of pier, from contracted cross section
g =	32.20	32.20			(ft/s^2)	Acceleration of gravity
Fr_1 =	0.03	0.02				Froude Number directly upstream of pier: $V_1/(gy_1)^{1/2}$
y_s =	11.3	11.4			(ft)	Pier scour depth
	14.4	14.4				Maximum Scour Depth check from HEC-18 7.2
						For round nose piers: $y_s \leq 2.4$ times the pier width (a) for Fr ≤ 0.8
						$y_s \leq 3.0$ times the pier width (a) for Fr > 0.8
y_s =	11.3	11.4			**(ft)**	Pier scour depth

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100-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment Flow does not hit left abutment**

D	=	211	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	34.20	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.17		Left Set Back Ratio

Right Abutment

D	=	224.00	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	34.20	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.55		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Right Abutment

Q_1	=	81.49	(cfs)	Flow at the approach cross section
A_1	=	814.90	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.29	(ft)	Hydraulic depth at the approach cross section
q_1	=	0.23	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	114.00	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	438.46	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.26	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	1.03	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	0.27	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.17		(Use minimum value of 1.0 in finding α)
α	=	1.55		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	2.62	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	4.06	(ft)	HEC-18 equation 8.3
Y_0	=	1.03	(ft)	
Y_s	=	3.03	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 195-ft Upstream of Contracted Section

100-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Right Abutment

Q_1	=	81.49	(cfs)	Flow at the approach cross section
A_1	=	814.90	(ft^2)	Flow area at the approach cross section
V_1	=	0.10	(ft/s)	Velocity at the approach cross section
Y_1	=	2.29	(ft)	Hydraulic depth at the approach cross section
q_f	=	0.23	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	114.00	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	438.46	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.26	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	1.03	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	0.27	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.20000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	0.23	(ft^2/s)	Upstream unit discharge
q_{2f}	=	0.27	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.17		(Use minimum value of 1.0 in finding α)
α	=	2.50		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	0.33	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	0.83	(ft)	HEC-18 equation 8.3
Y_0	=	1.03	(ft)	
Y_s	=	0.00	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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200-year

Determine Set Back Ratio (HEC-18 pg 8.16)

Left Abutment Flow does not hit left abutment**

D	=	211	(ft)	Distance from left top of bank to left abutment toe at internal bridge section
Y1	=	35.36	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.0		Left Set Back Ratio

Right Abutment

D	=	224.00	(ft)	Distance from right top of bank to right abutment toe at internal bridge section
Y1	=	35.36	(ft)	Average channel flow depth at internal bridge section
SBR	=	6.3		Right Set Back Ratio

Note: From HEC-18 Section 8.6.3, on page 8.16

a. If SBR is less than 5 for both abutments (Figure 8.14), compute a velocity, Q/A, based on the entire contracted area through the bridge opening. This includes the total upstream flow, exclusive of that which overtops the roadway. Unit discharge in the channel is the computed velocity times channel flow depth. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

b. If SBR is greater than 5 for an abutment (Figure 8.15), compute a velocity, Q/A, for the respective overbank flow only. Assume that the entire upstream overbank flow stays in the overbank section through the bridge opening. Unit discharge at the abutment is the computed velocity times the floodplain flow depth.

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NCHRP LIVE-BED METHOD (HEC-18 Equation 8.5) Approach Cross Section: 195-ft Upstream of Contracted Section

200-year

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7}$$

Right Abutment

Q_1	=	328.91	(cfs)	Flow at the approach cross section
A_1	=	1644.55	(ft^2)	Flow area at the approach cross section
V_1	=	0.20	(ft/s)	Velocity at the approach cross section
Y_1	=	4.38	(ft)	Hydraulic depth at the approach cross section
q_1	=	0.88	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	434.37	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	1809.88	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.24	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	4.27	(ft)	Hydraulic depth at the internal bridge cross section
q_{2c}	=	1.02	(ft^2/s)	Unit Discharge at the internal bridge cross section
q_{2c} / q_1	=	1.17		(Use minimum value of 1.0 in finding α)
α	=	1.70		Amplification factor for live bed conditions from HEC-18 Fig. 8.9 or 8.10
Y_c	=	5.01	(ft)	Live-Bed HEC-18 equation 8.5
Y_{max}	=	8.52	(ft)	HEC-18 equation 8.3
Y_0	=	4.27	(ft)	
Y_s	=	4.25	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

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NCHRP CLEAR-WATER METHOD (HEC-18 Equation 8.6)

Approach Cross Section: 195-ft Upstream of Contracted Section

200-year

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7}$$

Right Abutment

Q_1	=	328.91	(cfs)	Flow at the approach cross section
A_1	=	1644.55	(ft^2)	Flow area at the approach cross section
V_1	=	0.20	(ft/s)	Velocity at the approach cross section
Y_1	=	4.38	(ft)	Hydraulic depth at the approach cross section
q_f	=	0.88	(ft^2/s)	Unit Discharge at the approach cross section
Q_{bridge}	=	434.37	(cfs)	Flow at the internal bridge cross section
A_{bridge}	=	1809.875	(ft^2)	Flow area at the internal bridge cross section
V_{bridge}	=	0.24	(ft/s)	Velocity at the internal bridge cross section
Y_0	=	4.27	(ft)	Hydraulic depth at the internal bridge cross section
q_{2f}	=	1.02	(ft^2/s)	Unit Discharge at the internal bridge cross section
K_u	=	11.17		Coefficient, use 11.17 for English units and 6.19 for SI units
$D_{50\ actual}$	=	0.02000	(mm)	Particle size with 50% finer
D_{50}	=	0.20000	(mm)	Lower limit particle size for calculation from HEC-18 Page 8.13
q_f	=	0.88	(ft^2/s)	Upstream unit discharge
q_{2f}	=	1.02	(ft^2/s)	Unit discharge in the constricted opening accounting for non-uniform flow distribution
q_{2f} / q_f	=	1.17		(Use minimum value of 1.0 in finding α)
α	=	2.60		Amplification factor for clear-water conditions from HEC-18 Fig. 8.11 or 8.12
Y_c	=	1.05	(ft)	Clear-water HEC-18 equation 8.6
Y_{max}	=	2.72	(ft)	HEC-18 equation 8.3
Y_0	=	4.27	(ft)	
Y_s	=	0.00	(ft)	Calculated contraction and abutment scour depth using HEC-18 equation 8.4

South Wilmington Infrastructure Improvements

Wilmington, DE

2D MODELING, SCOUR, AND DRAINAGE ANALYSIS REPORT

Appendix F

Drainage Computations

Storm Drainage Design Computations
Hydraulic Gradient Line (HGL) Summary for Market Street

I. Jones Street Outfall

Table 1. 1-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	3.2	18.22	3.60	18.22	3.60
2	3.4	18.42	3.80	18.42	3.80
10	6.9	21.92	7.30	21.92	7.30
25	7.4	22.42	7.80	22.42	7.80
50	7.8	22.82	8.20	22.82	8.20
100	8.3	23.32	8.70	23.32	8.70
100	9.0	24.02	9.40	24.02	9.40
200	9.5	24.52	9.90	24.52	9.90
500	10.8	25.82	11.20	25.82	11.20
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	5.74	20.76	6.14	20.76	6.14
2	5.94	20.96	6.34	20.96	6.34
10	9.44	24.46	9.84	24.46	9.84
25	9.94	24.96	10.34	24.96	10.34
50	10.34	25.36	10.74	25.36	10.74
100	10.84	25.86	11.24	25.86	11.24
100	11.54	26.56	11.94	26.56	11.94
200	12.04	27.06	12.44	27.06	12.44
500	13.34	28.36	13.74	28.36	13.74

Table 2. 2-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	3.2	24.19	3.77	24.20	3.78
2	3.4	24.39	3.97	24.40	3.98
10	6.9	27.89	7.47	27.90	7.48

25	7.4	28.39	7.97	28.40	7.98
50	7.8	28.79	8.37	28.80	8.38
100	8.3	29.29	8.87	29.30	8.88
100	9.0	29.99	9.57	30.00	9.58
200	9.5	30.49	10.07	30.50	10.08
500	10.8	31.79	11.37	31.80	11.38
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	5.74	26.73	6.31	26.74	6.32
2	5.94	26.93	6.51	26.94	6.52
10	9.44	30.43	10.01	30.44	10.02
25	9.94	30.93	10.51	30.94	10.52
50	10.34	31.33	10.91	31.34	10.92
100	10.84	31.83	11.41	31.84	11.42
100	11.54	32.53	12.11	32.54	12.12
200	12.04	33.03	12.61	33.04	12.62
500	13.34	34.33	13.91	34.34	13.92

Table 3. 10-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	3.2	38.41	4.17	38.41	4.17
2	3.4	38.61	4.37	38.61	4.37
10	6.9	42.11	7.87	42.11	7.87
25	7.4	42.61	8.37	42.61	8.37
50	7.8	43.01	8.77	43.01	8.77
100	8.3	43.51	9.27	43.51	9.27
100	9.0	44.21	9.97	44.21	9.97
200	9.5	44.71	10.47	44.71	10.47
500	10.8	46.01	11.77	46.01	11.77
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	5.74	40.95	6.71	40.95	6.71
2	5.94	41.15	6.91	41.15	6.91

10	9.44	44.65	10.41	44.65	10.41
25	9.94	45.15	10.91	45.15	10.91
50	10.34	45.55	11.31	45.55	11.31
100	10.84	46.05	11.81	46.05	11.81
100	11.54	46.75	12.51	46.75	12.51
200	12.04	47.25	13.01	47.25	13.01
500	13.34	48.55	14.31	48.55	14.31

Table 4. 25-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	3.2	52.88	4.54	52.88	4.54
2	3.4	53.08	4.74	53.08	4.74
10	6.9	56.58	8.24	56.58	8.24
25	7.4	57.08	8.74	57.08	8.74
50	7.8	57.48	9.14	57.48	9.14
100	8.3	57.98	9.64	57.98	9.64
100	9.0	58.68	10.34	58.68	10.34
200	9.5	59.18	10.84	59.18	10.84
500	10.8	60.48	12.14	60.48	12.14
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	5.74	55.42	7.08	55.42	7.08
2	5.94	55.62	7.28	55.62	7.28
10	9.44	59.12	10.78	59.12	10.78
25	9.94	59.62	11.28	59.62	11.28
50	10.34	60.02	11.68	60.02	11.68
100	10.84	60.52	12.18	60.52	12.18
100	11.54	61.22	12.88	61.22	12.88
200	12.04	61.72	13.38	61.72	13.38
500	13.34	63.02	14.68	63.02	14.68

Table 5. 50-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	3.2	63.45	4.63	63.46	4.64
2	3.4	63.65	4.83	63.66	4.84
10	6.9	67.15	8.33	67.16	8.34
25	7.4	67.65	8.83	67.66	8.84
50	7.8	68.05	9.23	68.06	9.24
100	8.3	68.55	9.73	68.56	9.74
100	9.0	69.25	10.43	69.26	10.44
200	9.5	69.75	10.93	69.76	10.94
500	10.8	71.05	12.23	71.06	12.24
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	5.74	65.99	7.17	66.00	7.18
2	5.94	66.19	7.37	66.20	7.38
10	9.44	69.69	10.87	69.70	10.88
25	9.94	70.19	11.37	70.20	11.38
50	10.34	70.59	11.77	70.60	11.78
100	10.84	71.09	12.27	71.10	12.28
100	11.54	71.79	12.97	71.80	12.98
200	12.04	72.29	13.47	72.30	13.48
500	13.34	73.59	14.77	73.60	14.78

Table 6. 100-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	3.2	72.64	4.83	72.65	4.83
2	3.4	72.84	5.03	72.85	5.03
10	6.9	76.34	8.53	76.35	8.53
25	7.4	76.84	9.03	76.85	9.03
50	7.8	77.24	9.43	77.25	9.43
100	8.3	77.74	9.93	77.75	9.93
100	9.0	78.44	10.63	78.45	10.63

200	9.5	78.94	11.13	78.95	11.13
500	10.8	80.24	12.43	80.25	12.43
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	5.74	75.18	7.37	75.19	7.37
2	5.94	75.38	7.57	75.39	7.57
10	9.44	78.88	11.07	78.89	11.07
25	9.94	79.38	11.57	79.39	11.57
50	10.34	79.78	11.97	79.79	11.97
100	10.84	80.28	12.47	80.29	12.47
100	11.54	80.98	13.17	80.99	13.17
200	12.04	81.48	13.67	81.49	13.67
500	13.34	82.78	14.97	82.79	14.97

Table 7. 200-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	3.2	79.14	4.98	79.14	4.99
2	3.4	79.34	5.18	79.34	5.19
10	6.9	82.84	8.68	82.84	8.69
25	7.4	83.34	9.18	83.34	9.19
50	7.8	83.74	9.58	83.74	9.59
100	8.3	84.24	10.08	84.24	10.09
100	9.0	84.94	10.78	84.94	10.79
200	9.5	85.44	11.28	85.44	11.29
500	10.8	86.74	12.58	86.74	12.59
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	5.74	81.68	7.52	81.68	7.53
2	5.94	81.88	7.72	81.88	7.73
10	9.44	85.38	11.22	85.38	11.23
25	9.94	85.88	11.72	85.88	11.73
50	10.34	86.28	12.12	86.28	12.13
100	10.84	86.78	12.62	86.78	12.63

100	11.54	87.48	13.32	87.48	13.33
200	12.04	87.98	13.82	87.98	13.83
500	13.34	89.28	15.12	89.28	15.13

Table 8. 500-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	3.2	86.77	5.17	86.78	5.17
2	3.4	86.97	5.37	86.98	5.37
10	6.9	90.47	8.87	90.48	8.87
25	7.4	90.97	9.37	90.98	9.37
50	7.8	91.37	9.77	91.38	9.77
100	8.3	91.87	10.27	91.88	10.27
100	9.0	92.57	10.97	92.58	10.97
200	9.5	93.07	11.47	93.08	11.47
500	10.8	94.37	12.77	94.38	12.77
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 110+28.25			
		DI-72 TG El. 5.76		DI-73 TG El. 5.87	
		Exist.	Prop.	Exist.	Prop.
1	5.74	89.31	7.71	89.32	7.71
2	5.94	89.51	7.91	89.52	7.91
10	9.44	93.01	11.41	93.02	11.41
25	9.94	93.51	11.91	93.52	11.91
50	10.34	93.91	12.31	93.92	12.31
100	10.84	94.41	12.81	94.42	12.81
100	11.54	95.11	13.51	95.12	13.51
200	12.04	95.61	14.01	95.62	14.01
500	13.34	96.91	15.31	96.92	15.31

II. Central Green Outfall

Table 1. 1-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-04 TG El. 6.48		DI-18 TG El. 6.56		DI-08 TG El. 6.92		DI-22 TG El. 6.74	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	3.2	7.10	4.39	7.10	4.34	7.63	4.64	7.64	4.64
2	3.4	7.30	4.39	7.30	4.34	7.83	4.64	7.84	4.64
10	6.9	10.80	7.74	10.80	7.74	11.33	7.72	11.34	7.72
25	7.4	11.30	8.24	11.30	8.24	11.83	8.22	11.84	8.22
50	7.8	11.70	8.64	11.70	8.64	12.23	8.62	12.24	8.62
100	8.3	12.20	9.14	12.20	9.14	12.73	9.12	12.74	9.12
100	9.0	12.90	9.84	12.90	9.84	13.43	9.82	13.44	9.82
200	9.5	13.40	10.34	13.40	10.34	13.93	10.32	13.94	10.32
500	10.8	14.70	11.64	14.70	11.64	15.23	11.62	15.24	11.62
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-18 TG El. 6.56		DI-04 TG El. 6.48		DI-22 TG El. 6.74		DI-08 TG El. 6.92	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	5.74	9.64	6.58	9.64	6.58	10.17	6.56	10.18	6.56
2	5.94	9.84	6.78	9.84	6.78	10.37	6.76	10.38	6.76
10	9.44	13.34	10.28	13.34	10.28	13.87	10.26	13.88	10.26
25	9.94	13.84	10.78	13.84	10.78	14.37	10.76	14.38	10.76
50	10.34	14.24	11.18	14.24	11.18	14.77	11.16	14.78	11.16
100	10.84	14.74	11.68	14.74	11.68	15.27	11.66	15.28	11.66
100	11.54	15.44	12.38	15.44	12.38	15.97	12.36	15.98	12.36
200	12.04	15.94	12.88	15.94	12.88	16.47	12.86	16.48	12.86
500	13.34	17.24	14.18	17.24	14.18	17.24	14.16	17.24	14.16

Table 2. 2-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-04 TG El. 6.48		DI-18 TG El. 6.56		DI-08 TG El. 6.92		DI-22 TG El. 6.74	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	3.2	8.69	4.40	8.69	4.40	9.44	4.65	9.46	4.65
2	3.4	8.89	4.60	8.89	4.60	9.64	4.65	9.66	4.65
10	6.9	12.39	8.10	12.39	8.10	13.14	8.07	13.16	8.07
25	7.4	12.89	8.60	12.89	8.60	13.64	8.57	13.66	8.57
50	7.8	13.29	9.00	13.29	9.00	14.04	8.97	14.06	8.97
100	8.3	13.79	9.50	13.79	9.50	14.54	9.47	14.56	9.47

100	9.0	14.49	10.20	14.49	10.20	15.24	10.17	15.26	10.17
200	9.5	14.99	10.70	14.99	10.70	15.74	10.67	15.76	10.67
500	10.8	16.29	12.00	16.29	12.00	17.04	11.97	17.06	11.97
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-18 TG El. 6.56		DI-04 TG El. 6.48		DI-22 TG El. 6.74		DI-08 TG El. 6.92	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	5.74	11.23	6.94	11.23	6.94	11.98	6.91	12.00	6.91
2	5.94	11.43	7.14	11.43	7.14	12.18	7.11	12.20	7.11
10	9.44	14.93	10.64	14.93	10.64	15.68	10.61	15.70	10.61
25	9.94	15.43	11.14	15.43	11.14	16.18	11.11	16.20	11.11
50	10.34	15.83	11.54	15.83	11.54	16.58	11.51	16.60	11.51
100	10.84	16.33	12.04	16.33	12.04	17.08	12.01	17.10	12.01
100	11.54	17.03	12.74	17.03	12.74	17.78	12.71	17.80	12.71
200	12.04	17.53	13.24	17.53	13.24	18.28	13.21	18.30	13.21
500	13.34	18.83	14.54	18.83	14.54	19.58	14.51	19.60	14.51

Table 3. 10-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-04 TG El. 6.48		DI-18 TG El. 6.56		DI-08 TG El. 6.92		DI-22 TG El. 6.74	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	3.2	12.49	5.21	12.49	5.21	13.76	5.17	13.79	5.18
2	3.4	12.69	5.41	12.69	5.41	13.96	5.37	13.99	5.38
10	6.9	16.19	8.91	16.19	8.91	17.46	8.87	17.49	8.88
25	7.4	16.69	9.41	16.69	9.41	17.96	9.37	17.99	9.38
50	7.8	17.09	9.81	17.09	9.81	18.36	9.77	18.39	9.78
100	8.3	17.59	10.31	17.59	10.31	18.86	10.27	18.89	10.28
100	9.0	18.29	11.01	18.29	11.01	19.56	10.97	19.59	10.98
200	9.5	18.79	11.51	18.79	11.51	20.06	11.47	20.09	11.48
500	10.8	20.09	12.81	20.09	12.81	21.36	12.77	21.39	12.78
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-18 TG El. 6.56		DI-04 TG El. 6.48		DI-22 TG El. 6.74		DI-08 TG El. 6.92	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	5.74	15.03	7.75	15.03	7.75	16.30	7.71	16.33	7.72
2	5.94	15.23	7.95	15.23	7.95	16.50	7.91	16.53	7.92
10	9.44	18.73	11.45	18.73	11.45	20.00	11.41	20.03	11.42
25	9.94	19.23	11.95	19.23	11.95	20.50	11.91	20.53	11.92
50	10.34	19.63	12.35	19.63	12.35	20.90	12.31	20.93	12.32

100	10.84	20.13	12.85	20.13	12.85	21.40	12.81	21.43	12.82
100	11.54	20.83	13.55	20.83	13.55	22.10	13.51	22.13	13.52
200	12.04	21.33	14.05	21.33	14.05	22.60	14.01	22.63	14.02
500	13.34	22.63	15.35	22.63	15.35	23.90	15.31	23.93	15.32

Table 4. 25-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-04 TG El. 6.48		DI-18 TG El. 6.56		DI-08 TG El. 6.92		DI-22 TG El. 6.74	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	3.2	16.34	6.11	16.34	6.11	18.10	6.07	18.15	6.07
2	3.4	16.54	6.31	16.54	6.31	18.30	6.27	18.35	6.27
10	6.9	20.04	9.81	20.04	9.81	21.80	9.77	21.85	9.77
25	7.4	20.54	10.31	20.54	10.31	22.30	10.27	22.35	10.27
50	7.8	20.94	10.71	20.94	10.71	22.70	10.67	22.75	10.67
100	8.3	21.44	11.21	21.44	11.21	23.20	11.17	23.25	11.17
100	9.0	22.14	11.91	22.14	11.91	23.90	11.87	23.95	11.87
200	9.5	22.64	12.41	22.64	12.41	24.40	12.37	24.45	12.37
500	10.8	23.94	13.71	23.94	13.71	25.70	13.67	25.75	13.67
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-18 TG El. 6.56		DI-04 TG El. 6.48		DI-22 TG El. 6.74		DI-08 TG El. 6.92	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	5.74	18.88	8.65	18.88	8.65	20.64	8.61	20.69	8.61
2	5.94	19.08	8.85	19.08	8.85	20.84	8.81	20.89	8.81
10	9.44	22.58	12.35	22.58	12.35	24.34	12.31	24.39	12.31
25	9.94	23.08	12.85	23.08	12.85	24.84	12.81	24.89	12.81
50	10.34	23.48	13.25	23.48	13.25	25.24	13.21	25.29	13.21
100	10.84	23.98	13.75	23.98	13.75	25.74	13.71	25.79	13.71
100	11.54	24.68	14.45	24.68	14.45	26.44	14.41	26.49	14.41
200	12.04	25.18	14.95	25.18	14.95	26.94	14.91	26.99	14.91
500	13.34	26.48	16.25	26.48	16.25	28.24	16.21	28.29	16.21

Table 5. 50-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-04 TG El. 6.48		DI-18 TG El. 6.56		DI-08 TG El. 6.92		DI-22 TG El. 6.74	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	3.2	19.38	6.83	19.38	6.83	21.47	6.76	21.53	6.77
2	3.4	19.58	7.03	19.58	7.03	21.67	6.96	21.73	6.97

10	6.9	23.08	10.53	23.08	10.53	25.17	10.46	25.23	10.47
25	7.4	23.58	11.03	23.58	11.03	25.67	10.96	25.73	10.97
50	7.8	23.98	11.43	23.98	11.43	26.07	11.36	26.13	11.37
100	8.3	24.48	11.93	24.48	11.93	26.57	11.86	26.63	11.87
100	9.0	25.18	12.63	25.18	12.63	27.27	12.56	27.33	12.57
200	9.5	25.68	13.13	25.68	13.13	27.77	13.06	27.83	13.07
500	10.8	26.98	14.43	26.98	14.43	29.07	14.36	29.13	14.37
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-18 TG El. 6.56		DI-04 TG El. 6.48		DI-22 TG El. 6.74		DI-08 TG El. 6.92	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	5.74	21.92	9.37	21.92	9.37	24.01	9.30	24.07	9.31
2	5.94	22.12	9.57	22.12	9.57	24.21	9.50	24.27	9.51
10	9.44	25.62	13.07	25.62	13.07	27.71	13.00	27.77	13.01
25	9.94	26.12	13.57	26.12	13.57	28.21	13.50	28.27	13.51
50	10.34	26.52	13.97	26.52	13.97	28.61	13.90	28.67	13.91
100	10.84	27.02	14.47	27.02	14.47	29.11	14.40	29.17	14.41
100	11.54	27.72	15.17	27.72	15.17	29.81	15.10	29.87	15.11
200	12.04	28.22	15.67	28.22	15.67	30.31	15.60	30.37	15.61
500	13.34	29.52	16.97	29.52	16.97	31.61	16.90	31.67	16.91

Table 6. 100-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-04 TG El. 6.48		DI-18 TG El. 6.56		DI-08 TG El. 6.92		DI-22 TG El. 6.74	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	3.2	22.01	7.44	22.01	7.44	24.38	7.34	24.44	7.35
2	3.4	22.21	7.64	22.21	7.64	24.58	7.54	24.64	7.55
10	6.9	25.71	11.14	25.71	11.14	28.08	11.04	28.14	11.05
25	7.4	26.21	11.64	26.21	11.64	28.58	11.54	28.64	11.55
50	7.8	26.61	12.04	26.61	12.04	28.98	11.94	29.04	11.95
100	8.3	27.11	12.54	27.11	12.54	29.48	12.44	29.54	12.45
100	9.0	27.81	13.24	27.81	13.34	30.18	13.14	30.24	13.15
200	9.5	28.31	13.74	28.31	13.74	30.68	13.64	30.74	13.65
500	10.8	29.61	15.04	29.61	15.04	31.98	14.94	32.04	14.95
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-18 TG El. 6.56		DI-04 TG El. 6.48		DI-22 TG El. 6.74		DI-08 TG El. 6.92	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	5.74	24.55	9.98	24.55	9.98	26.92	9.88	26.98	9.89

2	5.94	24.75	10.18	24.75	10.18	27.12	10.08	27.18	10.09
10	9.44	28.25	13.68	28.25	13.68	30.62	13.58	30.68	13.59
25	9.94	28.75	14.18	28.75	14.18	31.12	14.08	31.18	14.09
50	10.34	29.15	14.58	29.15	14.58	31.52	14.48	31.58	14.49
100	10.84	29.65	15.08	29.65	15.08	32.02	14.98	32.08	14.99
100	11.54	30.35	15.78	30.35	15.78	32.72	15.68	32.78	15.69
200	12.04	30.85	16.28	30.85	16.28	33.22	16.18	33.28	16.19
500	13.34	32.15	17.58	32.15	17.58	34.52	17.48	34.58	17.49

Table 7. 200-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-04 TG El. 6.48		DI-18 TG El. 6.56		DI-08 TG El. 6.92		DI-22 TG El. 6.74	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	3.2	23.79	7.84	23.79	7.84	26.38	7.75	26.45	7.75
2	3.4	23.99	8.04	23.99	8.04	26.58	7.95	26.65	7.95
10	6.9	27.49	11.54	27.49	11.54	30.08	11.45	30.15	11.45
25	7.4	27.99	12.04	27.99	12.04	30.58	11.95	30.65	11.95
50	7.8	28.39	12.44	28.39	12.44	30.98	12.35	31.05	12.35
100	8.3	28.89	12.94	28.89	12.94	31.48	12.85	31.55	12.85
100	9.0	29.59	13.64	29.59	13.64	32.18	13.55	32.25	13.55
200	9.5	30.09	14.14	30.09	14.14	32.68	14.05	32.75	14.05
500	10.8	31.39	15.44	31.39	15.44	33.98	15.35	34.05	15.35
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-18 TG El. 6.56		DI-04 TG El. 6.48		DI-22 TG El. 6.74		DI-08 TG El. 6.92	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	5.74	26.33	10.38	26.33	10.38	28.92	10.29	28.99	10.29
2	5.94	26.53	10.58	26.53	10.58	29.12	10.49	29.19	10.49
10	9.44	30.03	14.08	30.03	14.08	32.62	13.99	32.69	13.99
25	9.94	30.53	14.85	30.53	14.85	33.12	14.49	33.19	14.49
50	10.34	30.93	14.98	30.93	14.98	33.52	14.89	33.59	14.89
100	10.84	31.43	15.48	31.43	15.48	34.02	15.39	34.09	15.39
100	11.54	32.13	16.18	32.13	16.18	34.72	16.09	34.79	16.09
200	12.04	32.63	16.68	32.63	16.68	35.22	16.59	35.29	16.59
500	13.34	33.93	17.98	33.93	17.98	36.52	17.89	36.59	17.89

Table 8. 500-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-04 TG El. 6.48		DI-18 TG El. 6.56		DI-08 TG El. 6.92		DI-22 TG El. 6.74	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	3.2	25.79	8.33	25.79	8.33	28.64	8.22	28.71	8.23
2	3.4	25.99	8.53	25.99	8.53	28.84	8.42	28.91	8.43
10	6.9	29.49	12.03	29.49	12.03	32.34	11.92	32.41	11.93
25	7.4	29.99	12.53	29.99	12.53	32.84	12.42	32.91	12.43
50	7.8	30.39	12.93	30.39	12.93	33.24	12.82	33.31	12.83
100	8.3	30.89	13.43	30.89	13.43	33.74	13.32	33.81	13.33
100	9.0	31.59	14.13	31.59	14.13	34.44	14.02	34.51	14.03
200	9.5	32.09	14.63	32.09	14.63	34.94	14.52	35.01	14.53
500	10.8	33.39	15.93	33.39	15.93	36.24	15.82	36.31	15.83
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 116+93.40				Market Street Low Point Sta. 121+47.67			
		DI-18 TG El. 6.56		DI-04 TG El. 6.48		DI-22 TG El. 6.74		DI-08 TG El. 6.92	
		Exist.	Prop.	Exist.	Prop.	Exist.	Prop.	Exist.	Prop.
1	5.74	28.33	10.87	28.33	10.87	31.18	10.76	31.25	10.77
2	5.94	28.53	11.07	28.53	11.07	31.38	10.96	31.45	10.97
10	9.44	32.03	14.57	32.03	14.57	34.88	14.46	34.95	14.47
25	9.94	32.53	15.07	32.53	15.07	35.38	14.96	35.45	14.97
50	10.34	32.93	15.47	32.93	15.47	35.78	15.36	35.85	15.37
100	10.84	33.43	15.97	33.43	15.97	36.28	15.86	36.35	15.87
100	11.54	34.13	16.67	34.13	16.67	36.98	16.56	37.05	16.57
200	12.04	34.63	17.17	34.63	17.17	37.48	17.06	37.55	17.07
500	13.34	35.93	18.47	35.93	18.47	38.78	18.36	38.85	18.37

III. Market Street Outfall

Table 1. 1-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	3.2	-	4.80	-	4.79
2	3.4	-	4.80	-	4.79
10	6.9	-	7.39	-	7.39
25	7.4	-	7.89	-	7.89
50	7.8	-	8.29	-	8.29
100	8.3	-	8.79	-	8.79
100	9.0	-	9.49	-	9.49
200	9.5	-	9.99	-	9.99
500	10.8	-	11.29	-	11.29
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	5.74	-	6.23	-	6.23
2	5.94	-	6.43	-	6.43
10	9.44	-	9.93	-	9.93
25	9.94	-	10.43	-	10.43
50	10.34	-	10.83	-	10.83
100	10.84	-	11.33	-	11.33
100	11.54	-	12.03	-	12.03
200	12.04	-	12.53	-	12.53
500	13.34	-	13.83	-	13.83

Table 2. 2-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	3.2	-	4.96	-	4.96
2	3.4	-	4.96	-	4.96
10	6.9	-	7.59	-	7.59
25	7.4	-	8.09	-	8.09
50	7.8	-	8.49	-	8.49
100	8.3	-	8.99	-	8.99

100	9.0	-	9.69	-	9.69
200	9.5	-	10.19	-	10.19
500	10.8	-	11.49	-	11.49
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	5.74	-	6.43	-	6.43
2	5.94	-	6.63	-	6.63
10	9.44	-	10.13	-	10.13
25	9.94	-	10.63	-	10.63
50	10.34	-	11.03	-	11.03
100	10.84	-	11.53	-	11.53
100	11.54	-	12.23	-	12.23
200	12.04	-	12.73	-	12.73
500	13.34	-	14.03	-	14.03

Table 3. 10-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	3.2	-	5.33	-	5.34
2	3.4	-	5.33	-	5.34
10	6.9	-	8.05	-	8.06
25	7.4	-	8.55	-	8.56
50	7.8	-	8.95	-	8.96
100	8.3	-	9.45	-	9.46
100	9.0	-	10.15	-	10.16
200	9.5	-	10.65	-	10.66
500	10.8	-	11.95	-	11.96
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	5.74	-	6.89	-	6.90
2	5.94	-	7.09	-	7.10
10	9.44	-	10.59	-	10.60
25	9.94	-	11.09	-	11.10
50	10.34	-	11.49	-	11.50

100	10.84	-	11.99	-	12.00
100	11.54	-	12.69	-	12.70
200	12.04	-	13.19	-	13.20
500	13.34	-	14.49	-	14.50

Table 4. 25-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	3.2	-	5.73	-	5.75
2	3.4	-	5.73	-	5.75
10	6.9	-	8.54	-	8.56
25	7.4	-	9.04	-	9.06
50	7.8	-	9.44	-	9.46
100	8.3	-	9.94	-	9.96
100	9.0	-	10.64	-	10.66
200	9.5	-	11.14	-	11.16
500	10.8	-	12.44	-	12.46
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	5.74	-	7.38	-	7.40
2	5.94	-	7.58	-	7.60
10	9.44	-	11.08	-	11.10
25	9.94	-	11.58	-	11.60
50	10.34	-	11.98	-	12.00
100	10.84	-	12.48	-	12.50
100	11.54	-	13.18	-	13.20
200	12.04	-	13.68	-	13.70
500	13.34	-	14.98	-	15.00

Table 5. 50-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	3.2	-	5.96	-	5.98
2	3.4	-	5.96	-	5.98

10	6.9	-	8.82	-	8.84
25	7.4	-	9.32	-	9.34
50	7.8	-	9.72	-	9.74
100	8.3	-	10.92	-	10.94
100	9.0	-	9.69	-	9.69
200	9.5	-	11.42	-	11.44
500	10.8	-	12.72	-	12.74
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	5.74	-	7.66	-	7.68
2	5.94	-	7.86	-	7.88
10	9.44	-	11.36	-	11.38
25	9.94	-	11.86	-	11.88
50	10.34	-	12.26	-	12.28
100	10.84	-	12.76	-	12.78
100	11.54	-	13.46	-	13.48
200	12.04	-	13.96	-	13.98
500	13.34	-	15.26	-	15.28

Table 6. 100-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	3.2	-	6.15	-	6.18
2	3.4	-	6.15	-	6.18
10	6.9	-	9.06	-	9.08
25	7.4	-	9.56	-	9.58
50	7.8	-	9.96	-	9.98
100	8.3	-	10.46	-	10.48
100	9.0	-	11.16	-	11.18
200	9.5	-	11.66	-	11.68
500	10.8	-	12.96	-	12.98
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	5.74	-	7.90	-	7.92

2	5.94	-	8.10	-	8.12
10	9.44	-	11.60	-	11.62
25	9.94	-	12.10	-	12.12
50	10.34	-	12.50	-	12.52
100	10.84	-	13.00	-	13.02
100	11.54	-	13.70	-	13.72
200	12.04	-	14.20	-	14.22
500	13.34	-	15.00	-	15.52

Table 7. 200-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	3.2	-	6.32	-	6.35
2	3.4	-	6.32	-	6.35
10	6.9	-	9.26	-	9.29
25	7.4	-	9.76	-	9.79
50	7.8	-	10.16	-	10.19
100	8.3	-	10.66	-	10.69
100	9.0	-	11.36	-	11.39
200	9.5	-	11.86	-	11.89
500	10.8	-	13.16	-	13.19
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	5.74	-	8.10	-	8.13
2	5.94	-	8.30	-	8.33
10	9.44	-	11.80	-	11.83
25	9.94	-	12.30	-	12.33
50	10.34	-	12.70	-	12.73
100	10.84	-	13.20	-	13.23
100	11.54	-	13.90	-	13.93
200	12.04	-	14.40	-	14.43
500	13.34	-	15.70	-	15.73

Table 8. 500-year Design Storm

Recurrence Interval	Tailwater Elevation	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	3.2	-	6.52	-	6.55
2	3.4	-	6.52	-	6.55
10	6.9	-	9.51	-	9.54
25	7.4	-	10.01	-	10.04
50	7.8	-	10.41	-	10.44
100	8.3	-	10.91	-	10.94
100	9.0	-	11.61	-	11.64
200	9.5	-	12.11	-	12.14
500	10.8	-	13.41	-	13.44
Recurrence Interval	Tailwater Elevation With Added SLR	Market Street Low Point Sta. 126+14.09			
		DI-11 TG El. 7.09		DI-241 TG El. 6.98	
		Exist.	Prop.	Exist.	Prop.
1	5.74	-	8.35	-	8.38
2	5.94	-	8.55	-	8.58
10	9.44	-	12.05	-	12.08
25	9.94	-	12.55	-	12.58
50	10.34	-	12.95	-	12.98
100	10.84	-	13.45	-	13.48
100	11.54	-	14.15	-	14.18
200	12.04	-	14.65	-	14.68
500	13.34	-	15.95	-	15.98

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 1 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
CRB Network STA 109+25 to 111+75																										
CRB-P72	CRB-DI72	CRB-MH-74	7961	0	7961	0.18	0.95	0.17	0.17	6.0	0.00	4.01	0.7	15	16	0.012	0.0001	0.019	7.8	9.6	3.8	0.07	6.07	2.60	2.30	Q ok
CRB-P74	CRB-MH-74	CRB-MH-67	1	0	1	0.00	0.95	0.00	0.33	6.0	6.23	3.98	1.3	15	154	0.012	0.0003	0.005	4.1	5.1	3.4	0.76	6.99	1.65	0.84	Q ok
CRB-P73	CRB-DI73	CRB-MH-74	7042	0	7042	0.16	0.95	0.15	0.15	6.0	0.00	4.01	0.6	15	34	0.012	0.0001	0.005	4.0	4.9	2.4	0.23	6.23	1.92	1.75	Q ok
MSS Network Sta 111+75 to 114+00																										
P-162	DI-162	EXMH-201	3794	0	3794	0.09	0.95	0.08	0.08	6.0	0.00	4.01	**0.33**	15	16	0.011	0.000019	0.0200	8.8	**10.8**	4.3	0.06	6.06	2.50	2.18	Q ok
P-201	EXMH-201	A1-MH-203	1	0	1	0.00	0.95	0.00	0.08	6.0	6.06	4.00	**0.33**	15	18	0.012	0.000022	0.0200	8.1	**9.9**	3.9	0.08	6.14	1.98	1.62	Q ok
Ploener Property																										
EX-P LOT	EXDI LOT	DI-MSS-41	13430	0	13430	0.31	0.95	0.29	0.29	6.0	0.00	4.01	**1.18**	12	47	0.012	0.000927	0.0074	4.2	**3.3**	3.8	0.21	6.21	2.50	2.15	Q ok
P-MSS-48	DI-MSS-40	DI-MSS-41	3590	0	3590	0.08	0.95	0.08	0.08	6.0	0.00	4.01	**0.31**	12	82	0.012	0.000066	0.0050	3.5	**2.7**	2.1	0.66	6.66	2.56	2.15	Q ok
P-MSS-48A	DI-MSS-41	EX-MH	3072	0	3072	0.07	0.95	0.07	0.44	6.0	6.66	3.89	**1.71**	12	41	0.012	0.001955	0.0051	3.5	**2.8**	3.7	0.19	6.84	2.05	1.84	Q ok
A1-P-202	EX-MH	A1-MH-203	1	0	1	0.00	0.95	0.00	0.44	6.0	6.84	3.88	**1.70**	18	26	0.012	0.000223	0.0046	4.4	**7.7**	3.3	0.13	6.97	1.74	1.62	Q ok
A1-P-204	A1-MH-204	CRB-MH-67	1	0	1	0.00	0.95	0.00	0.52	6.0	6.97	3.84	**2.00**	18	129	0.012	0.000310	0.0052	4.6	**8.2**	3.8	0.56	7.54	1.52	0.85	Q ok
A1-P-205	CRB-MH-67	CMH-1	1	0	1	0.00	0.95	0.00	0.99	6.0	7.54	3.76	**3.73**	18	14	0.012	0.001073	0.0057	4.9	**8.6**	4.7	0.05	7.59	0.75	0.67	Q ok
MSS Network Sta 111+75 to 114+00																										
MSS-P2	MSS-DI2	MSS-DI1	3846	1139	4985	0.11	0.77	0.09	0.09	6.0	0.00	4.01	0.4	15	70	0.012	0.0000	0.005	4.0	4.9	2.0	0.59	6.59	4.03	3.68	Q ok
MSS-P1	MSS-DI1	EXMH	2301	1082	3383	0.08	0.70	0.05	0.14	6.0	6.59	3.91	0.6	15	5	0.012	0.0001	0.003	3.3	4.0	2.3	0.04	6.63	3.39	3.37	Q ok
A1-P-203	EX MH	MH-CRB-67	1	0	1	0.00	0.95	0.00	0.14	6.0	6.63	3.91	**0.56**	18	25	0.012	0.000024	0.0050	4.6	**8.0**	2.2	0.19	6.82	0.92	0.84	Q ok
Jones Street Constructed Under Area 1																										
A1-P-206	CMH-1	A1-DI-207	1	0	1	0.00	0.95	0.00	1.16	6.0	7.59	3.74	**4.33**	24	60	0.012	0.000312	0.0035	4.6	**14.5**	3.9	0.25	7.84	0.57	0.36	Q ok
A1-P-207	A1-DI-207	A1-DI-208	3414	0	3414	0.08	0.95	0.07	1.84	6.0	7.84	3.71	**6.82**	24	82	0.012	0.000775	0.0040	4.9	**15.5**	4.8	0.28	8.13	0.36	0.03	Q ok
A1-P-208	A1-DI-208	A1-DI-209	2490	0	2490	0.06	0.95	0.05	1.89	6.0	8.13	3.66	**6.93**	36	59	0.012	0.000092	0.0041	6.5	**46.1**	4.6	0.22	8.34	0.03	-0.21	Q ok
A1-P-209	A1-DI-209	A1-MH-210	2433	0	2433	0.06	0.95	0.05	2.42	6.0	8.34	3.63	**8.76**	48	54	0.012	0.000032	0.0041	7.9	**99.3**	4.7	0.19	8.53	-0.21	-0.43	Q ok
A1-P-210	A1-MH-210	A1-DI-211	1	0	1	0.00	0.95	0.00	2.47	6.0	8.53	3.59	**8.89**	48	68	0.012	0.000033	0.0040	7.8	**98.1**	4.7	0.24	8.78	-0.43	-0.70	Q ok
A1-P-211	A1-DI-211	A1-DI-212	3353	0	3353	0.08	0.95	0.07	2.86	6.0	8.78	3.54	**10.11**	48	180	0.012	0.000042	0.0040	7.8	**98.4**	4.7	0.64	9.41	-0.70	-1.42	Q ok
A1-P-212	A1-DI-212	A1-DI-213	1885	0	1885	0.04	0.95	0.04	3.58	6.0	9.41	3.44	**12.32**	48	58	0.012	0.000063	0.0040	7.8	**98.0**	5.5	0.18	9.59	-1.42	-1.65	Q ok
A1-P-213	A1-DI-213	A1-DI-214	15288	0	15288	0.35	0.95	0.33	4.58	6.0	9.59	3.41	**15.61**	48	158	0.012	0.000101	0.0040	7.8	**98.3**	5.5	0.48	10.07	-1.65	-2.28	Q ok
A1-P-214	A1-DI-214	A1-DI-215	**1**	0	1	0.00	0.95	0.00	4.93	6.0	10.07	3.33	**16.41**	48	35	0.012	0.000111	0.0040	7.8	**98.4**	5.5	0.11	10.18	-2.28	-2.42	Q ok
A1-P-215	A1-DI-215	A1-MH-216	**1**	0	1	0.00	0.95	0.00	4.93	6.0	10.18	3.32	**16.35**	48	48	0.012	0.000110	0.0040	7.8	**97.9**	5.5	0.15	10.32	-2.42	-2.61	Q ok
MSS-P3 A	MSS-DI14	DI-161	3612	330	3942	0.09	0.89	0.08	0.08	6.0	0.00	4.01	0.3	15	44	0.012	0.0000	0.005	4.0	4.9	2.0	0.37	6.37	4.03	3.81	Q ok
MSS-P3 B	DI-161	MSS-DI13	2062	222	2284	0.05	0.88	0.05	0.13	6.0	6.37	3.94	0.5	15	25	0.012	0.0001	0.005	4.1	5.0	2.4	0.17	6.54	3.81	3.68	Q ok
	DOGHOUSE																									
P-160	DI-160	CMH-1	1768	257	2025	0.05	0.85	0.04	0.04	6.0	0.00	4.01	**0.16**	8	96	0.011	0.000124	0.0200	5.8	**2.0**	3.5	0.46	6.46	2.99	1.07	Q ok
A1 P-200	PARCEL J	A1-DI-207	27861	0	27861	0.64	0.95	0.61	0.61	6.0	0.00	4.01	**2.44**	18	23	0.012	0.000459	0.0100	6.4	11.4	4.8	0.08	6.08	1.59	1.36	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

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Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 1 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-336	PARCEL J	A1-DI-209	21549	0	21549	0.49	0.95	0.47	0.47	6.0	0.00	4.01	**1.89**	18	19	0.012	0.000275	0.0100	6.4	11.4	4.5	0.07	6.07	1.48	1.29	Q ok
P-337	PARCEL J	A1-DI-211	14148	0	14148	0.32	0.95	0.31	0.31	6.0	0.00	4.01	**1.24**	18	23	0.012	0.000118	0.0100	6.4	11.4	3.9	0.10	6.10	1.53	1.30	Q ok
P-335	PARCEL N	A1-DI-213	15379	0	15379	0.35	0.95	0.34	0.34	6.0	0.00	4.01	**1.35**	18	56	0.012	0.000140	0.0100	6.4	11.4	3.9	0.24	6.24	1.91	1.35	Q ok
P-340	PARCEL K	A1-DI-213	15267	0	15267	0.35	0.95	0.33	0.33	6.0	0.00	4.01	**1.34**	18	18	0.012	0.000138	0.0100	6.4	11.4	3.9	0.08	6.08	1.53	1.35	Q ok
P-165	DI-165	DI-166	7237	0	7237	0.17	0.95	0.16	0.16	6.0	0.00	4.01	**0.63**	18	28	0.012	0.000031	0.0100	6.4	**11.4**	3.2	0.15	6.15	2.95	2.67	Q ok
P-166	DI-166	DI-167	2265	0	2265	0.05	0.95	0.05	0.21	6.0	6.15	4.00	**0.83**	18	54	0.012	0.000053	0.0100	6.4	**11.4**	3.2	0.29	6.43	2.47	1.93	Q ok
P-167	DI-167	DI-168	3648	0	3648	0.08	0.95	0.08	0.29	6.0	6.43	3.94	**1.13**	24	91	0.012	0.000021	0.0100	7.8	**24.5**	3.8	0.40	6.83	1.73	0.82	Q ok
P-168	DI-168	DI-209	6136	0	6136	0.14	0.95	0.13	0.67	6.0	6.83	3.88	**2.60**	24	33	0.012	0.000113	0.0100	7.8	**24.5**	4.7	0.12	6.95	0.62	0.29	Q ok
P-327	PARCEL L	DI-168	11517	0	11517	0.26	0.95	0.25	0.25	6.0	0.00	4.01	**1.01**	18	19	0.012	0.000078	0.0100	6.4	11.4	3.9	0.08	6.08	1.31	1.12	Q ok
P-326	PARCEL L	DI-170	14378	0	14378	0.33	0.95	0.31	0.31	6.0	0.00	4.01	**1.26**	18	23	0.012	0.000122	0.0100	6.4	11.4	3.9	0.10	6.10	3.99	3.76	Q ok
P-170	DI-170	DI-171	2801	0	2801	0.06	0.95	0.06	0.37	6.0	6.10	4.00	**1.50**	18	68	0.012	0.000173	0.0100	6.4	**11.4**	4.5	0.25	6.35	3.26	2.58	Q ok
P-171	DI-171	DI-173	2811	0	2811	0.06	0.95	0.06	0.44	6.0	6.35	3.94	**1.72**	18	29	0.012	0.000228	0.0100	6.4	**11.4**	4.5	0.11	6.46	2.38	2.09	Q ok
P-173	DI-173	DI-174	2818	0	2818	0.06	0.95	0.06	0.77	6.0	6.46	3.93	**3.01**	24	46	0.012	0.000150	0.0100	7.8	**24.5**	4.7	0.16	6.62	1.89	1.43	Q ok
P-174	DI-174	DI-175	1817	0	1817	0.04	0.95	0.04	0.80	6.0	6.62	3.91	**3.15**	24	44	0.012	0.000165	0.0100	7.8	**24.5**	5.5	0.13	6.76	1.23	0.79	Q ok
P-175	DI-175	DI-211	3620	0	3620	0.08	0.95	0.08	1.17	6.0	6.76	3.88	**4.52**	24	29	0.012	0.000340	0.0100	7.8	**24.5**	5.9	0.08	6.84	0.59	0.30	Q ok
P-331	PARCEL M	DI-175	12913	0	12913	0.30	0.95	0.28	0.28	6.0	0.00	4.01	**1.13**	18	19	0.012	0.000099	0.0100	6.4	11.4	3.9	0.08	6.08	1.28	1.09	Q ok
P-328	PARCEL M	DI-172	9475	0	9475	0.22	0.95	0.21	0.21	6.0	0.00	4.01	**0.83**	18	22	0.012	0.000053	0.0100	6.4	11.4	3.2	0.12	6.12	3.49	3.27	Q ok
P-172	DI-172	DI-173	2798	0	2798	0.06	0.95	0.06	0.27	6.0	6.12	4.00	**1.07**	18	68	0.012	0.000088	0.0100	6.4	**11.4**	3.9	0.29	6.41	2.77	2.09	Q ok
P-169	DI-169	MH-210	2626	0	2626	0.06	0.95	0.06	0.06	6.0	0.00	4.01	**0.23**	18	7	0.012	0.000004	0.0100	6.4	**11.4**	3.2	0.04	6.04	1.64	1.57	Q ok
P-178	DI-178	DI-179	3573	0	3573	0.08	0.95	0.08	0.08	6.0	0.00	4.01	**0.31**	18	39	0.012	0.000008	0.0100	6.4	**11.4**	3.2	0.21	6.21	2.63	2.24	Q ok
P-179	DI-179	DI-180	1913	0	1913	0.04	0.95	0.04	0.12	6.0	0.00	4.01	**0.48**	18	34	0.012	0.000018	0.0100	6.4	**11.4**	3.2	0.18	6.18	2.04	1.70	Q ok
P-180	DI-180	DI-181	1165	0	1165	0.03	0.95	0.03	0.15	6.0	0.00	4.01	**0.58**	18	49	0.012	0.000026	0.0100	6.4	**11.4**	3.2	0.26	6.26	1.50	1.01	Q ok
P-181	DI-181	DI-212	1967	0	1967	0.05	0.95	0.04	0.19	6.0	0.00	4.01	**0.75**	18	23	0.012	0.000044	0.0100	6.4	**11.4**	3.2	0.12	6.12	0.81	0.58	Q ok
P-182	DI-182	DI-186	1887	0	1887	0.04	0.95	0.04	0.04	6.0	0.00	4.01	**0.17**	18	43	0.012	0.000002	0.0100	6.4	**11.4**	3.2	0.23	6.23	4.28	3.85	Q ok
P-338	PARCEL J	DI-185	10195	0	10195	0.23	0.95	0.22	0.22	6.0	0.00	4.01	**0.89**	18	23	0.012	0.000061	0.0100	6.4	11.4	3.9	0.10	6.10	3.86	3.63	Q ok

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County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 1 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to	Pervious Area, C = 0.18 to	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-183	DI-183	DI-184	2436	0	2436	0.06	0.95	0.05	0.05	6.0	0.00	4.01	**0.21**	18	59	0.012	0.000004	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.74	4.15	Q ok
P-184	DI-184	DI-185	2508	0	2508	0.06	0.95	0.05	0.11	6.0	0.00	4.01	**0.43**	18	62	0.012	0.000014	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.95	3.33	Q ok
P-185	DI-185	DI-186	3002	0	3002	0.07	0.95	0.07	0.40	6.0	0.00	4.01	**1.59**	18	108	0.012	0.000195	0.0100	6.4	**11.4**	4.5	0.40	6.40	3.13	2.05	Q ok
P-186	DI-186	DI-190	1354	0	1354	0.03	0.95	0.03	0.47	6.0	0.00	4.01	**1.87**	18	27	0.012	0.000270	0.0100	6.4	**11.4**	4.5	0.10	6.10	1.85	1.58	Q ok
check San x-ing																										
P-339	PARCEL K	DI-189	12930	0	12930	0.30	0.95	0.28	0.28	6.0	0.00	4.01	**1.13**	18	23	0.012	0.000099	0.0100	6.4	11.4	3.9	0.10	6.10	3.20	2.97	Q ok
P-187	DI-187	DI-188	2448	0	2448	0.06	0.95	0.05	0.05	6.0	0.00	4.01	**0.21**	18	59	0.012	0.000004	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.08	3.49	Q ok
P-188	DI-188	DI-189	2550	0	2550	0.06	0.95	0.06	0.11	6.0	0.00	4.01	**0.44**	18	62	0.012	0.000015	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.29	2.67	Q ok
P-189	DI-189	DI-190	3025	0	3025	0.07	0.95	0.07	0.46	6.0	0.00	4.01	**1.83**	18	119	0.012	0.000260	0.0100	6.4	**11.4**	4.5	0.44	6.44	2.47	1.28	Q ok
P-190	DI-190	DI-191	1765	0	1765	0.04	0.95	0.04	0.50	6.0	0.00	4.01	**1.99**	18	50	0.012	0.000305	0.0100	6.4	**11.4**	4.5	0.18	6.18	1.08	0.58	Q ok
P-341	PARCEL K	DI-195	13999	0	13999	0.32	0.95	0.31	0.31	6.0	0.00	4.01	**1.22**	18	53	0.012	0.000116	0.0100	6.4	11.4	3.9	0.23	6.23	3.96	3.43	Q ok
P-195	DI-195	A1-DI-214	**1887**	0	1887	0.04	0.95	0.04	0.35	6.0	6.23	3.98	**1.38**	18	43	0.012	0.000147	0.0100	6.4	**11.4**	3.9	0.19	6.41	2.43	2.00	Q ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	3.60	3.60	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.60	5.76	HGL ok
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	3.54	3.54	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	3.60	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	3.60	3.60	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.60	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	3.59	3.59	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.59	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	3.59	3.59	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	3.59	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	3.76	3.76	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	3.81	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	3.75	3.75	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.76	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	3.63	3.63	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	3.75	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	3.59	3.59	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	3.63	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	3.54	3.54	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	3.59	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	3.51	3.51	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	3.54	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.38	4.68	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	3.54	4.37	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	4.38	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	3.54	3.54	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	3.54	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	3.47	3.47	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	3.51	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.37	3.37	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	3.47	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.33	3.33	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	3.37	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.32	3.32	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	3.33	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.32	3.32	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	3.32	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.27	3.27	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	3.32	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.26	3.26	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	3.27	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.23	3.23	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	3.26	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.22	3.22	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	3.23	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.20**	**3.20**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**3.22**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	3.51	4.81	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.81	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	3.47	4.68	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	3.51	3.51	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.52	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	3.47	3.47	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.48	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.33	3.33	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.34	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.32	3.32	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.32	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.26	3.26	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.27	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.26	3.26	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.27	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.36	3.87	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.87	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.35	3.35	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	3.36	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.35	3.35	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	3.35	7.12	HGL ok

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Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.33	3.33	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	3.35	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.35	3.35	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.35	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	3.81	4.96	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.96	10.00	HGL ok
P-170	DI-170	DI-171	1.20	3.45	3.78	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	3.81	10.79	HGL ok
P-171	DI-171	DI-173	1.20	3.42	3.42	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	3.45	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.39	3.39	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	3.42	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.37	3.37	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	3.39	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.32	3.32	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	3.37	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.37	3.37	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.37	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	3.44	4.47	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.47	10.00	HGL ok
P-172	DI-172	DI-173	1.20	3.42	3.42	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	3.44	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.32	3.32	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.32	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.28	3.44	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.44	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.28	3.28	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	3.28	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.28	3.28	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	3.28	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.27	3.27	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	3.28	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.34	5.05	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.37	4.83	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.83	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.37	4.53	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.34	3.34	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	3.37	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.31	3.31	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	3.34	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.35	4.17	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.17	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.87	4.69	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.35	3.87	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.87	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.31	3.31	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	3.35	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.27	3.27	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	3.31	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.25	4.63	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.64	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.23	3.23	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	3.25	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	3.80	3.80	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.80	5.76	HGL ok
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	3.74	3.74	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	3.80	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	3.80	3.80	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.80	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	3.79	3.79	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.79	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	3.79	3.79	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	3.79	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	3.96	3.96	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	4.01	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	3.95	3.95	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.96	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	3.83	3.83	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	3.95	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	3.79	3.79	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	3.83	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	3.74	3.74	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	3.79	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	3.71	3.71	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	3.74	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.38	4.68	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	3.74	4.37	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	4.38	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	3.74	3.74	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	3.74	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	3.67	3.67	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	3.71	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.57	3.57	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	3.67	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.53	3.53	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	3.57	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.52	3.52	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	3.53	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.52	3.52	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	3.52	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.47	3.47	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	3.52	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.46	3.46	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	3.47	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.43	3.43	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	3.46	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.42	3.42	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	3.43	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.40**	**3.40**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**3.42**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	3.71	4.81	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.81	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	3.67	4.68	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	3.71	3.71	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.72	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	3.67	3.67	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.68	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.53	3.53	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.54	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.52	3.52	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.52	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.46	3.46	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.47	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.46	3.46	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.47	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.56	3.87	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.87	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.55	3.55	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	3.56	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.55	3.55	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	3.55	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 1

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.53	3.53	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	3.55	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.55	3.55	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.55	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	3.81	4.96	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.96	10.00	HGL ok
P-170	DI-170	DI-171	1.20	3.65	3.78	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	3.81	10.79	HGL ok
P-171	DI-171	DI-173	1.20	3.62	3.62	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	3.65	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.59	3.59	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	3.62	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.57	3.57	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	3.59	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.52	3.52	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	3.57	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.57	3.57	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.57	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	3.64	4.47	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.47	10.00	HGL ok
P-172	DI-172	DI-173	1.20	3.62	3.62	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	3.64	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.52	3.52	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.52	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.48	3.48	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.48	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.48	3.48	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	3.48	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.48	3.48	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	3.48	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.47	3.47	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	3.48	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.54	5.05	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.57	4.83	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.83	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.57	4.53	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.54	3.54	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	3.57	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.51	3.51	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	3.54	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.55	4.17	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.17	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.87	4.69	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.55	3.87	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.87	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.51	3.51	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	3.55	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.47	3.47	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	3.51	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.45	4.63	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.64	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.43	3.43	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	3.45	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.30	7.30	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.30	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.24	7.24	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	7.30	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.30	7.30	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.30	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.29	7.29	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.29	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.29	7.29	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	7.29	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	7.46	7.46	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	7.51	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	7.45	7.45	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.46	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.33	7.33	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	7.45	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.29	7.29	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	7.33	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.24	7.24	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	7.29	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.21	7.21	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	7.24	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.25	7.25	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.25	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.24	7.24	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	7.25	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.24	7.24	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	7.24	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.17	7.17	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	7.21	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.07	7.07	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	7.17	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.03	7.03	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	7.07	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.02	7.02	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	7.03	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.02	7.02	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	7.02	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.97	6.97	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	7.02	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.96	6.96	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	6.97	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	6.93	6.93	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	6.96	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.92	6.92	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	6.93	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**6.90**	**6.90**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**6.92**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.21	7.21	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.21	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.17	7.17	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.17	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.21	7.21	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.22	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.17	7.17	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.18	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.03	7.03	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.04	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.02	7.02	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.02	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.96	6.96	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.97	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.96	6.96	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.97	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.06	7.06	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.06	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.05	7.05	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.06	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.05	7.05	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.05	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 1 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.03	7.03	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	7.05	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.05	7.05	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.05	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.18	7.18	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.18	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.15	7.15	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	7.18	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.12	7.12	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	7.15	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.09	7.09	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	7.12	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.07	7.07	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	7.09	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.02	7.02	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	7.07	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.07	7.07	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.07	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.14	7.14	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.14	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.12	7.12	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	7.14	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.02	7.02	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.02	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.98	6.98	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.98	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.98	6.98	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	6.98	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.98	6.98	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	6.98	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.97	6.97	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	6.98	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.04	7.04	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.04	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.07	7.07	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.07	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.07	7.07	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.07	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.07	7.07	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.07	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.04	7.04	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	7.07	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.01	7.01	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	7.04	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.05	7.05	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.06	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.06	7.06	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.06	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.05	7.05	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.06	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.01	7.01	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	7.05	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.97	6.97	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	7.01	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.95	6.95	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.96	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	6.93	6.93	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	6.95	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: ____ of ____
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077.001
Segment:	Jones Street Outfall	Design Freq.:	1	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.80	7.80	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.80	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.74	7.74	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	7.80	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.80	7.80	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.80	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.79	7.79	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.79	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.79	7.79	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	7.79	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	7.96	7.96	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	8.01	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	7.95	7.95	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.96	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.83	7.83	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	7.95	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.79	7.79	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	7.83	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.74	7.74	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	7.79	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.71	7.71	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	7.74	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.75	7.75	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.75	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.74	7.74	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	7.75	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.74	7.74	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	7.74	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.67	7.67	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	7.71	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.57	7.57	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	7.67	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.53	7.53	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	7.57	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.52	7.52	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	7.53	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.52	7.52	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	7.52	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.47	7.47	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	7.52	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.46	7.46	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	7.47	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.43	7.43	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	7.46	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.42	7.42	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	7.43	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.40**	**7.40**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**7.42**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.71	7.71	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.71	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.67	7.67	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.67	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.71	7.71	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.72	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.67	7.67	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.68	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.53	7.53	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.54	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.52	7.52	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.52	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.46	7.46	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.47	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.46	7.46	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.47	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.56	7.56	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.56	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.55	7.55	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.56	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.55	7.55	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.55	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ____ of ____
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077.001
Segment: Jones Street Outfall — Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.53	7.53	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	7.55	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.55	7.55	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.55	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.68	7.68	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.68	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.65	7.65	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	7.68	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.62	7.62	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	7.65	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.59	7.59	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	7.62	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.57	7.57	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	7.59	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.52	7.52	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	7.57	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.57	7.57	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.57	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.64	7.64	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.64	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.62	7.62	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	7.64	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.52	7.52	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.52	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.48	7.48	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.48	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.48	7.48	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	7.48	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.48	7.48	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	7.48	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.47	7.47	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	7.48	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.54	7.54	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.54	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.57	7.57	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.57	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.57	7.57	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.57	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.57	7.57	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.57	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.54	7.54	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	7.57	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.51	7.51	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	7.54	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.55	7.55	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.56	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.56	7.56	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.56	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.55	7.55	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.56	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.51	7.51	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	7.55	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.47	7.47	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	7.51	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.45	7.45	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.46	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.43	7.43	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	7.45	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.20	8.20	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.20	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.14	8.14	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	8.20	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.20	8.20	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.20	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.19	8.19	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.19	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.19	8.19	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	8.19	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.36	8.36	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	8.41	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.35	8.35	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.36	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.23	8.23	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	8.35	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.19	8.19	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	8.23	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.14	8.14	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	8.19	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.11	8.11	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	8.14	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.15	8.15	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.15	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.14	8.14	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	8.15	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.14	8.14	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	8.14	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.07	8.07	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	8.11	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.97	7.97	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	8.07	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.93	7.93	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	7.97	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.92	7.92	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	7.93	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.92	7.92	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	7.92	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.87	7.87	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	7.92	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.86	7.86	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	7.87	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.83	7.83	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	7.86	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.82	7.82	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	7.83	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.80**	**7.80**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**7.82**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.11	8.11	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.11	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.07	8.07	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	8.07	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.11	8.11	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.12	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.07	8.07	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.08	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.93	7.93	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.94	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.92	7.92	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.92	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.86	7.86	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.87	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.86	7.86	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.87	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.96	7.96	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.96	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.95	7.95	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.96	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.95	7.95	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.95	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 1 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.93	7.93	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	7.95	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.95	7.95	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.95	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.08	8.08	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.08	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.05	8.05	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	8.08	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.02	8.02	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	8.05	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.99	7.99	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	8.02	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.97	7.97	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	7.99	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.92	7.92	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	7.97	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.97	7.97	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.97	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.04	8.04	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.04	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.02	8.02	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	8.04	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.92	7.92	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.92	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.88	7.88	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.88	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.88	7.88	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	7.88	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.88	7.88	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	7.88	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.87	7.87	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	7.88	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.94	7.94	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.94	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.97	7.97	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.97	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.97	7.97	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.97	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.97	7.97	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.97	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.94	7.94	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	7.97	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.91	7.91	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	7.94	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.95	7.95	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.96	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.96	7.96	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.96	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.95	7.95	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.96	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.91	7.91	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	7.95	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.87	7.87	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	7.91	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.85	7.85	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.86	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.83	7.83	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	7.85	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.70	8.70	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.70	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.64	8.64	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	8.70	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.70	8.70	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.70	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.69	8.69	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.69	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.69	8.69	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	8.69	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.86	8.86	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	8.91	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.85	8.85	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.86	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.73	8.73	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	8.85	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.69	8.69	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	8.73	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.64	8.64	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	8.69	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.61	8.61	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	8.64	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.65	8.65	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.65	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.64	8.64	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	8.65	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.64	8.64	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	8.64	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.57	8.57	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	8.61	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.47	8.47	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	8.57	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.43	8.43	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	8.47	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.42	8.42	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	8.43	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.42	8.42	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	8.42	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.37	8.37	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	8.42	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.36	8.36	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	8.37	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	8.33	8.33	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	8.36	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	8.32	8.32	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	8.33	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**8.30**	**8.30**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**8.32**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.61	8.61	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.61	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.57	8.57	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	8.57	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.61	8.61	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.62	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.57	8.57	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.58	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	8.43	8.43	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.44	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.42	8.42	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.42	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.36	8.36	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.37	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.36	8.36	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.37	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.46	8.46	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.46	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.45	8.45	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	8.46	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.45	8.45	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	8.45	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.43	8.43	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	8.45	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.45	8.45	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.45	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.58	8.58	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.58	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.55	8.55	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	8.58	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.52	8.52	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	8.55	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.49	8.49	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	8.52	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.47	8.47	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	8.49	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.42	8.42	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	8.47	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.47	8.47	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.47	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.54	8.54	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.54	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.52	8.52	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	8.54	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.42	8.42	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.42	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.38	8.38	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.38	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.38	8.38	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	8.38	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.38	8.38	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	8.38	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.37	8.37	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	8.38	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.44	8.44	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.44	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.47	8.47	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.47	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.47	8.47	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.47	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.47	8.47	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.47	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.44	8.44	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	8.47	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.41	8.41	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	8.44	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.45	8.45	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.46	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.46	8.46	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.46	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.45	8.45	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.46	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.41	8.41	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	8.45	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.37	8.37	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	8.41	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.35	8.35	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.36	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	8.33	8.33	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	8.35	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	of
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077.001
Segment:	Jones Street Outfall	Design Freq.:	1	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.40	9.40	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.40	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.34	9.34	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	9.40	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.40	9.40	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.40	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.39	9.39	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.39	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.39	9.39	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	9.39	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.56	9.56	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	9.61	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.55	9.55	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.56	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.43	9.43	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	9.55	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.39	9.39	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	9.43	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.34	9.34	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	9.39	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.31	9.31	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	9.34	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.35	9.35	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.35	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.34	9.34	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	9.35	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.34	9.34	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	9.34	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.27	9.27	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	9.31	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.17	9.17	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	9.27	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.13	9.13	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	9.17	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.12	9.12	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	9.13	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.12	9.12	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	9.12	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.07	9.07	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	9.12	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.06	9.06	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	9.07	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.03	9.03	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	9.06	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.02	9.02	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	9.03	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.00**	**9.00**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**9.02**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.31	9.31	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.31	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.27	9.27	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.27	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.31	9.31	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.32	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.27	9.27	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.28	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.13	9.13	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.14	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.12	9.12	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.12	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.06	9.06	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.07	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.06	9.06	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.07	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.16	9.16	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.16	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.15	9.15	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.16	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.15	9.15	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.15	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.13	9.13	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	9.15	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.15	9.15	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.15	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	9.28	9.28	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.28	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.25	9.25	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	9.28	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.22	9.22	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	9.25	10.30	HGL ok
P-173	DI-173	DI-174	1.60	9.19	9.19	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	9.22	10.30	HGL ok
P-174	DI-174	DI-175	1.60	9.17	9.17	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	9.19	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.12	9.12	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	9.17	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.17	9.17	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.17	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.24	9.24	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.24	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.22	9.22	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	9.24	10.79	HGL ok
P-169	DI-169	MH-210	1.20	9.12	9.12	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.12	10.25	HGL ok
P-178	DI-178	DI-179	1.20	9.08	9.08	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.08	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.08	9.08	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	9.08	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.08	9.08	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	9.08	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.07	9.07	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	9.08	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.14	9.14	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.14	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.17	9.17	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.17	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.17	9.17	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.17	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.17	9.17	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.17	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.14	9.14	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	9.17	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.11	9.11	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	9.14	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.15	9.15	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.16	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.16	9.16	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.16	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.15	9.15	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.16	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.11	9.11	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	9.15	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.07	9.07	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	9.11	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.05	9.05	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.06	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.03	9.03	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	9.05	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.90	9.90	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.90	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.84	9.84	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	9.90	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.90	9.90	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.90	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.89	9.89	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.89	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.89	9.89	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	9.89	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.06	10.06	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	10.11	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.05	10.05	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.06	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.93	9.93	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	10.05	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.89	9.89	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	9.93	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.84	9.84	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	9.89	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.81	9.81	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	9.84	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.85	9.85	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.85	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.84	9.84	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	9.85	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.84	9.84	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	9.84	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.77	9.77	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	9.81	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.67	9.67	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	9.77	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.63	9.63	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	9.67	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.62	9.62	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	9.63	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.62	9.62	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	9.62	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.57	9.57	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	9.62	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.56	9.56	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	9.57	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.53	9.53	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	9.56	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.52	9.52	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	9.53	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.50**	**9.50**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**9.52**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.81	9.81	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.81	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.77	9.77	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.77	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.81	9.81	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.82	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.77	9.77	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.78	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.63	9.63	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.64	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.62	9.62	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.62	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.56	9.56	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.57	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.56	9.56	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.57	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.66	9.66	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.66	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.65	9.65	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.66	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.65	9.65	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.65	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.63	9.63	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	9.65	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.65	9.65	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.65	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	9.78	9.78	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.78	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.75	9.75	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	9.78	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.72	9.72	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	9.75	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.69	9.69	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	9.72	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.67	9.67	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	9.69	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.62	9.62	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	9.67	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.67	9.67	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.67	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.74	9.74	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.74	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.72	9.72	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	9.74	10.79	HGL ok
P-169	DI-169	MH-210	1.20	9.62	9.62	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.62	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.58	9.58	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.58	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.58	9.58	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	9.58	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.58	9.58	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	9.58	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.57	9.57	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	9.58	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.64	9.64	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.64	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.67	9.67	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.67	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.67	9.67	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.67	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.67	9.67	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.67	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.64	9.64	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	9.67	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.61	9.61	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	9.64	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.65	9.65	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.66	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.66	9.66	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.66	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.65	9.65	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.66	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.61	9.61	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	9.65	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.57	9.57	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	9.61	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.55	9.55	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.56	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.53	9.53	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	9.55	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.20	11.20	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.20	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.14	11.14	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	11.20	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.20	11.20	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.20	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.19	11.19	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.19	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.19	11.19	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.19	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.36	11.36	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	11.41	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.35	11.35	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.36	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.23	11.23	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	11.35	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.19	11.19	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	11.23	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.14	11.14	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	11.19	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.11	11.11	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	11.14	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.15	11.15	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.15	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.14	11.14	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	11.15	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.14	11.14	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	11.14	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.07	11.07	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	11.11	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.97	10.97	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	11.07	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.93	10.93	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	10.97	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.92	10.92	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	10.93	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.92	10.92	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	10.92	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.87	10.87	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	10.92	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.86	10.86	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	10.87	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.83	10.83	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	10.86	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.82	10.82	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	10.83	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.80**	**10.80**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**10.82**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.11	11.11	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.11	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.07	11.07	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	11.07	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.11	11.11	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.12	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.07	11.07	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.08	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.93	10.93	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.94	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.92	10.92	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.92	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.86	10.86	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.87	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.86	10.86	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.87	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.96	10.96	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.96	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.95	10.95	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.96	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.95	10.95	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.95	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 1 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.93	10.93	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	10.95	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.95	10.95	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.95	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.08	11.08	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.08	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.05	11.05	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	11.08	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.02	11.02	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	11.05	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.99	10.99	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	11.02	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.97	10.97	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	10.99	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.92	10.92	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	10.97	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.97	10.97	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.97	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.04	11.04	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.04	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.02	11.02	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	11.04	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.92	10.92	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.92	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.88	10.88	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.88	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.88	10.88	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.88	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	10.88	10.88	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	10.88	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	10.87	10.87	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	10.88	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	10.94	10.94	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.94	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.97	10.97	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.97	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.97	10.97	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.97	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	10.97	10.97	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.97	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	10.94	10.94	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	10.97	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.91	10.91	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	10.94	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.95	10.95	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.96	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.96	10.96	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.96	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	10.95	10.95	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.96	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	10.91	10.91	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	10.95	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.87	10.87	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	10.91	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.85	10.85	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.86	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.83	10.83	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	10.85	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	of
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077.001
Segment:	Jones Street Outfall	Design Freq.:	1	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	6.14	6.14	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.14	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	6.08	6.08	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	6.14	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	6.14	6.14	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.14	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	6.13	6.13	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.13	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	6.13	6.13	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	6.13	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	6.30	6.30	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	6.35	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	6.29	6.29	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.30	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	6.17	6.17	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	6.29	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	6.13	6.13	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	6.17	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	6.08	6.08	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	6.13	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	6.05	6.05	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	6.08	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	6.09	6.09	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.09	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	6.08	6.08	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	6.09	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	6.08	6.08	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	6.08	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.01	6.01	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	6.05	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	5.91	5.91	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	6.01	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	5.87	5.87	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	5.91	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	5.86	5.86	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	5.87	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	5.86	5.86	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	5.86	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	5.81	5.81	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	5.86	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	5.80	5.80	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	5.81	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.77	5.77	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	5.80	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.76	5.76	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	5.77	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.74**	**5.74**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**5.76**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.05	6.05	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.05	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	6.01	6.01	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	6.01	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.05	6.05	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.06	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.01	6.01	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.02	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	5.87	5.87	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	5.88	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	5.86	5.86	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.86	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	5.80	5.80	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	5.81	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	5.80	5.80	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.81	10.00	HGL ok
P-165	DI-165	DI-166	1.20	5.90	5.90	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.90	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	5.89	5.89	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	5.90	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	5.89	5.89	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	5.89	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	5.87	5.87	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	5.89	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	5.89	5.89	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.89	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.02	6.02	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.02	10.00	HGL ok
P-170	DI-170	DI-171	1.20	5.99	5.99	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	6.02	10.79	HGL ok
P-171	DI-171	DI-173	1.20	5.96	5.96	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	5.99	10.30	HGL ok
P-173	DI-173	DI-174	1.60	5.93	5.93	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	5.96	10.30	HGL ok
P-174	DI-174	DI-175	1.60	5.91	5.91	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	5.93	11.19	HGL ok
P-175	DI-175	DI-211	1.60	5.86	5.86	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	5.91	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	5.91	5.91	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.91	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	5.98	5.98	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.98	10.00	HGL ok
P-172	DI-172	DI-173	1.20	5.96	5.96	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	5.98	10.79	HGL ok
P-169	DI-169	MH-210	1.20	5.86	5.86	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.86	10.25	HGL ok
P-178	DI-178	DI-179	1.20	5.82	5.82	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.82	11.90	HGL ok
P-179	DI-179	DI-180	1.20	5.82	5.82	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	5.82	11.68	HGL ok
P-180	DI-180	DI-181	1.20	5.82	5.82	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	5.82	11.68	HGL ok
P-181	DI-181	DI-212	1.20	5.81	5.81	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	5.82	11.82	HGL ok
P-182	DI-182	DI-186	1.20	5.88	5.88	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.88	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	5.91	5.91	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.91	10.00	HGL ok
P-183	DI-183	DI-184	1.20	5.91	5.91	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.91	11.58	HGL ok
P-184	DI-184	DI-185	1.20	5.91	5.91	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	5.91	11.91	HGL ok
P-185	DI-185	DI-186	1.20	5.88	5.88	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	5.91	12.23	HGL ok
P-186	DI-186	DI-190	1.20	5.85	5.85	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	5.88	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	5.89	5.89	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.90	10.00	HGL ok
P-187	DI-187	DI-188	1.20	5.90	5.90	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.90	11.58	HGL ok
P-188	DI-188	DI-189	1.20	5.89	5.89	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	5.90	11.91	HGL ok
P-189	DI-189	DI-190	1.20	5.85	5.85	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	5.89	12.23	HGL ok
P-190	DI-190	DI-191	1.20	5.81	5.81	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	5.85	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	5.79	5.79	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	5.80	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.77	5.77	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	5.79	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	6.34	6.34	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.34	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	6.28	6.28	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	6.34	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	6.34	6.34	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.34	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	6.33	6.33	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.33	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	6.33	6.33	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	6.33	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	6.50	6.50	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	6.55	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	6.49	6.49	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.50	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	6.37	6.37	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	6.49	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	6.33	6.33	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	6.37	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	6.28	6.28	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	6.33	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	6.25	6.25	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	6.28	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	6.29	6.29	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.29	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	6.28	6.28	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	6.29	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	6.28	6.28	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	6.28	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.21	6.21	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	6.25	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.11	6.11	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	6.21	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.07	6.07	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	6.11	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.06	6.06	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	6.07	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.06	6.06	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	6.06	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.01	6.01	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	6.06	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.00	6.00	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	6.01	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.97	5.97	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	6.00	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.96	5.96	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	5.97	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.94**	**5.94**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**5.96**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.25	6.25	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.25	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.21	6.21	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	6.21	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.25	6.25	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.26	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.21	6.21	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.22	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.07	6.07	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.08	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.06	6.06	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.06	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.00	6.00	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.01	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.00	6.00	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.01	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.10	6.10	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.10	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.09	6.09	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	6.10	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.09	6.09	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	6.09	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.07	6.07	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	6.09	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.09	6.09	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.09	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.22	6.22	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.22	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.19	6.19	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	6.22	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.16	6.16	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	6.19	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.13	6.13	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	6.16	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.11	6.11	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	6.13	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.06	6.06	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	6.11	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.11	6.11	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.11	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.18	6.18	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.18	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.16	6.16	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	6.18	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.06	6.06	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.06	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.02	6.02	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.02	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.02	6.02	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	6.02	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.02	6.02	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	6.02	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.01	6.01	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	6.02	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.08	6.08	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.08	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.11	6.11	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.11	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.11	6.11	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.11	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.11	6.11	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	6.11	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.08	6.08	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	6.11	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.05	6.05	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	6.08	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.09	6.09	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.10	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.10	6.10	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.10	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.09	6.09	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	6.10	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.05	6.05	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	6.09	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.01	6.01	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	6.05	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	5.99	5.99	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.00	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.97	5.97	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	5.99	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	of
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077.001
Segment:	Jones Street Outfall	Design Freq.:	1	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.84	9.84	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.84	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.78	9.78	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	9.84	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.84	9.84	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.84	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.83	9.83	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.83	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.83	9.83	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	9.83	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.00	10.00	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	10.05	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.99	9.99	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.00	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.87	9.87	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	9.99	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.83	9.83	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	9.87	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.78	9.78	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	9.83	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.75	9.75	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	9.78	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.79	9.79	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.79	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.78	9.78	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	9.79	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.78	9.78	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	9.78	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.71	9.71	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	9.75	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.61	9.61	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	9.71	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.57	9.57	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	9.61	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.56	9.56	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	9.57	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.56	9.56	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	9.56	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.51	9.51	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	9.56	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.50	9.50	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	9.51	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.47	9.47	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	9.50	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.46	9.46	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	9.47	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.44**	**9.44**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**9.46**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.75	9.75	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.75	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.71	9.71	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.71	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.75	9.75	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.76	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.71	9.71	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.72	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.57	9.57	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.58	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.56	9.56	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.56	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.50	9.50	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.51	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.50	9.50	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.51	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.60	9.60	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.60	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.59	9.59	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.60	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.59	9.59	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.59	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.57	9.57	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	9.59	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.59	9.59	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.59	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	9.72	9.72	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.72	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.69	9.69	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	9.72	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.66	9.66	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	9.69	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.63	9.63	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	9.66	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.61	9.61	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	9.63	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.56	9.56	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	9.61	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.61	9.61	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.61	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.68	9.68	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.68	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.66	9.66	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	9.68	10.79	HGL ok
P-169	DI-169	MH-210	1.20	9.56	9.56	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.56	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.52	9.52	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.52	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.52	9.52	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	9.52	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.52	9.52	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	9.52	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.51	9.51	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	9.52	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.58	9.58	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.58	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.61	9.61	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.61	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.61	9.61	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.61	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.61	9.61	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.61	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.58	9.58	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	9.61	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.55	9.55	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	9.58	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.59	9.59	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.60	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.60	9.60	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.60	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.59	9.59	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.60	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.55	9.55	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	9.59	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.51	9.51	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	9.55	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.49	9.49	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.50	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.47	9.47	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	9.49	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.34	10.34	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.34	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.28	10.28	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	10.34	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.34	10.34	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.34	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.33	10.33	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.33	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.33	10.33	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.33	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.50	10.50	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	10.55	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.49	10.49	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.50	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.37	10.37	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	10.49	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.33	10.33	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	10.37	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.28	10.28	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	10.33	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.25	10.25	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	10.28	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.29	10.29	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.29	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.28	10.28	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	10.29	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.28	10.28	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	10.28	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.21	10.21	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	10.25	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.11	10.11	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	10.21	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.07	10.07	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	10.11	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.06	10.06	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	10.07	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.06	10.06	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	10.06	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.01	10.01	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	10.06	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.00	10.00	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	10.01	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.97	9.97	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	10.00	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.96	9.96	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	9.97	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.94**	**9.94**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**9.96**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.25	10.25	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.25	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.21	10.21	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.21	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.25	10.25	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.26	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.21	10.21	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.22	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.07	10.07	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.08	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.06	10.06	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.06	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.00	10.00	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.01	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.00	10.00	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.01	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.10	10.10	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.10	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.09	10.09	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.10	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.09	10.09	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.09	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.07	10.07	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	10.09	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.09	10.09	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.09	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.22	10.22	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.22	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.19	10.19	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	10.22	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.16	10.16	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	10.19	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.13	10.13	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	10.16	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.11	10.11	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	10.13	11.19	HGL ok
P-175	DI-175	DI-211	1.60	10.06	10.06	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	10.11	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.11	10.11	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.11	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.18	10.18	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.18	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.16	10.16	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	10.18	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.06	10.06	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.06	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.02	10.02	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.02	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.02	10.02	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.02	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.02	10.02	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	10.02	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.01	10.01	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	10.02	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.08	10.08	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.08	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.11	10.11	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.11	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.11	10.11	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.11	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.11	10.11	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.11	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.08	10.08	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	10.11	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.05	10.05	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	10.08	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.09	10.09	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.10	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.10	10.10	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.10	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.09	10.09	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.10	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.05	10.05	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	10.09	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.01	10.01	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	10.05	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.99	9.99	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.00	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.97	9.97	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	9.99	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.74	10.74	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.74	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.68	10.68	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	10.74	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.74	10.74	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.74	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.73	10.73	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.73	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.73	10.73	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.73	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.90	10.90	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	10.95	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.89	10.89	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.90	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.77	10.77	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	10.89	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.73	10.73	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	10.77	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.68	10.68	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	10.73	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.65	10.65	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	10.68	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.69	10.69	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.69	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.68	10.68	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	10.69	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.68	10.68	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	10.68	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.61	10.61	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	10.65	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.51	10.51	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	10.61	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.47	10.47	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	10.51	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.46	10.46	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	10.47	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.46	10.46	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	10.46	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.41	10.41	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	10.46	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.40	10.40	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	10.41	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.37	10.37	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	10.40	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.36	10.36	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	10.37	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.34**	**10.34**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**10.36**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.65	10.65	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.65	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.61	10.61	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.61	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.65	10.65	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.66	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.61	10.61	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.62	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.47	10.47	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.48	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.46	10.46	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.46	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.40	10.40	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.41	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.40	10.40	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.41	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.50	10.50	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.50	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.49	10.49	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.50	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.49	10.49	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.49	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 1 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.47	10.47	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	10.49	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.49	10.49	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.49	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.62	10.62	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.62	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.59	10.59	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	10.62	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.56	10.56	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	10.59	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.53	10.53	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	10.56	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.51	10.51	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	10.53	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.46	10.46	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	10.51	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.51	10.51	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.51	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.58	10.58	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.58	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.56	10.56	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	10.58	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.46	10.46	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.46	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.42	10.42	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.42	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.42	10.42	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.42	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.42	10.42	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	10.42	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.41	10.41	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	10.42	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.48	10.48	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.48	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.51	10.51	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.51	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.51	10.51	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.51	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.51	10.51	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.51	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.48	10.48	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	10.51	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.45	10.45	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	10.48	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.49	10.49	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.50	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.50	10.50	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.50	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.49	10.49	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.50	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.45	10.45	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	10.49	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.41	10.41	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	10.45	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.39	10.39	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.40	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.37	10.37	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	10.39	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.24	11.24	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.24	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.18	11.18	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	11.24	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.24	11.24	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.24	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.23	11.23	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.23	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.23	11.23	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.23	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.40	11.40	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	11.45	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.39	11.39	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.40	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.27	11.27	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	11.39	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.23	11.23	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	11.27	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.18	11.18	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	11.23	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.15	11.15	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	11.18	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.19	11.19	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.19	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.18	11.18	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	11.19	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.18	11.18	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	11.18	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.11	11.11	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	11.15	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.01	11.01	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	11.11	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.97	10.97	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	11.01	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.96	10.96	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	10.97	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.96	10.96	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	10.96	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.91	10.91	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	10.96	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.90	10.90	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	10.91	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.87	10.87	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	10.90	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.86	10.86	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	10.87	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.84**	**10.84**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**10.86**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.15	11.15	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.15	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.11	11.11	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	11.11	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.15	11.15	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.16	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.11	11.11	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.12	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.97	10.97	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.98	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.96	10.96	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.96	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.90	10.90	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.91	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.90	10.90	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.91	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.00	11.00	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.00	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.99	10.99	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	11.00	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.99	10.99	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.99	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.97	10.97	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	10.99	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.99	10.99	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.99	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.12	11.12	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.12	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.09	11.09	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	11.12	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.06	11.06	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	11.09	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.03	11.03	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	11.06	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.01	11.01	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	11.03	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.96	10.96	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	11.01	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.01	11.01	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.01	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.08	11.08	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.08	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.06	11.06	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	11.08	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.96	10.96	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.96	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.92	10.92	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.92	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	10.92	10.92	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.92	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	10.92	10.92	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	10.92	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	10.91	10.91	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	10.92	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	10.98	10.98	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.98	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	11.01	11.01	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.01	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.01	11.01	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.01	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.01	11.01	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.01	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	10.98	10.98	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	11.01	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.95	10.95	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	10.98	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.99	10.99	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.00	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.00	11.00	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.00	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	10.99	10.99	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.00	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	10.95	10.95	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	10.99	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.91	10.91	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	10.95	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.89	10.89	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.90	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.87	10.87	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	10.89	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.94	11.94	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.94	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.88	11.88	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	11.94	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.94	11.94	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.94	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.93	11.93	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.93	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.93	11.93	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.93	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.10	12.10	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	12.15	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.09	12.09	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.10	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.97	11.97	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	12.09	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.93	11.93	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	11.97	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.88	11.88	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	11.93	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.85	11.85	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	11.88	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.89	11.89	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.89	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.88	11.88	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	11.89	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.88	11.88	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	11.88	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.81	11.81	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	11.85	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.71	11.71	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	11.81	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.67	11.67	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	11.71	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.66	11.66	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	11.67	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.66	11.66	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	11.66	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.61	11.61	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	11.66	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.60	11.60	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	11.61	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.57	11.57	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	11.60	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	11.56	11.56	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	11.57	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**11.54**	**11.54**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**11.56**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.85	11.85	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.85	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.81	11.81	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	11.81	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.85	11.85	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.86	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.81	11.81	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.82	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.67	11.67	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.68	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.66	11.66	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.66	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.60	11.60	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.61	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.60	11.60	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.61	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.70	11.70	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.70	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.69	11.69	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	11.70	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.69	11.69	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	11.69	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.67	11.67	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	*1.3*	1.0	0.01	0.01	11.69	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.69	11.69	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.00	11.69	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.82	11.82	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.00	11.82	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.79	11.79	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	*1.3*	1.0	0.01	0.03	11.82	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.76	11.76	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	*1.3*	1.0	0.02	0.03	11.79	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.73	11.73	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	*1.3*	1.0	0.02	0.03	11.76	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.71	11.71	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	11.73	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.66	11.66	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	11.71	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.71	11.71	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.00	11.71	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.78	11.78	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.00	11.78	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.76	11.76	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	*1.3*	1.0	0.01	0.01	11.78	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.66	11.66	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.66	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.62	11.62	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.62	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.62	11.62	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	*1.3*	1.0	0.00	0.00	11.62	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.62	11.62	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	*1.3*	1.0	0.00	0.00	11.62	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.61	11.61	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	*1.3*	1.0	0.00	0.00	11.62	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.68	11.68	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.68	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.71	11.71	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.00	11.71	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.71	11.71	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.71	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.71	11.71	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	*1.3*	1.0	0.00	0.00	11.71	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.68	11.68	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	*1.3*	1.0	0.01	0.03	11.71	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.65	11.65	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	*1.3*	1.0	0.02	0.03	11.68	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.69	11.69	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.00	11.70	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.70	11.70	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.70	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.69	11.69	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	*1.3*	1.0	0.00	0.00	11.70	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.65	11.65	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	*1.3*	1.0	0.01	0.05	11.69	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.61	11.61	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	11.65	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.59	11.59	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	11.60	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.57	11.57	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	*1.3*	1.0	0.01	0.02	11.59	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.44	12.44	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.44	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.38	12.38	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	12.44	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.44	12.44	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.44	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.43	12.43	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.43	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.43	12.43	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	12.43	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.60	12.60	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	12.65	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.59	12.59	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.60	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.47	12.47	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	12.59	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.43	12.43	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	12.47	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.38	12.38	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	12.43	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.35	12.35	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	12.38	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.39	12.39	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.39	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.38	12.38	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	12.39	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.38	12.38	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	12.38	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.31	12.31	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	12.35	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.21	12.21	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	12.31	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.17	12.17	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	12.21	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	12.16	12.16	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	12.17	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	12.16	12.16	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	12.16	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	12.11	12.11	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	12.16	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	12.10	12.10	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	12.11	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	12.07	12.07	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	12.10	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	12.06	12.06	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	12.07	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**12.04**	**12.04**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**12.06**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.35	12.35	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.35	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.31	12.31	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	12.31	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.35	12.35	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.36	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.31	12.31	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.32	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.17	12.17	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.18	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	12.16	12.16	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.16	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	12.10	12.10	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.11	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	12.10	12.10	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.11	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.20	12.20	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.20	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.19	12.19	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	12.20	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.19	12.19	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	12.19	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 1

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.17	12.17	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	12.19	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.19	12.19	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.19	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.32	12.32	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.32	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.29	12.29	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	12.32	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.26	12.26	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	12.29	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.23	12.23	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	12.26	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.21	12.21	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	12.23	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	12.16	12.16	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	12.21	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.21	12.21	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.21	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.28	12.28	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.28	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.26	12.26	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	12.28	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	12.16	12.16	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.16	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	12.12	12.12	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.12	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	12.12	12.12	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	12.12	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	12.12	12.12	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	12.12	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	12.11	12.11	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	12.12	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.18	12.18	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.18	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.21	12.21	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.21	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.21	12.21	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.21	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.21	12.21	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	12.21	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.18	12.18	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	12.21	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.15	12.15	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	12.18	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.19	12.19	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.20	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.20	12.20	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.20	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.19	12.19	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	12.20	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.15	12.15	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	12.19	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	12.11	12.11	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	12.15	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	12.09	12.09	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.10	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	12.07	12.07	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	12.09	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.74	13.74	15	0.7	0.6	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.74	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	13.68	13.68	15	1.3	1.1	91	154	0.0003	0.05	0	0.00	0.00	0.3	0.4	0.0	0.6	0.0	95	0.00	0.01	1.0	0.5	0.00	0.06	13.74	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.74	13.74	15	0.6	0.5	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.74	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.73	13.73	15	0.3	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.73	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.73	13.73	15	0.3	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	13.73	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.90	13.90	12	1.2	1.5	0	47	0.0009	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	13.95	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.89	13.89	12	0.3	0.4	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.90	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.77	13.77	12	1.7	2.2	72	41	0.0020	0.08	0	0.00	0.02	0.1	1.8	0.0	1.5	0.0	0	0.00	0.03	1.3	1.0	0.04	0.12	13.89	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.73	13.73	18	1.7	1.0	77	26	0.0002	0.01	0	0.00	0.00	3.7	0.0	0.0	2.2	0.0	72	0.04	0.07	1.0	0.5	0.04	0.04	13.77	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	13.68	13.68	18	2.0	1.1	90	129	0.0003	0.04	0	0.00	0.00	1.6	0.1	0.0	1.0	0.0	77	0.01	0.02	1.0	0.5	0.01	0.05	13.73	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	13.65	13.65	18	3.7	2.1	3	14	0.0011	0.02	0	0.00	0.02	2.3	0.2	1.4	1.1	0.0	90	0.01	0.04	1.0	0.5	0.02	0.03	13.68	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	13.69	13.69	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.69	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	13.68	13.68	15	0.6	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	13.69	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	13.68	13.68	18	0.6	0.3	2	25	0.0000	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	13.68	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	13.61	13.61	24	4.3	1.4	4	60	0.0003	0.02	0	0.00	0.01	7.9	0.2	0.1	2.1	0.0	3	0.01	0.04	1.0	0.5	0.02	0.04	13.65	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	13.51	13.51	24	6.8	2.2	4	82	0.0008	0.06	0	0.00	0.02	6.0	3.4	0.0	1.4	0.0	4	0.00	0.03	1.0	1.0	0.03	0.10	13.61	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	13.47	13.47	36	6.9	1.0	7	59	0.0001	0.01	0	0.00	0.00	14.8	0.0	0.0	2.2	0.0	4	0.01	0.04	1.0	1.0	0.04	0.04	13.51	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	13.46	13.46	48	8.8	0.7	3	54	0.0000	0.00	0	0.00	0.00	6.8	2.0	2.2	1.0	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	13.47	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	13.46	13.46	48	8.9	0.7	3	68	0.0000	0.00	0	0.00	0.00	6.1	0.0	0.0	0.7	0.0	3	0.00	0.01	1.0	0.5	0.00	0.00	13.46	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	13.41	13.41	48	10.1	0.8	4	180	0.0000	0.01	0	0.00	0.00	6.3	6.5	0.9	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.04	13.46	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	13.40	13.40	48	12.3	1.0	2	58	0.0001	0.00	0	0.00	0.00	8.1	0.3	2.2	0.8	0.0	4	0.00	0.01	1.0	1.0	0.01	0.01	13.41	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	13.37	13.37	48	15.6	1.2	0	158	0.0001	0.02	0	0.00	0.01	12.1	1.0	1.0	1.0	0.0	2	0.00	0.01	1.0	1.0	0.01	0.03	13.40	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	13.36	13.36	48	16.4	1.3	16	35	0.0001	0.00	0	0.00	0.01	19.4	1.1	0.0	1.2	0.0	0	0.00	0.02	1.0	1.0	0.02	0.02	13.37	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**13.34**	**13.34**	**48**	**16.4**	**1.3**	**0**	**48**	**0.0001**	**0.01**	**0**	**0.00**	**0.01**	**21.4**	**0.0**	**0.0**	**1.3**	**0.0**	**16**	**0.01**	**0.02**	**1.0**	**0.5**	**0.01**	**0.02**	**13.36**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	13.65	13.65	15	0.3	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.65	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	13.61	13.61	15	0.5	0.4	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	13.61	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	13.65	13.65	8	0.2	0.5	93	96	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.66	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	13.61	13.61	18	2.4	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.62	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	13.47	13.47	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.48	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	13.46	13.46	18	1.2	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.46	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	13.40	13.40	18	1.3	0.8	90	56	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.41	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	13.40	13.40	18	1.3	0.8	90	18	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.41	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	13.50	13.50	18	0.6	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.50	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	13.49	13.49	18	0.8	0.5	0	54	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	13.50	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	13.49	13.49	24	1.1	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	13.49	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 1 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	13.47	13.47	24	2.6	0.8	94	33	0.0001	0.00	0	0.00	0.00	0.4	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	13.49	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	13.49	13.49	18	1.0	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.49	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	13.62	13.62	18	1.3	0.7	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.62	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	13.59	13.59	18	1.5	0.8	90	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.01	0.03	13.62	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	13.56	13.56	18	1.7	1.0	79	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	13.59	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	13.53	13.53	24	3.0	1.0	69	46	0.0002	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	79	0.01	0.02	1.3	1.0	0.02	0.03	13.56	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	13.51	13.51	24	3.1	1.0	80	44	0.0002	0.01	0	0.00	0.00	2.9	0.0	0.0	1.0	0.0	69	0.01	0.02	1.0	1.0	0.02	0.02	13.53	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	13.46	13.46	24	4.5	1.4	88	29	0.0003	0.01	0	0.00	0.01	3.2	6.5	0.0	1.4	0.0	88	0.02	0.04	1.0	1.0	0.04	0.05	13.51	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	13.51	13.51	18	1.1	0.6	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.51	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	13.58	13.58	18	0.8	0.5	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.58	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	13.56	13.56	18	1.1	0.6	12	68	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.01	13.58	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	13.46	13.46	18	0.2	0.1	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.46	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	13.42	13.42	18	0.3	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.42	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	13.42	13.42	18	0.5	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	13.42	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	13.42	13.42	18	0.6	0.3	12	49	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	13.42	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	13.41	13.41	18	0.8	0.4	98	23	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	13.42	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	13.48	13.48	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.48	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	13.51	13.51	18	0.9	0.5	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.51	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	13.51	13.51	18	0.2	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.51	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	13.51	13.51	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	13.51	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	13.48	13.48	18	1.6	0.9	70	108	0.0002	0.02	0	0.00	0.00	0.1	0.5	0.0	0.5	0.0	90	0.00	0.01	1.3	1.0	0.01	0.03	13.51	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	13.45	13.45	18	1.9	1.1	57	27	0.0003	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	70	0.01	0.02	1.3	1.0	0.02	0.03	13.48	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	13.49	13.49	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.50	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	13.50	13.50	18	0.2	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.50	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	13.49	13.49	18	0.4	0.2	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	13.50	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	13.45	13.45	18	1.8	1.0	14	119	0.0003	0.03	0	0.00	0.00	0.1	0.7	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.05	13.49	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	13.41	13.41	18	2.0	1.1	67	50	0.0003	0.02	0	0.00	0.00	1.9	2.0	0.0	1.1	0.0	57	0.01	0.02	1.0	1.0	0.02	0.04	13.45	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	13.39	13.39	18	1.2	0.7	105	53	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.40	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	13.37	13.37	18	1.4	0.8	90	43	0.0001	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	105	0.01	0.01	1.3	1.0	0.01	0.02	13.39	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 2 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
CRB Network STA 109+25 to 111+75																										
CRB-P72	CRB-DI72	CRB-MH-74	7961	0	7961	0.18	0.95	0.17	0.17	6.0	0.00	4.77	0.8	15	16	0.012	0.0001	0.019	7.8	9.6	4.7	0.06	6.06	2.60	2.30	Q ok
CRB-P74	CRB-MH-74	CRB-MH-67	1	0	1	0.00	0.95	0.00	0.33	6.0	6.20	4.73	1.5	15	154	0.012	0.0005	0.005	4.1	5.1	3.5	0.73	6.93	1.65	0.84	Q ok
CRB-P73	CRB-DI73	CRB-MH-74	7042	0	7042	0.16	0.95	0.15	0.15	6.0	0.00	4.77	0.7	15	34	0.012	0.0001	0.005	4.0	4.9	2.8	0.20	6.20	1.92	1.75	Q ok
MSS Network Sta 111+75 to 114+00																										
P-162	DI-162	EXMH-201	3794	0	3794	0.09	0.95	0.08	0.08	6.0	0.00	4.77	**0.39**	15	16	0.011	0.000027	0.0200	8.8	**10.8**	4.3	0.06	6.06	2.50	2.18	Q ok
P-201	EXMH-201	A1-MH-203	1	0	1	0.00	0.95	0.00	0.08	6.0	6.06	4.75	**0.39**	15	18	0.012	0.000032	0.0200	8.1	**9.9**	3.9	0.08	6.14	1.98	1.62	Q ok
Ploener Property																										
EX-P LOT	EXDI LOT	DI-MSS-41	13430	0	13430	0.31	0.95	0.29	0.29	6.0	0.00	4.77	**1.40**	12	47	0.012	0.001310	0.0074	4.2	**3.3**	3.9	0.20	6.20	2.50	2.15	Q ok
P-MSS-48	DI-MSS-40	DI-MSS-41	3590	0	3590	0.08	0.95	0.08	0.08	6.0	0.00	4.77	**0.37**	12	82	0.012	0.000094	0.0050	3.5	**2.7**	2.4	0.56	6.56	2.56	2.15	Q ok
P-MSS-48A	DI-MSS-41	EX-MH	3072	0	3072	0.07	0.95	0.07	0.44	6.0	6.56	4.65	**2.04**	12	41	0.012	0.002787	0.0051	3.5	**2.8**	3.9	0.18	6.74	2.05	1.84	Q ok
A1-P-202	EX-MH	A1-MH-203	1	0	1	0.00	0.95	0.00	0.44	6.0	6.74	4.63	**2.03**	18	26	0.012	0.000318	0.0046	4.4	**7.7**	3.6	0.12	6.86	1.74	1.62	Q ok
A1-P-204	A1-MH-204	CRB-MH-67	1	0	1	0.00	0.95	0.00	0.52	6.0	6.86	4.59	**2.39**	18	129	0.012	0.000442	0.0052	4.6	**8.2**	3.9	0.54	7.40	1.52	0.85	Q ok
A1-P-205	CRB-MH-67	CMH-1	1	0	1	0.00	0.95	0.00	0.99	6.0	7.40	4.49	**4.45**	18	14	0.012	0.001530	0.0057	4.9	**8.6**	4.8	0.05	7.45	0.75	0.67	Q ok
MSS Network Sta 111+75 to 114+00																										
MSS-P2	MSS-DI2	MSS-DI1	3846	1139	4985	0.11	0.77	0.09	0.09	6.0	0.00	4.77	0.4	15	70	0.012	0.0000	0.005	4.0	4.9	2.4	0.48	6.48	4.03	3.68	Q ok
MSS-P1	MSS-DI1	EXMH	2301	1082	3383	0.08	0.70	0.05	0.14	6.0	6.48	4.67	0.7	15	5	0.012	0.0001	0.003	3.3	4.0	2.3	0.04	6.52	3.39	3.37	Q ok
A1-P-203	EX MH	MH-CRB-67	1	0	1	0.00	0.95	0.00	0.14	6.0	6.52	4.67	**0.67**	18	25	0.012	0.000035	0.0050	4.6	**8.0**	2.7	0.15	6.67	0.92	0.84	Q ok
Jones Street Constructed Under Area 1																										
A1-P-206	CMH-1	A1-DI-207	1	0	1	0.00	0.95	0.00	1.16	6.0	7.45	4.47	**5.17**	24	60	0.012	0.000445	0.0035	4.6	**14.5**	4.2	0.24	7.69	0.57	0.36	Q ok
A1-P-207	A1-DI-207	A1-DI-208	3414	0	3414	0.08	0.95	0.07	1.84	6.0	7.69	4.43	**8.15**	24	82	0.012	0.001105	0.0040	4.9	**15.5**	4.9	0.28	7.97	0.36	0.03	Q ok
A1-P-208	A1-DI-208	A1-DI-209	2490	0	2490	0.06	0.95	0.05	1.89	6.0	7.97	4.37	**8.27**	36	59	0.012	0.000131	0.0041	6.5	**46.1**	4.9	0.20	8.17	0.03	-0.21	Q ok
A1-P-209	A1-DI-209	A1-MH-210	2433	0	2433	0.06	0.95	0.05	2.42	6.0	8.17	4.33	**10.46**	48	54	0.012	0.000045	0.0041	7.9	**99.3**	4.7	0.19	8.36	-0.21	-0.43	Q ok
A1-P-210	A1-MH-210	A1-DI-211	1	0	1	0.00	0.95	0.00	2.47	6.0	8.36	4.29	**10.61**	48	68	0.012	0.000047	0.0040	7.8	**98.1**	4.7	0.24	8.60	-0.43	-0.70	Q ok
A1-P-211	A1-DI-211	A1-DI-212	3353	0	3353	0.08	0.95	0.07	2.86	6.0	8.60	4.25	**12.14**	48	180	0.012	0.000061	0.0040	7.8	**98.4**	4.7	0.64	9.24	-0.70	-1.42	Q ok
A1-P-212	A1-DI-212	A1-DI-213	1885	0	1885	0.04	0.95	0.04	3.58	6.0	9.24	4.13	**14.79**	48	58	0.012	0.000090	0.0040	7.8	**98.0**	5.5	0.18	9.42	-1.42	-1.65	Q ok
A1-P-213	A1-DI-213	A1-DI-214	15288	0	15288	0.35	0.95	0.33	4.58	6.0	9.42	4.09	**18.74**	48	158	0.012	0.000145	0.0040	7.8	**98.3**	5.9	0.45	9.87	-1.65	-2.28	Q ok
A1-P-214	A1-DI-214	A1-DI-215	**1**	0	1	0.00	0.95	0.00	4.93	6.0	9.87	3.99	**19.66**	48	35	0.012	0.000160	0.0040	7.8	**98.4**	5.9	0.10	9.97	-2.28	-2.42	Q ok
A1-P-215	A1-DI-215	A1-MH-216	**1**	0	1	0.00	0.95	0.00	4.93	6.0	9.97	3.97	**19.57**	48	48	0.012	0.000158	0.0040	7.8	**97.9**	5.8	0.14	10.11	-2.42	-2.61	Q ok
MSS-P3 A	MSS-DI14	DI-161	3612	330	3942	0.09	0.89	0.08	0.08	6.0	0.00	4.77	0.4	15	44	0.012	0.0000	0.005	4.0	4.9	2.4	0.30	6.30	4.03	3.81	Q ok
MSS-P3 B	DI-161	MSS-DI13	2062	222	2284	0.05	0.88	0.05	0.13	6.0	6.30	4.71	0.6	15	25	0.012	0.0001	0.005	4.1	5.0	2.4	0.17	6.47	3.81	3.68	Q ok
	DOGHOUSE																									
P-160	DI-160	CMH-1	1768	257	2025	0.05	0.85	0.04	0.04	6.0	0.00	4.77	**0.19**	8	96	0.011	0.000175	0.0200	5.8	**2.0**	3.5	0.46	6.46	2.99	1.07	Q ok
A1 P-200	PARCEL J	A1-DI-207	27861	0	27861	0.64	0.95	0.61	0.61	6.0	0.00	4.77	**2.90**	18	23	0.012	0.000649	0.0100	6.4	11.4	5.3	0.07	6.07	1.59	1.36	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1

County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001

Segment: Jones Street Outfall Storm Frequency: 2 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-336	PARCEL J	A1-DI-209	21549	0	21549	0.49	0.95	0.47	0.47	6.0	0.00	4.77	**2.24**	18	19	0.012	0.000388	0.0100	6.4	11.4	4.8	0.07	6.07	1.48	1.29	Q ok
P-337	PARCEL J	A1-DI-211	14148	0	14148	0.32	0.95	0.31	0.31	6.0	0.00	4.77	**1.47**	18	23	0.012	0.000167	0.0100	6.4	11.4	4.5	0.09	6.09	1.53	1.30	Q ok
P-335	PARCEL N	A1-DI-213	15379	0	15379	0.35	0.95	0.34	0.34	6.0	0.00	4.77	**1.60**	18	56	0.012	0.000198	0.0100	6.4	11.4	4.5	0.21	6.21	1.91	1.35	Q ok
P-340	PARCEL K	A1-DI-213	15267	0	15267	0.35	0.95	0.33	0.33	6.0	0.00	4.77	**1.59**	18	18	0.012	0.000195	0.0100	6.4	11.4	4.5	0.07	6.07	1.53	1.35	Q ok
P-165	DI-165	DI-166	7237	0	7237	0.17	0.95	0.16	0.16	6.0	0.00	4.77	**0.75**	18	28	0.012	0.000044	0.0100	6.4	**11.4**	3.2	0.15	6.15	2.95	2.67	Q ok
P-166	DI-166	DI-167	2265	0	2265	0.05	0.95	0.05	0.21	6.0	6.15	4.75	**0.98**	18	54	0.012	0.000075	0.0100	6.4	**11.4**	3.9	0.23	6.38	2.47	1.93	Q ok
P-167	DI-167	DI-168	3648	0	3648	0.08	0.95	0.08	0.29	6.0	6.38	4.69	**1.35**	24	91	0.012	0.000030	0.0100	7.8	**24.5**	3.8	0.40	6.78	1.73	0.82	Q ok
P-168	DI-168	DI-209	6136	0	6136	0.14	0.95	0.13	0.67	6.0	6.78	4.61	**3.10**	24	33	0.012	0.000160	0.0100	7.8	**24.5**	5.5	0.10	6.88	0.62	0.29	Q ok
P-327	PARCEL L	DI-168	11517	0	11517	0.26	0.95	0.25	0.25	6.0	0.00	4.77	**1.20**	18	19	0.012	0.000111	0.0100	6.4	11.4	3.9	0.08	6.08	1.31	1.12	Q ok
P-326	PARCEL L	DI-170	14378	0	14378	0.33	0.95	0.31	0.31	6.0	0.00	4.77	**1.50**	18	23	0.012	0.000173	0.0100	6.4	11.4	4.5	0.09	6.09	3.99	3.76	Q ok
P-170	DI-170	DI-171	2801	0	2801	0.06	0.95	0.06	0.37	6.0	6.09	4.75	**1.78**	18	68	0.012	0.000245	0.0100	6.4	**11.4**	4.5	0.25	6.34	3.26	2.58	Q ok
P-171	DI-171	DI-173	2811	0	2811	0.06	0.95	0.06	0.44	6.0	6.34	4.71	**2.05**	18	29	0.012	0.000326	0.0100	6.4	**11.4**	4.8	0.10	6.44	2.38	2.09	Q ok
P-173	DI-173	DI-174	2818	0	2818	0.06	0.95	0.06	0.77	6.0	6.44	4.69	**3.59**	24	46	0.012	0.000214	0.0100	7.8	**24.5**	5.5	0.14	6.58	1.89	1.43	Q ok
P-174	DI-174	DI-175	1817	0	1817	0.04	0.95	0.04	0.80	6.0	6.58	4.65	**3.74**	24	44	0.012	0.000233	0.0100	7.8	**24.5**	5.5	0.13	6.71	1.23	0.79	Q ok
P-175	DI-175	DI-211	3620	0	3620	0.08	0.95	0.08	1.17	6.0	6.71	4.63	**5.40**	24	29	0.012	0.000485	0.0100	7.8	**24.5**	5.9	0.08	6.79	0.59	0.30	Q ok
P-331	PARCEL M	DI-175	12913	0	12913	0.30	0.95	0.28	0.28	6.0	0.00	4.77	**1.34**	18	19	0.012	0.000139	0.0100	6.4	11.4	3.9	0.08	6.08	1.28	1.09	Q ok
P-328	PARCEL M	DI-172	9475	0	9475	0.22	0.95	0.21	0.21	6.0	0.00	4.77	**0.99**	18	22	0.012	0.000075	0.0100	6.4	11.4	3.9	0.09	6.09	3.49	3.27	Q ok
P-172	DI-172	DI-173	2798	0	2798	0.06	0.95	0.06	0.27	6.0	6.09	4.75	**1.27**	18	68	0.012	0.000125	0.0100	6.4	**11.4**	3.9	0.29	6.39	2.77	2.09	Q ok
P-169	DI-169	MH-210	2626	0	2626	0.06	0.95	0.06	0.06	6.0	0.00	4.77	**0.27**	18	7	0.012	0.000006	0.0100	6.4	**11.4**	3.2	0.04	6.04	1.64	1.57	Q ok
P-178	DI-178	DI-179	3573	0	3573	0.08	0.95	0.08	0.08	6.0	0.00	4.77	**0.37**	18	39	0.012	0.000011	0.0100	6.4	**11.4**	3.2	0.21	6.21	2.63	2.24	Q ok
P-179	DI-179	DI-180	1913	0	1913	0.04	0.95	0.04	0.12	6.0	0.00	4.77	**0.57**	18	34	0.012	0.000025	0.0100	6.4	**11.4**	3.2	0.18	6.18	2.04	1.70	Q ok
P-180	DI-180	DI-181	1165	0	1165	0.03	0.95	0.03	0.15	6.0	0.00	4.77	**0.69**	18	49	0.012	0.000037	0.0100	6.4	**11.4**	3.2	0.26	6.26	1.50	1.01	Q ok
P-181	DI-181	DI-212	1967	0	1967	0.05	0.95	0.04	0.19	6.0	0.00	4.77	**0.90**	18	23	0.012	0.000062	0.0100	6.4	**11.4**	3.9	0.10	6.10	0.81	0.58	Q ok
P-182	DI-182	DI-186	1887	0	1887	0.04	0.95	0.04	0.04	6.0	0.00	4.77	**0.20**	18	43	0.012	0.000003	0.0100	6.4	**11.4**	3.2	0.23	6.23	4.28	3.85	Q ok
P-338	PARCEL J	DI-185	10195	0	10195	0.23	0.95	0.22	0.22	6.0	0.00	4.77	**1.06**	18	23	0.012	0.000087	0.0100	6.4	11.4	3.9	0.10	6.10	3.86	3.63	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 2 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-183	DI-183	DI-184	2436	0	2436	0.06	0.95	0.05	0.05	6.0	0.00	4.77	**0.25**	18	59	0.012	0.000005	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.74	4.15	Q ok
P-184	DI-184	DI-185	2508	0	2508	0.06	0.95	0.05	0.11	6.0	0.00	4.77	**0.51**	18	62	0.012	0.000020	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.95	3.33	Q ok
P-185	DI-185	DI-186	3002	0	3002	0.07	0.95	0.07	0.40	6.0	0.00	4.77	**1.89**	18	108	0.012	0.000275	0.0100	6.4	**11.4**	4.5	0.40	6.40	3.13	2.05	Q ok
P-186	DI-186	DI-190	1354	0	1354	0.03	0.95	0.03	0.47	6.0	0.00	4.77	**2.22**	18	27	0.012	0.000382	0.0100	6.4	**11.4**	4.8	0.09	6.09	1.85	1.58	Q ok
check San x-ing																										
P-339	PARCEL K	DI-189	12930	0	12930	0.30	0.95	0.28	0.28	6.0	0.00	4.77	**1.35**	18	23	0.012	0.000140	0.0100	6.4	11.4	3.9	0.10	6.10	3.20	2.97	Q ok
P-187	DI-187	DI-188	2448	0	2448	0.06	0.95	0.05	0.05	6.0	0.00	4.77	**0.25**	18	59	0.012	0.000005	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.08	3.49	Q ok
P-188	DI-188	DI-189	2550	0	2550	0.06	0.95	0.06	0.11	6.0	0.00	4.77	**0.52**	18	62	0.012	0.000021	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.29	2.67	Q ok
P-189	DI-189	DI-190	3025	0	3025	0.07	0.95	0.07	0.46	6.0	0.00	4.77	**2.18**	18	119	0.012	0.000367	0.0100	6.4	**11.4**	4.8	0.41	6.41	2.47	1.28	Q ok
P-190	DI-190	DI-191	1765	0	1765	0.04	0.95	0.04	0.50	6.0	0.00	4.77	**2.36**	18	50	0.012	0.000431	0.0100	6.4	**11.4**	4.8	0.17	6.17	1.08	0.58	Q ok
P-341	PARCEL K	DI-195	13999	0	13999	0.32	0.95	0.31	0.31	6.0	0.00	4.77	**1.46**	18	53	0.012	0.000164	0.0100	6.4	11.4	4.5	0.20	6.20	3.96	3.43	Q ok
P-195	DI-195	A1-DI-214	**1887**	0	1887	0.04	0.95	0.04	0.35	6.0	6.20	4.73	**1.64**	18	43	0.012	0.000207	0.0100	6.4	**11.4**	4.5	0.16	6.35	2.43	2.00	Q ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	3.77	3.77	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.77	5.76	HGL ok
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	3.69	3.69	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	3.77	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	3.77	3.77	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.78	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	3.76	3.76	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.76	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	3.76	3.76	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	3.76	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	4.00	4.00	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	4.07	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	3.99	3.99	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.00	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	3.82	3.82	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	3.99	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	3.76	3.76	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	3.82	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	3.69	3.69	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	3.76	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	3.64	3.64	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	3.69	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.38	4.68	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	3.69	4.37	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	4.38	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	3.69	3.69	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	3.69	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	3.59	3.59	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	3.64	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.45	3.45	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	3.59	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.39	3.39	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	3.45	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.38	3.38	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	3.39	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.37	3.37	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	3.38	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.31	3.31	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	3.37	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.29	3.29	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	3.31	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.25	3.25	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	3.29	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.22	3.22	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	3.25	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.20**	**3.20**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**3.22**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	3.64	4.81	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.81	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	3.59	4.68	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	3.64	3.64	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	3.66	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	3.59	3.59	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.61	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.39	3.39	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.40	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.37	3.37	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.37	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.29	3.29	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.30	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.29	3.29	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.29	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.42	3.87	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.87	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.42	3.42	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	3.42	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.41	3.41	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	3.42	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.39	3.39	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	3.41	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.41	3.41	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.41	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	3.82	4.96	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	3.56	3.78	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	3.82	10.79	HGL ok
P-171	DI-171	DI-173	1.20	3.52	3.52	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	3.56	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.48	3.48	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	3.52	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.44	3.44	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	3.48	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.37	3.37	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	3.44	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.44	3.44	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.45	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	3.54	4.47	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.47	10.00	HGL ok
P-172	DI-172	DI-173	1.20	3.52	3.52	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	3.54	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.38	3.38	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.38	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.32	3.44	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.44	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.31	3.31	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	3.32	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.31	3.31	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	3.31	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.31	3.31	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	3.31	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.40	5.05	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.44	4.83	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.83	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.44	4.53	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.40	3.40	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	3.44	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.36	3.36	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	3.40	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.42	4.17	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.17	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.87	4.69	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.42	3.87	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.87	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.36	3.36	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	3.42	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.31	3.31	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	3.36	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.28	4.63	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.64	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.25	3.25	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	3.28	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	3.97	3.97	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.97	5.76	HGL ok
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	3.89	3.89	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	3.97	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	3.97	3.97	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.98	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	3.96	3.96	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.96	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	3.96	3.96	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	3.96	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	4.20	4.20	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	4.27	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	4.19	4.19	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.20	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	4.02	4.02	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	4.19	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	3.96	3.96	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	4.02	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	3.89	3.89	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	3.96	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	3.84	3.84	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	3.89	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.38	4.68	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	3.89	4.37	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	4.38	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	3.89	3.89	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	3.89	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	3.79	3.79	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	3.84	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.65	3.65	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	3.79	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.59	3.59	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	3.65	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.58	3.58	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	3.59	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.57	3.57	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	3.58	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.51	3.51	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	3.57	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.49	3.49	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	3.51	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.45	3.45	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	3.49	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.42	3.42	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	3.45	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.40**	**3.40**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**3.42**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	3.84	4.81	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.81	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	3.79	4.68	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	3.84	3.84	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	3.86	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	3.79	3.79	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.81	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.59	3.59	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.60	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.57	3.57	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.57	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.49	3.49	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.50	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.49	3.49	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.49	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.62	3.87	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.87	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.62	3.62	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	3.62	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.61	3.61	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	3.62	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.59	3.59	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	3.61	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.61	3.61	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.61	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	3.82	4.96	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	3.76	3.78	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	3.82	10.79	HGL ok
P-171	DI-171	DI-173	1.20	3.72	3.72	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	3.76	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.68	3.68	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	3.72	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.64	3.64	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	3.68	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.57	3.57	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	3.64	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.64	3.64	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	3.65	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	3.74	4.47	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.47	10.00	HGL ok
P-172	DI-172	DI-173	1.20	3.72	3.72	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	3.74	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.58	3.58	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.58	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.52	3.52	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.52	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.51	3.51	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	3.52	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.51	3.51	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	3.51	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.51	3.51	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	3.51	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.60	5.05	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.64	4.83	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.83	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.64	4.53	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.60	3.60	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	3.64	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.56	3.56	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	3.60	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.62	4.17	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.17	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.87	4.69	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.62	3.87	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.87	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.56	3.56	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	3.62	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.51	3.51	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	3.56	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.48	4.63	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.64	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.45	3.45	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	3.48	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.47	7.47	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.47	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.39	7.39	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	7.47	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.47	7.47	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.48	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.46	7.46	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.46	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.46	7.46	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	7.46	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	7.70	7.70	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	7.77	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	7.69	7.69	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.70	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.52	7.52	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	7.69	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.46	7.46	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	7.52	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.39	7.39	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	7.46	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.34	7.34	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	7.39	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.40	7.40	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.40	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.39	7.39	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	7.40	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.39	7.39	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	7.39	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.29	7.29	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	7.34	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.15	7.15	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	7.29	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.09	7.09	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	7.15	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.08	7.08	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	7.09	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.07	7.07	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	7.08	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.01	7.01	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	7.07	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.99	6.99	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	7.01	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	6.95	6.95	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	6.99	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.92	6.92	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	6.95	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**6.90**	**6.90**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**6.92**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.34	7.34	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.34	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.29	7.29	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.29	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.34	7.34	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.36	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.29	7.29	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.31	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.09	7.09	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.10	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.07	7.07	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.07	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.99	6.99	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.00	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.99	6.99	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.99	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.12	7.12	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.12	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.12	7.12	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	7.12	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.11	7.11	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	7.12	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.09	7.09	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	7.11	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.11	7.11	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.11	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.30	7.30	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.30	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.26	7.26	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	7.30	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.22	7.22	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	7.26	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.18	7.18	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	7.22	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.14	7.14	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	7.18	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.07	7.07	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	7.14	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.14	7.14	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.15	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.24	7.24	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.24	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.22	7.22	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	7.24	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.08	7.08	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.08	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.02	7.02	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.02	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.01	7.01	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	7.02	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.01	7.01	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	7.01	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.01	7.01	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	7.01	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.10	7.10	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.10	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.14	7.14	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.14	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.14	7.14	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.14	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.14	7.14	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.14	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.10	7.10	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	7.14	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.06	7.06	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	7.10	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.12	7.12	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.12	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.12	7.12	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.12	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.12	7.12	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.12	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.06	7.06	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	7.12	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.01	7.01	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	7.06	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.98	6.98	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.99	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	6.95	6.95	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	6.98	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.97	7.97	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.97	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.89	7.89	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	7.97	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.97	7.97	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.98	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.96	7.96	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.96	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.96	7.96	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	7.96	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.20	8.20	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	8.27	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.19	8.19	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.20	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.02	8.02	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	8.19	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.96	7.96	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	8.02	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.89	7.89	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	7.96	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.84	7.84	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	7.89	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.90	7.90	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.90	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.89	7.89	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	7.90	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.89	7.89	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	7.89	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.79	7.79	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	7.84	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.65	7.65	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	7.79	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.59	7.59	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	7.65	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.58	7.58	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	7.59	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.57	7.57	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	7.58	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.51	7.51	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	7.57	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.49	7.49	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	7.51	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.45	7.45	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	7.49	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.42	7.42	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	7.45	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.40**	**7.40**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**7.42**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.84	7.84	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.84	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.79	7.79	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	7.79	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.84	7.84	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.86	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.79	7.79	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.81	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.59	7.59	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.60	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.57	7.57	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.57	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.49	7.49	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.50	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.49	7.49	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.49	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.62	7.62	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.62	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.62	7.62	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	7.62	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.61	7.61	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	7.62	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.59	7.59	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	7.61	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.61	7.61	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.61	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.80	7.80	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.80	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.76	7.76	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	7.80	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.72	7.72	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	7.76	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.68	7.68	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	7.72	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.64	7.64	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	7.68	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.57	7.57	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	7.64	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.64	7.64	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.65	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.74	7.74	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.74	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.72	7.72	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	7.74	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.58	7.58	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.58	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.52	7.52	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.52	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.51	7.51	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	7.52	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.51	7.51	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	7.51	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.51	7.51	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	7.51	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.60	7.60	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.60	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.64	7.64	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.64	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.64	7.64	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.64	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.64	7.64	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.64	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.60	7.60	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	7.64	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.56	7.56	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	7.60	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.62	7.62	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.62	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.62	7.62	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.62	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.62	7.62	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.62	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.56	7.56	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	7.62	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.51	7.51	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	7.56	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.48	7.48	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.49	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.45	7.45	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	7.48	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.37	8.37	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.37	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.29	8.29	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	8.37	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.37	8.37	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.38	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.36	8.36	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.36	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.36	8.36	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	8.36	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.60	8.60	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	8.67	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.59	8.59	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.60	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.42	8.42	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	8.59	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.36	8.36	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	8.42	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.29	8.29	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	8.36	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.24	8.24	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	8.29	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.30	8.30	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.30	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.29	8.29	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	8.30	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.29	8.29	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	8.29	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.19	8.19	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	8.24	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.05	8.05	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	8.19	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.99	7.99	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	8.05	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.98	7.98	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	7.99	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.97	7.97	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	7.98	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.91	7.91	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	7.97	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.89	7.89	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	7.91	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.85	7.85	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	7.89	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.82	7.82	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	7.85	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.80**	**7.80**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**7.82**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.24	8.24	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.24	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.19	8.19	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	8.19	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.24	8.24	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.26	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.19	8.19	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.21	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.99	7.99	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.00	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.97	7.97	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.97	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.89	7.89	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.90	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.89	7.89	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.89	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.02	8.02	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.02	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.02	8.02	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.02	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.01	8.01	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.02	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.99	7.99	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	8.01	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.01	8.01	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.01	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.20	8.20	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.20	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.16	8.16	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	8.20	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.12	8.12	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	8.16	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.08	8.08	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	8.12	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.04	8.04	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	8.08	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.97	7.97	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	8.04	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.04	8.04	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.05	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.14	8.14	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.14	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.12	8.12	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	8.14	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.98	7.98	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.98	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.92	7.92	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.92	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.91	7.91	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	7.92	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.91	7.91	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	7.91	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.91	7.91	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	7.91	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.00	8.00	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.00	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.04	8.04	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.04	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.04	8.04	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.04	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.04	8.04	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.04	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.00	8.00	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	8.04	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.96	7.96	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	8.00	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.02	8.02	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.02	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.02	8.02	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.02	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.02	8.02	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.02	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.96	7.96	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	8.02	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.91	7.91	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	7.96	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.88	7.88	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.89	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.85	7.85	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	7.88	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.87	8.87	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.87	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.79	8.79	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	8.87	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.87	8.87	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.88	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.86	8.86	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.86	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.86	8.86	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	8.86	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.10	9.10	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	9.17	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.09	9.09	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.10	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.92	8.92	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	9.09	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.86	8.86	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	8.92	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.79	8.79	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	8.86	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.74	8.74	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	8.79	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.80	8.80	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.80	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.79	8.79	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	8.80	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.79	8.79	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	8.79	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.69	8.69	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	8.74	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.55	8.55	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	8.69	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.49	8.49	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	8.55	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.48	8.48	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	8.49	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.47	8.47	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	8.48	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.41	8.41	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	8.47	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.39	8.39	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	8.41	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	8.35	8.35	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	8.39	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	8.32	8.32	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	8.35	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**8.30**	**8.30**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**8.32**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.74	8.74	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.74	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.69	8.69	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	8.69	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.74	8.74	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.76	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.69	8.69	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.71	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	8.49	8.49	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.50	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.47	8.47	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.47	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.39	8.39	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.40	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.39	8.39	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.39	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.52	8.52	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.52	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.52	8.52	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.52	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.51	8.51	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.52	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.49	8.49	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	8.51	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.51	8.51	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.51	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.70	8.70	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.70	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.66	8.66	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	8.70	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.62	8.62	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	8.66	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.58	8.58	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	8.62	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.54	8.54	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	8.58	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.47	8.47	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	8.54	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.54	8.54	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.55	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.64	8.64	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.64	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.62	8.62	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	8.64	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.48	8.48	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.48	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.42	8.42	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.42	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.41	8.41	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	8.42	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.41	8.41	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	8.41	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.41	8.41	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	8.41	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.50	8.50	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.50	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.54	8.54	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.54	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.54	8.54	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.54	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.54	8.54	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.54	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.50	8.50	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	8.54	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.46	8.46	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	8.50	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.52	8.52	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.52	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.52	8.52	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.52	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.52	8.52	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.52	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.46	8.46	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	8.52	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.41	8.41	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	8.46	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.38	8.38	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.39	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	8.35	8.35	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	8.38	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.57	9.57	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.57	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.49	9.49	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	9.57	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.57	9.57	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.58	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.56	9.56	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.56	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.56	9.56	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	9.56	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.80	9.80	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	9.87	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.79	9.79	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.80	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.62	9.62	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	9.79	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.56	9.56	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	9.62	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.49	9.49	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	9.56	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.44	9.44	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	9.49	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.50	9.50	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.50	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.49	9.49	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	9.50	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.49	9.49	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	9.49	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.39	9.39	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	9.44	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.25	9.25	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	9.39	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.19	9.19	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	9.25	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.18	9.18	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	9.19	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.17	9.17	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	9.18	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.11	9.11	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	9.17	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.09	9.09	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	9.11	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.05	9.05	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	9.09	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.02	9.02	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	9.05	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.00**	**9.00**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**9.02**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.44	9.44	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.44	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.39	9.39	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.39	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.44	9.44	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.46	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.39	9.39	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.41	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.19	9.19	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.20	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.17	9.17	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.17	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.09	9.09	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.10	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.09	9.09	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.09	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.22	9.22	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.22	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.22	9.22	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.22	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.21	9.21	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.22	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.19	9.19	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	9.21	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.21	9.21	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.21	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	9.40	9.40	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.40	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.36	9.36	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	9.40	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.32	9.32	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	9.36	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.28	9.28	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	9.32	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.24	9.24	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	9.28	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.17	9.17	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	9.24	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.24	9.24	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.25	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.34	9.34	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.34	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.32	9.32	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	9.34	10.79	HGL ok
P-169	DI-169	MH-210	1.20	9.18	9.18	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.18	10.25	HGL ok
P-178	DI-178	DI-179	1.20	9.12	9.12	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.12	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.11	9.11	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	9.12	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.11	9.11	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	9.11	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.11	9.11	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	9.11	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.20	9.20	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.20	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.24	9.24	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.24	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.24	9.24	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.24	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.24	9.24	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.24	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.20	9.20	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	9.24	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.16	9.16	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	9.20	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.22	9.22	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.22	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.22	9.22	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.22	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.22	9.22	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.22	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.16	9.16	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	9.22	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.11	9.11	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	9.16	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.08	9.08	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.09	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.05	9.05	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	9.08	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.07	10.07	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.07	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.99	9.99	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	*0.5*	0.01	0.08	10.07	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.07	10.07	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.08	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.06	10.06	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.06	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.06	10.06	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	*0.5*	0.00	0.00	10.06	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.30	10.30	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	10.37	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.29	10.29	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.30	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.12	10.12	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	*1.3*	1.0	0.06	0.17	10.29	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.06	10.06	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	*0.5*	0.05	0.06	10.12	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.99	9.99	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	*0.5*	0.01	0.07	10.06	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.94	9.94	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	*0.5*	0.03	0.05	9.99	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.00	10.00	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.00	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.99	9.99	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	*1.3*	1.0	0.00	0.00	10.00	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.99	9.99	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	*0.5*	0.00	0.00	9.99	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.89	9.89	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	*0.5*	0.03	0.05	9.94	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.75	9.75	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	9.89	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.69	9.69	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	9.75	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.68	9.68	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	9.69	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.67	9.67	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	*0.5*	0.00	0.01	9.68	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.61	9.61	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	9.67	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.59	9.59	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	9.61	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.55	9.55	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	9.59	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.52	9.52	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	9.55	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.50**	**9.50**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	*0.5*	**0.01**	**0.02**	**9.52**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.94	9.94	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.94	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.89	9.89	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	*1.3*	1.0	0.00	0.00	9.89	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.94	9.94	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.96	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.89	9.89	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.01	0.02	9.91	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.69	9.69	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	9.70	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.67	9.67	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	9.67	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.59	9.59	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	9.60	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.59	9.59	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	9.59	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.72	9.72	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.72	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.72	9.72	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	*1.3*	1.0	0.00	0.01	9.72	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.71	9.71	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	*1.3*	1.0	0.00	0.01	9.72	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
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Date: 2/23/23
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-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.69	9.69	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	9.71	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.71	9.71	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.71	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	9.90	9.90	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.90	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.86	9.86	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	9.90	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	9.82	9.82	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	9.86	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.78	9.78	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	9.82	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.74	9.74	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	9.78	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.67	9.67	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	9.74	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.74	9.74	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.75	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.84	9.84	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.84	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.82	9.82	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	9.84	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.68	9.68	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.68	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.62	9.62	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.62	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.61	9.61	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	9.62	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.61	9.61	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	9.61	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.61	9.61	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	9.61	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.70	9.70	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.70	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.74	9.74	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.74	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.74	9.74	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.74	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.74	9.74	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.74	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.70	9.70	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	9.74	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.66	9.66	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	9.70	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.72	9.72	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.72	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.72	9.72	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.72	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.72	9.72	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.72	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.66	9.66	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	9.72	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.61	9.61	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	9.66	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.58	9.58	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.59	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.55	9.55	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	9.58	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.37	11.37	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.37	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.29	11.29	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	11.37	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.37	11.37	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.38	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.36	11.36	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.36	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.36	11.36	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.36	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.60	11.60	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	11.67	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.59	11.59	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.60	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.42	11.42	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	11.59	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.36	11.36	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	11.42	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.29	11.29	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	11.36	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.24	11.24	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	11.29	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.30	11.30	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.30	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.29	11.29	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	11.30	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.29	11.29	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	11.29	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.19	11.19	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	11.24	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.05	11.05	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	11.19	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.99	10.99	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	11.05	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.98	10.98	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	10.99	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.97	10.97	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	10.98	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.91	10.91	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	10.97	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.89	10.89	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	10.91	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.85	10.85	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	10.89	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.82	10.82	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	10.85	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.80**	**10.80**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**10.82**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.24	11.24	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.24	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.19	11.19	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	11.19	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.24	11.24	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.26	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.19	11.19	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.21	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.99	10.99	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.00	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.97	10.97	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.97	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.89	10.89	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.90	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.89	10.89	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.89	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.02	11.02	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.02	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.02	11.02	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.02	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.01	11.01	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.02	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.99	10.99	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	11.01	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.01	11.01	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.01	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.20	11.20	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.20	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.16	11.16	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	11.20	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.12	11.12	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	11.16	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.08	11.08	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	11.12	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.04	11.04	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	11.08	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.97	10.97	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	11.04	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.04	11.04	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.05	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.14	11.14	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.14	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.12	11.12	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	11.14	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.98	10.98	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.98	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.92	10.92	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.92	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	10.91	10.91	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.92	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	10.91	10.91	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	10.91	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	10.91	10.91	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	10.91	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.00	11.00	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.00	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	11.04	11.04	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.04	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.04	11.04	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.04	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.04	11.04	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.04	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.00	11.00	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	11.04	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.96	10.96	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	11.00	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.02	11.02	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.02	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.02	11.02	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.02	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.02	11.02	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.02	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	10.96	10.96	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	11.02	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.91	10.91	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	10.96	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.88	10.88	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.89	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.85	10.85	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	10.88	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	6.31	6.31	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.31	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	6.23	6.23	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	6.31	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	6.31	6.31	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.32	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	6.30	6.30	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.30	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	6.30	6.30	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	6.30	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	6.54	6.54	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	6.61	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	6.53	6.53	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.54	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	6.36	6.36	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	6.53	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	6.30	6.30	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	6.36	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	6.23	6.23	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	6.30	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	6.18	6.18	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	6.23	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	6.24	6.24	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.24	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	6.23	6.23	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	6.24	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	6.23	6.23	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	6.23	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.13	6.13	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	6.18	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	5.99	5.99	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	6.13	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	5.93	5.93	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	5.99	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	5.92	5.92	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	5.93	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	5.91	5.91	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	5.92	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	5.85	5.85	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	5.91	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	5.83	5.83	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	5.85	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.79	5.79	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	5.83	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.76	5.76	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	5.79	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.74**	**5.74**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**5.76**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.18	6.18	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.18	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.13	6.13	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	6.13	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.18	6.18	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	6.20	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.13	6.13	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.15	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	5.93	5.93	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	5.94	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	5.91	5.91	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	5.91	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	5.83	5.83	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	5.84	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	5.83	5.83	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	5.83	10.00	HGL ok
P-165	DI-165	DI-166	1.20	5.96	5.96	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.96	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	5.96	5.96	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	5.96	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	5.95	5.95	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	5.96	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	5.93	5.93	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	5.95	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	5.95	5.95	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.95	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.14	6.14	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.14	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.10	6.10	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	6.14	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.06	6.06	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	6.10	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.02	6.02	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	6.06	10.30	HGL ok
P-174	DI-174	DI-175	1.60	5.98	5.98	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	6.02	11.19	HGL ok
P-175	DI-175	DI-211	1.60	5.91	5.91	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	5.98	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	5.98	5.98	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.99	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.08	6.08	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.08	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.06	6.06	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	6.08	10.79	HGL ok
P-169	DI-169	MH-210	1.20	5.92	5.92	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.92	10.25	HGL ok
P-178	DI-178	DI-179	1.20	5.86	5.86	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.86	11.90	HGL ok
P-179	DI-179	DI-180	1.20	5.85	5.85	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	5.86	11.68	HGL ok
P-180	DI-180	DI-181	1.20	5.85	5.85	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	5.85	11.68	HGL ok
P-181	DI-181	DI-212	1.20	5.85	5.85	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	5.85	11.82	HGL ok
P-182	DI-182	DI-186	1.20	5.94	5.94	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.94	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	5.98	5.98	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.98	10.00	HGL ok
P-183	DI-183	DI-184	1.20	5.98	5.98	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.98	11.58	HGL ok
P-184	DI-184	DI-185	1.20	5.98	5.98	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	5.98	11.91	HGL ok
P-185	DI-185	DI-186	1.20	5.94	5.94	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	5.98	12.23	HGL ok
P-186	DI-186	DI-190	1.20	5.90	5.90	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	5.94	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	5.96	5.96	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.96	10.00	HGL ok
P-187	DI-187	DI-188	1.20	5.96	5.96	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.96	11.58	HGL ok
P-188	DI-188	DI-189	1.20	5.96	5.96	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	5.96	11.91	HGL ok
P-189	DI-189	DI-190	1.20	5.90	5.90	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	5.96	12.23	HGL ok
P-190	DI-190	DI-191	1.20	5.85	5.85	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	5.90	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	5.82	5.82	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	5.83	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.79	5.79	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	5.82	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	6.51	6.51	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.51	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	6.43	6.43	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	6.51	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	6.51	6.51	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.52	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	6.50	6.50	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.50	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	6.50	6.50	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	6.50	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	6.74	6.74	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	6.81	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	6.73	6.73	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.74	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	6.56	6.56	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	6.73	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	6.50	6.50	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	6.56	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	6.43	6.43	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	6.50	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	6.38	6.38	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	6.43	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	6.44	6.44	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.44	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	6.43	6.43	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	6.44	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	6.43	6.43	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	6.43	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.33	6.33	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	6.38	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.19	6.19	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	6.33	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.13	6.13	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	6.19	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.12	6.12	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	6.13	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.11	6.11	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	6.12	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.05	6.05	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	6.11	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.03	6.03	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	6.05	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.99	5.99	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	6.03	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.96	5.96	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	5.99	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.94**	**5.94**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**5.96**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.38	6.38	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.38	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.33	6.33	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	6.33	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.38	6.38	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	6.40	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.33	6.33	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.35	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.13	6.13	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.14	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.11	6.11	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.11	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.03	6.03	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.04	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.03	6.03	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.03	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.16	6.16	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.16	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.16	6.16	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	6.16	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.15	6.15	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	6.16	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.13	6.13	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	6.15	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.15	6.15	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.15	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.34	6.34	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.34	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.30	6.30	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	6.34	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.26	6.26	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	6.30	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.22	6.22	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	6.26	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.18	6.18	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	6.22	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.11	6.11	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	6.18	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.18	6.18	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.19	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.28	6.28	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.28	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.26	6.26	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	6.28	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.12	6.12	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.12	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.06	6.06	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.06	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.05	6.05	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	6.06	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.05	6.05	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	6.05	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.05	6.05	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	6.05	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.14	6.14	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.14	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.18	6.18	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.18	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.18	6.18	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.18	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.18	6.18	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	6.18	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.14	6.14	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	6.18	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.10	6.10	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	6.14	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.16	6.16	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.16	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.16	6.16	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.16	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.16	6.16	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	6.16	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.10	6.10	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	6.16	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.05	6.05	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	6.10	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.02	6.02	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.03	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.99	5.99	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	6.02	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.01	10.01	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.01	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.93	9.93	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	10.01	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.01	10.01	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.02	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.00	10.00	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.00	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.00	10.00	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.00	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.24	10.24	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	10.31	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.23	10.23	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.24	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.06	10.06	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	10.23	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.00	10.00	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	10.06	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.93	9.93	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	10.00	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.88	9.88	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	9.93	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.94	9.94	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.94	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.93	9.93	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	9.94	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.93	9.93	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	9.93	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.83	9.83	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	9.88	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.69	9.69	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	9.83	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.63	9.63	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	9.69	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.62	9.62	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	9.63	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.61	9.61	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	9.62	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.55	9.55	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	9.61	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.53	9.53	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	9.55	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.49	9.49	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	9.53	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.46	9.46	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	9.49	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.44**	**9.44**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**9.46**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.88	9.88	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.88	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.83	9.83	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	9.83	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.88	9.88	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.90	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.83	9.83	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.85	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.63	9.63	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.64	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.61	9.61	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.61	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.53	9.53	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.54	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.53	9.53	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.53	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.66	9.66	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.66	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.66	9.66	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.66	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.65	9.65	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.66	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.63	9.63	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	9.65	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.65	9.65	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.65	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	9.84	9.84	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.84	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.80	9.80	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	9.84	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	9.76	9.76	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	9.80	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.72	9.72	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	9.76	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.68	9.68	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	9.72	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.61	9.61	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	9.68	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.68	9.68	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.69	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.78	9.78	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.78	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.76	9.76	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	9.78	10.79	HGL ok
P-169	DI-169	MH-210	1.20	9.62	9.62	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.62	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.56	9.56	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.56	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.55	9.55	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	9.56	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.55	9.55	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	9.55	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.55	9.55	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	9.55	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.64	9.64	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.64	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.68	9.68	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.68	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.68	9.68	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.68	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.68	9.68	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.68	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.64	9.64	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	9.68	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.60	9.60	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	9.64	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.66	9.66	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.66	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.66	9.66	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.66	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.66	9.66	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.66	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.60	9.60	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	9.66	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.55	9.55	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	9.60	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.52	9.52	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.53	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.49	9.49	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	9.52	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.51	10.51	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.51	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.43	10.43	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	10.51	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.51	10.51	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.52	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.50	10.50	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.50	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.50	10.50	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.50	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.74	10.74	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	10.81	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.73	10.73	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.74	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.56	10.56	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	10.73	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.50	10.50	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	10.56	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.43	10.43	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	10.50	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.38	10.38	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	10.43	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.44	10.44	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.44	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.43	10.43	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	10.44	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.43	10.43	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	10.43	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.33	10.33	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	10.38	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.19	10.19	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	10.33	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.13	10.13	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	10.19	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.12	10.12	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	10.13	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.11	10.11	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	10.12	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.05	10.05	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	10.11	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.03	10.03	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	10.05	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.99	9.99	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	10.03	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.96	9.96	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	9.99	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.94**	**9.94**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**9.96**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.38	10.38	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.38	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.33	10.33	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.33	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.38	10.38	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.40	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.33	10.33	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.35	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.13	10.13	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.14	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.11	10.11	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.11	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.03	10.03	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.04	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.03	10.03	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.03	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.16	10.16	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.16	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.16	10.16	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.16	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.15	10.15	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.16	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.13	10.13	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	10.15	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.15	10.15	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.15	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.34	10.34	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.34	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.30	10.30	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	10.34	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.26	10.26	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	10.30	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.22	10.22	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	10.26	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.18	10.18	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	10.22	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.11	10.11	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	10.18	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.18	10.18	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.19	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.28	10.28	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.28	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.26	10.26	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	10.28	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.12	10.12	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.12	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.06	10.06	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.06	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.05	10.05	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.06	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.05	10.05	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	10.05	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.05	10.05	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	10.05	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.14	10.14	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.14	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.18	10.18	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.18	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.18	10.18	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.18	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.18	10.18	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.18	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.14	10.14	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	10.18	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.10	10.10	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	10.14	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.16	10.16	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.16	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.16	10.16	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.16	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.16	10.16	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.16	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.10	10.10	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	10.16	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.05	10.05	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	10.10	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.02	10.02	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.03	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.99	9.99	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	10.02	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.91	10.91	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.91	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.83	10.83	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	10.91	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.91	10.91	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.92	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.90	10.90	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.90	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.90	10.90	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.90	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.14	11.14	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	11.21	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.13	11.13	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.14	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.96	10.96	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	11.13	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.90	10.90	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	10.96	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.83	10.83	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	10.90	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.78	10.78	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	10.83	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.84	10.84	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.84	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.83	10.83	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	10.84	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.83	10.83	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	10.83	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.73	10.73	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	10.78	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.59	10.59	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	10.73	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.53	10.53	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	10.59	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.52	10.52	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	10.53	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.51	10.51	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	10.52	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.45	10.45	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	10.51	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.43	10.43	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	10.45	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.39	10.39	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	10.43	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.36	10.36	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	10.39	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.34**	**10.34**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**10.36**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.78	10.78	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.78	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.73	10.73	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	10.73	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.78	10.78	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.80	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.73	10.73	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.75	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.53	10.53	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.54	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.51	10.51	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.51	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.43	10.43	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.44	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.43	10.43	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.43	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.56	10.56	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.56	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.56	10.56	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.56	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.55	10.55	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.56	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.53	10.53	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	10.55	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.55	10.55	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.55	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.74	10.74	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.74	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.70	10.70	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	10.74	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.66	10.66	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	10.70	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.62	10.62	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	10.66	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.58	10.58	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	10.62	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.51	10.51	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	10.58	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.58	10.58	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.59	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.68	10.68	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.68	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.66	10.66	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	10.68	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.52	10.52	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.52	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.46	10.46	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.46	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.45	10.45	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.46	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.45	10.45	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	10.45	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.45	10.45	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	10.45	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.54	10.54	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.54	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.58	10.58	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.58	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.58	10.58	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.58	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	10.58	10.58	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.58	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.54	10.54	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	10.58	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.50	10.50	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	10.54	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.56	10.56	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.56	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.56	10.56	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.56	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.56	10.56	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.56	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.50	10.50	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	10.56	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.45	10.45	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	10.50	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.42	10.42	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.43	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.39	10.39	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	10.42	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.41	11.41	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.41	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.33	11.33	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	11.41	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.41	11.41	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.42	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.40	11.40	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.40	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.40	11.40	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.40	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.64	11.64	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	11.71	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.63	11.63	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.64	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.46	11.46	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	11.63	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.40	11.40	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	11.46	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.33	11.33	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	11.40	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.28	11.28	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	11.33	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.34	11.34	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.34	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.33	11.33	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	11.34	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.33	11.33	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	11.33	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.23	11.23	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	11.28	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.09	11.09	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	11.23	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.03	11.03	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	11.09	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.02	11.02	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	11.03	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.01	11.01	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	11.02	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.95	10.95	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	11.01	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.93	10.93	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	10.95	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.89	10.89	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	10.93	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.86	10.86	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	10.89	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.84**	**10.84**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**10.86**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.28	11.28	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.28	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.23	11.23	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	11.23	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.28	11.28	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.30	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.23	11.23	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.25	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.03	11.03	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.04	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.01	11.01	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.01	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.93	10.93	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.94	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.93	10.93	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.93	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.06	11.06	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.06	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.06	11.06	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.06	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.05	11.05	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.06	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.03	11.03	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	11.05	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.05	11.05	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.05	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.24	11.24	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.24	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.20	11.20	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	11.24	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.16	11.16	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	11.20	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.12	11.12	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	11.16	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.08	11.08	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	11.12	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.01	11.01	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	11.08	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.08	11.08	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.09	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.18	11.18	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.18	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.16	11.16	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	11.18	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.02	11.02	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.02	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.96	10.96	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.96	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	10.95	10.95	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.96	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	10.95	10.95	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	10.95	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	10.95	10.95	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	10.95	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.04	11.04	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.04	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	11.08	11.08	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.08	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.08	11.08	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.08	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.08	11.08	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.08	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.04	11.04	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	11.08	12.23	HGL ok
P-186	DI-186	DI-190	1.20	11.00	11.00	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	11.04	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.06	11.06	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.06	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.06	11.06	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.06	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.06	11.06	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.06	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.00	11.00	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	11.06	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.95	10.95	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	11.00	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.92	10.92	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.93	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.89	10.89	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	10.92	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.11	12.11	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.11	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.03	12.03	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	12.11	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.11	12.11	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.12	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.10	12.10	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.10	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.10	12.10	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	12.10	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.34	12.34	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	12.41	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.33	12.33	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.34	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.16	12.16	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	12.33	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.10	12.10	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	12.16	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.03	12.03	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	12.10	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.98	11.98	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	12.03	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.04	12.04	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.04	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.03	12.03	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	12.04	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.03	12.03	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	12.03	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.93	11.93	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	11.98	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.79	11.79	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	11.93	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.73	11.73	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	11.79	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.72	11.72	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	11.73	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.71	11.71	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	11.72	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.65	11.65	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	11.71	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.63	11.63	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	11.65	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.59	11.59	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	11.63	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	11.56	11.56	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	11.59	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**11.54**	**11.54**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**11.56**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.98	11.98	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.98	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.93	11.93	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	11.93	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.98	11.98	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.00	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.93	11.93	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.95	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.73	11.73	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.74	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.71	11.71	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.71	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.63	11.63	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.64	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.63	11.63	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.63	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.76	11.76	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.76	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.76	11.76	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.76	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.75	11.75	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.76	7.12	HGL Too High!

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Hydraulic Grade Line Computations

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County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.73	11.73	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	11.75	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.75	11.75	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.75	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.94	11.94	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.94	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.90	11.90	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	11.94	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.86	11.86	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	11.90	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.82	11.82	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	11.86	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.78	11.78	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	11.82	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.71	11.71	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	11.78	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.78	11.78	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.79	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.88	11.88	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.88	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.86	11.86	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	11.88	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.72	11.72	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.72	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.66	11.66	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.66	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.65	11.65	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	11.66	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.65	11.65	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	11.65	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.65	11.65	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	11.65	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.74	11.74	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.74	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.78	11.78	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.78	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.78	11.78	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.78	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.78	11.78	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.78	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.74	11.74	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	11.78	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.70	11.70	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	11.74	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.76	11.76	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.76	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.76	11.76	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.76	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.76	11.76	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.76	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.70	11.70	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	11.76	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.65	11.65	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	11.70	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.62	11.62	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.63	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.59	11.59	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	11.62	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.61	12.61	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.61	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.53	12.53	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	12.61	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.61	12.61	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.62	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.60	12.60	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.60	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.60	12.60	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	12.60	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.84	12.84	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	12.91	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.83	12.83	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.84	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.66	12.66	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	12.83	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.60	12.60	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	12.66	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.53	12.53	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	12.60	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.48	12.48	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	12.53	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.54	12.54	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.54	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.53	12.53	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	12.54	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.53	12.53	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	12.53	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.43	12.43	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	12.48	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.29	12.29	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	12.43	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.23	12.23	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	12.29	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	12.22	12.22	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	12.23	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	12.21	12.21	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	12.22	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	12.15	12.15	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	12.21	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	12.13	12.13	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	12.15	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	12.09	12.09	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	12.13	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	12.06	12.06	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	12.09	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**12.04**	**12.04**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**12.06**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.48	12.48	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.48	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.43	12.43	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	12.43	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.48	12.48	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.50	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.43	12.43	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.45	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.23	12.23	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.24	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	12.21	12.21	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.21	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	12.13	12.13	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.14	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	12.13	12.13	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.13	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.26	12.26	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.26	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.26	12.26	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	12.26	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.25	12.25	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	12.26	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.23	12.23	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	12.25	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.25	12.25	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.25	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.44	12.44	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.44	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.40	12.40	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	12.44	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.36	12.36	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	12.40	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.32	12.32	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	12.36	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.28	12.28	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	12.32	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	12.21	12.21	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	12.28	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.28	12.28	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.29	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.38	12.38	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.38	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.36	12.36	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	12.38	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	12.22	12.22	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.22	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	12.16	12.16	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.16	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	12.15	12.15	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	12.16	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	12.15	12.15	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	12.15	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	12.15	12.15	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	12.15	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.24	12.24	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.24	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.28	12.28	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.28	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.28	12.28	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.28	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.28	12.28	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	12.28	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.24	12.24	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	12.28	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.20	12.20	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	12.24	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.26	12.26	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.26	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.26	12.26	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.26	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.26	12.26	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	12.26	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.20	12.20	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	12.26	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	12.15	12.15	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	12.20	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	12.12	12.12	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.13	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	12.09	12.09	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	12.12	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.91	13.91	15	0.8	0.7	95	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.91	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	13.83	13.83	15	1.5	1.3	91	154	0.0005	0.08	0	0.00	0.01	0.4	0.6	0.0	0.7	0.0	95	0.00	0.01	1.0	0.5	0.01	0.08	13.91	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.91	13.91	15	0.7	0.6	91	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.92	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.90	13.90	15	0.4	0.3	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.90	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.90	13.90	15	0.4	0.3	104	18	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	13.90	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	14.14	14.14	12	1.4	1.8	0	47	0.0013	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	14.21	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	14.13	14.13	12	0.4	0.5	90	82.1	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.14	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.96	13.96	12	2.0	2.6	72	41	0.0028	0.11	0	0.00	0.03	0.2	2.5	0.0	1.8	0.0	0	0.00	0.04	1.3	1.0	0.06	0.17	14.13	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.90	13.90	18	2.0	1.1	77	26	0.0003	0.01	0	0.00	0.01	5.3	0.0	0.0	2.6	0.0	72	0.06	0.11	1.0	0.5	0.05	0.06	13.96	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	13.83	13.83	18	2.4	1.4	90	129	0.0004	0.06	0	0.00	0.01	2.3	0.1	0.0	1.1	0.0	77	0.01	0.03	1.0	0.5	0.01	0.07	13.90	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	13.78	13.78	18	4.5	2.5	3	14	0.0015	0.02	0	0.00	0.02	3.2	0.3	2.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.03	0.05	13.83	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	13.84	13.84	15	0.4	0.3	70	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.84	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	13.83	13.83	15	0.7	0.5	22	5	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	70	0.00	0.00	1.3	1.0	0.00	0.00	13.84	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	13.83	13.83	18	0.7	0.4	2	25	0.0000	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	22	0.00	0.00	1.0	0.5	0.00	0.00	13.83	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	13.73	13.73	24	5.2	1.6	4	60	0.0004	0.03	0	0.00	0.01	11.2	0.3	0.1	2.5	0.0	3	0.01	0.05	1.0	0.5	0.03	0.05	13.78	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	13.59	13.59	24	8.1	2.6	4	82	0.0011	0.09	0	0.00	0.03	8.5	4.8	0.0	1.6	0.0	4	0.00	0.05	1.0	1.0	0.05	0.14	13.73	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	13.53	13.53	36	8.3	1.2	7	59	0.0001	0.01	0	0.00	0.01	21.1	0.0	0.0	2.6	0.0	4	0.01	0.05	1.0	1.0	0.05	0.06	13.59	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	13.52	13.52	48	10.5	0.8	3	54	0.0000	0.00	0	0.00	0.00	9.7	2.8	3.1	1.2	0.0	7	0.00	0.01	1.0	1.0	0.01	0.01	13.53	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	13.51	13.51	48	10.6	0.8	3	68	0.0000	0.00	0	0.00	0.00	8.7	0.0	0.0	0.8	0.0	3	0.00	0.01	1.0	0.5	0.00	0.01	13.52	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	13.45	13.45	48	12.1	1.0	4	180	0.0001	0.01	0	0.00	0.00	9.0	9.3	1.2	1.7	0.0	88	0.03	0.05	1.0	1.0	0.05	0.06	13.51	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	13.43	13.43	48	14.8	1.2	2	58	0.0001	0.01	0	0.00	0.01	11.7	0.5	3.2	1.0	0.0	4	0.00	0.01	1.0	1.0	0.01	0.02	13.45	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	13.39	13.39	48	18.7	1.5	0	158	0.0001	0.02	0	0.00	0.01	17.4	1.4	1.4	1.2	0.0	2	0.00	0.02	1.0	1.0	0.02	0.04	13.43	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	13.36	13.36	48	19.7	1.6	16	35	0.0002	0.01	0	0.00	0.01	27.9	1.5	0.0	1.5	0.0	0	0.00	0.02	1.0	1.0	0.02	0.03	13.39	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**13.34**	**13.34**	**48**	**19.6**	**1.6**	**0**	**48**	**0.0002**	**0.01**	**0**	**0.00**	**0.01**	**30.8**	**0.0**	**0.0**	**1.6**	**0.0**	**16**	**0.01**	**0.03**	**1.0**	**0.5**	**0.01**	**0.02**	**13.36**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	13.78	13.78	15	0.4	0.3	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.78	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	13.73	13.73	15	0.6	0.5	88	25	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	0	0.00	0.00	1.3	1.0	0.00	0.00	13.73	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	13.78	13.78	8	0.2	0.5	93	96	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.80	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	13.73	13.73	18	2.9	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.75	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	13.53	13.53	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.54	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	13.51	13.51	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.51	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	13.43	13.43	18	1.6	0.9	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.44	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	13.43	13.43	18	1.6	0.9	90	18	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.43	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	13.56	13.56	18	0.8	0.4	0	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.56	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	13.56	13.56	18	1.0	0.6	0	54	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	13.56	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	13.55	13.55	24	1.3	0.4	90	91	0.0000	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	13.56	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	13.53	13.53	24	3.1	1.0	94	33	0.0002	0.01	0	0.00	0.00	0.6	0.8	0.0	0.7	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	13.55	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	13.55	13.55	18	1.2	0.7	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.55	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	13.74	13.74	18	1.5	0.8	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.74	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	13.70	13.70	18	1.8	1.0	90	68	0.0002	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	13.74	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	13.66	13.66	18	2.1	1.2	79	29	0.0003	0.01	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.04	13.70	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	13.62	13.62	24	3.6	1.1	69	46	0.0002	0.01	0	0.00	0.01	2.4	0.0	0.0	1.2	0.0	79	0.01	0.03	1.3	1.0	0.03	0.04	13.66	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	13.58	13.58	24	3.7	1.2	80	44	0.0002	0.01	0	0.00	0.01	4.1	0.0	0.0	1.1	0.0	69	0.01	0.02	1.0	1.0	0.02	0.04	13.62	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	13.51	13.51	24	5.4	1.7	88	29	0.0005	0.01	0	0.00	0.01	4.5	9.3	0.0	1.7	0.0	88	0.03	0.06	1.0	1.0	0.06	0.07	13.58	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	13.58	13.58	18	1.3	0.8	90	19	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.59	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	13.68	13.68	18	1.0	0.6	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.68	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	13.66	13.66	18	1.3	0.7	12	68	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.02	13.68	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	13.52	13.52	18	0.3	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.52	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	13.46	13.46	18	0.4	0.2	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.46	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	13.45	13.45	18	0.6	0.3	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	13.46	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	13.45	13.45	18	0.7	0.4	12	49	0.0000	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	80	0.00	0.00	1.3	1.0	0.00	0.00	13.45	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	13.45	13.45	18	0.9	0.5	98	23	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	12	0.00	0.00	1.3	1.0	0.00	0.00	13.45	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	13.54	13.54	18	0.2	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.54	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	13.58	13.58	18	1.1	0.6	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.58	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	13.58	13.58	18	0.3	0.1	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.58	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	13.58	13.58	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	13.58	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	13.54	13.54	18	1.9	1.1	70	108	0.0003	0.03	0	0.00	0.00	0.1	0.6	0.0	0.6	0.0	90	0.00	0.01	1.3	1.0	0.01	0.04	13.58	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	13.50	13.50	18	2.2	1.3	57	27	0.0004	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	70	0.01	0.02	1.3	1.0	0.03	0.04	13.54	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	13.56	13.56	18	1.3	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.56	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	13.56	13.56	18	0.3	0.1	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.56	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	13.56	13.56	18	0.5	0.3	2	62	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	13.56	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	13.50	13.50	18	2.2	1.2	14	119	0.0004	0.04	0	0.00	0.01	0.2	1.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.06	13.56	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	13.45	13.45	18	2.4	1.3	67	50	0.0004	0.02	0	0.00	0.01	2.7	2.8	0.0	1.3	0.0	57	0.01	0.03	1.0	1.0	0.03	0.05	13.50	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	13.42	13.42	18	1.5	0.8	105	53	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.43	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	13.39	13.39	18	1.6	0.9	90	43	0.0002	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	105	0.01	0.01	1.3	1.0	0.02	0.03	13.42	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 10 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
CRB Network STA 109+25 to 111+75																										
CRB-P72	CRB-DI72	CRB-MH-74	7961	0	7961	0.18	0.95	0.17	0.17	6.0	0.00	6.16	1.1	15	16	0.012	0.0002	0.019	7.8	9.6	4.7	0.06	6.06	2.60	2.30	Q ok
CRB-P74	CRB-MH-74	CRB-MH-67	1	0	1	0.00	0.95	0.00	0.33	6.0	6.19	6.11	2.0	15	154	0.012	0.0008	0.005	4.1	5.1	3.8	0.67	6.86	1.65	0.84	Q ok
CRB-P73	CRB-DI73	CRB-MH-74	7042	0	7042	0.16	0.95	0.15	0.15	6.0	0.00	6.16	0.9	15	34	0.012	0.0002	0.005	4.0	4.9	3.0	0.19	6.19	1.92	1.75	Q ok
MSS Network Sta 111+75 to 114+00																										
P-162	DI-162	EXMH-201	3794	0	3794	0.09	0.95	0.08	0.08	6.0	0.00	6.16	**0.51**	15	16	0.011	0.000045	0.0200	8.8	**10.8**	4.3	0.06	6.06	2.50	2.18	Q ok
P-201	EXMH-201	A1-MH-203	1	0	1	0.00	0.95	0.00	0.08	6.0	6.06	6.14	**0.51**	15	18	0.012	0.000053	0.0200	8.1	**9.9**	3.9	0.08	6.14	1.98	1.62	Q ok
Ploener Property																										
EX-P LOT	EXDI LOT	DI-MSS-41	13430	0	13430	0.31	0.95	0.29	0.29	6.0	0.00	6.16	**1.80**	12	47	0.012	0.002187	0.0074	4.2	**3.3**	4.3	0.18	6.18	2.50	2.15	Q ok
P-MSS-48	DI-MSS-40	DI-MSS-41	3590	0	3590	0.08	0.95	0.08	0.08	6.0	0.00	6.16	**0.48**	12	82	0.012	0.000156	0.0050	3.5	**2.7**	2.6	0.53	6.53	2.56	2.15	Q ok
P-MSS-48A	DI-MSS-41	EX-MH	3072	0	3072	0.07	0.95	0.07	0.44	6.0	6.53	6.03	**2.64**	12	41	0.012	0.004691	0.0051	3.5	**2.8**	4.1	0.17	6.69	2.05	1.84	Q ok
A1-P-202	EX-MH	A1-MH-203	1	0	1	0.00	0.95	0.00	0.44	6.0	6.69	5.98	**2.62**	18	26	0.012	0.000531	0.0046	4.4	**7.7**	3.9	0.11	6.80	1.74	1.62	Q ok
A1-P-204	A1-MH-204	CRB-MH-67	1	0	1	0.00	0.95	0.00	0.52	6.0	6.80	5.96	**3.10**	18	129	0.012	0.000743	0.0052	4.6	**8.2**	4.3	0.50	7.31	1.52	0.85	Q ok
A1-P-205	CRB-MH-67	CMH-1	1	0	1	0.00	0.95	0.00	0.99	6.0	7.31	5.83	**5.78**	18	14	0.012	0.002577	0.0057	4.9	**8.6**	5.2	0.04	7.35	0.75	0.67	Q ok
MSS Network Sta 111+75 to 114+00																										
MSS-P2	MSS-DI2	MSS-DI1	3846	1139	4985	0.11	0.77	0.09	0.09	6.0	0.00	6.16	0.5	15	70	0.012	0.0001	0.005	4.0	4.9	2.4	0.48	6.48	4.03	3.68	Q ok
MSS-P1	MSS-DI1	EXMH	2301	1082	3383	0.08	0.70	0.05	0.14	6.0	6.48	6.03	0.9	15	5	0.012	0.0002	0.003	3.3	4.0	2.5	0.03	6.52	3.39	3.37	Q ok
A1-P-203	EX MH	MH-CRB-67	1	0	1	0.00	0.95	0.00	0.14	6.0	6.52	6.03	**0.86**	18	25	0.012	0.000058	0.0050	4.6	**8.0**	2.7	0.15	6.67	0.92	0.84	Q ok
Jones Street Constructed Under Area 1																										
A1-P-206	CMH-1	A1-DI-207	1	0	1	0.00	0.95	0.00	1.16	6.0	7.35	5.80	**6.71**	24	60	0.012	0.000750	0.0035	4.6	**14.5**	4.5	0.22	7.57	0.57	0.36	Q ok
A1-P-207	A1-DI-207	A1-DI-208	3414	0	3414	0.08	0.95	0.07	1.84	6.0	7.57	5.75	**10.57**	24	82	0.012	0.001862	0.0040	4.9	**15.5**	5.4	0.25	7.83	0.36	0.03	Q ok
A1-P-208	A1-DI-208	A1-DI-209	2490	0	2490	0.06	0.95	0.05	1.89	6.0	7.83	5.70	**10.79**	36	59	0.012	0.000223	0.0041	6.5	**46.1**	5.3	0.18	8.01	0.03	-0.21	Q ok
A1-P-209	A1-DI-209	A1-MH-210	2433	0	2433	0.06	0.95	0.05	2.42	6.0	8.01	5.65	**13.64**	48	54	0.012	0.000077	0.0041	7.9	**99.3**	5.5	0.16	8.17	-0.21	-0.43	Q ok
A1-P-210	A1-MH-210	A1-DI-211	1	0	1	0.00	0.95	0.00	2.47	6.0	8.17	5.59	**13.84**	48	68	0.012	0.000079	0.0040	7.8	**98.1**	5.5	0.21	8.38	-0.43	-0.70	Q ok
A1-P-211	A1-DI-211	A1-DI-212	3353	0	3353	0.08	0.95	0.07	2.86	6.0	8.38	5.54	**15.83**	48	180	0.012	0.000103	0.0040	7.8	**98.4**	5.5	0.55	8.93	-0.70	-1.42	Q ok
A1-P-212	A1-DI-212	A1-DI-213	1885	0	1885	0.04	0.95	0.04	3.58	6.0	8.93	5.41	**19.38**	48	58	0.012	0.000155	0.0040	7.8	**98.0**	5.8	0.17	9.09	-1.42	-1.65	Q ok
A1-P-213	A1-DI-213	A1-DI-214	15288	0	15288	0.35	0.95	0.33	4.58	6.0	9.09	5.36	**24.57**	48	158	0.012	0.000249	0.0040	7.8	**98.3**	6.4	0.41	9.51	-1.65	-2.28	Q ok
A1-P-214	A1-DI-214	A1-DI-215	**1**	0	1	0.00	0.95	0.00	4.93	6.0	9.51	5.26	**25.92**	48	35	0.012	0.000277	0.0040	7.8	**98.4**	6.4	0.09	9.60	-2.28	-2.42	Q ok
A1-P-215	A1-DI-215	A1-MH-216	**1**	0	1	0.00	0.95	0.00	4.93	6.0	9.60	5.23	**25.79**	48	48	0.012	0.000275	0.0040	7.8	**97.9**	6.4	0.13	9.72	-2.42	-2.61	Q ok
MSS-P3 A	MSS-DI14	DI-161	3612	330	3942	0.09	0.89	0.08	0.08	6.0	0.00	6.16	0.5	15	44	0.012	0.0000	0.005	4.0	4.9	2.4	0.30	6.30	4.03	3.81	Q ok
MSS-P3 B	DI-161	MSS-DI13	2062	222	2284	0.05	0.88	0.05	0.13	6.0	6.30	6.08	0.8	15	25	0.012	0.0001	0.005	4.1	5.0	2.8	0.15	6.45	3.81	3.68	Q ok
	DOGHOUSE																									
P-160	DI-160	CMH-1	1768	257	2025	0.05	0.85	0.04	0.04	6.0	0.00	6.16	**0.24**	8	96	0.011	0.000292	0.0200	5.8	**2.0**	3.5	0.46	6.46	2.99	1.07	Q ok
A1 P-200	PARCEL J	A1-DI-207	27861	0	27861	0.64	0.95	0.61	0.61	6.0	0.00	6.16	**3.74**	18	23	0.012	0.001083	0.0100	6.4	11.4	5.8	0.07	6.07	1.59	1.36	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 10 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to	Pervious Area, C = 0.18 to	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-336	PARCEL J	A1-DI-209	21549	0	21549	0.49	0.95	0.47	0.47	6.0	0.00	6.16	**2.90**	18	19	0.012	0.000648	0.0100	6.4	11.4	5.3	0.06	6.06	1.48	1.29	Q ok
P-337	PARCEL J	A1-DI-211	14148	0	14148	0.32	0.95	0.31	0.31	6.0	0.00	6.16	**1.90**	18	23	0.012	0.000279	0.0100	6.4	11.4	4.5	0.09	6.09	1.53	1.30	Q ok
P-335	PARCEL N	A1-DI-213	15379	0	15379	0.35	0.95	0.34	0.34	6.0	0.00	6.16	**2.07**	18	56	0.012	0.000330	0.0100	6.4	11.4	4.8	0.19	6.19	1.91	1.35	Q ok
P-340	PARCEL K	A1-DI-213	15267	0	15267	0.35	0.95	0.33	0.33	6.0	0.00	6.16	**2.05**	18	18	0.012	0.000325	0.0100	6.4	11.4	4.8	0.06	6.06	1.53	1.35	Q ok
P-165	DI-165	DI-166	7237	0	7237	0.17	0.95	0.16	0.16	6.0	0.00	6.16	**0.97**	18	28	0.012	0.000073	0.0100	6.4	**11.4**	3.9	0.12	6.12	2.95	2.67	Q ok
P-166	DI-166	DI-167	2265	0	2265	0.05	0.95	0.05	0.21	6.0	6.12	6.14	**1.27**	18	54	0.012	0.000125	0.0100	6.4	**11.4**	3.9	0.23	6.35	2.47	1.93	Q ok
P-167	DI-167	DI-168	3648	0	3648	0.08	0.95	0.08	0.29	6.0	6.35	6.06	**1.74**	24	91	0.012	0.000050	0.0100	7.8	**24.5**	3.8	0.40	6.75	1.73	0.82	Q ok
P-168	DI-168	DI-209	6136	0	6136	0.14	0.95	0.13	0.67	6.0	6.75	5.96	**4.00**	24	33	0.012	0.000267	0.0100	7.8	**24.5**	5.5	0.10	6.85	0.62	0.29	Q ok
P-327	PARCEL L	DI-168	11517	0	11517	0.26	0.95	0.25	0.25	6.0	0.00	6.16	**1.55**	18	19	0.012	0.000185	0.0100	6.4	11.4	4.5	0.07	6.07	1.31	1.12	Q ok
P-326	PARCEL L	DI-170	14378	0	14378	0.33	0.95	0.31	0.31	6.0	0.00	6.16	**1.93**	18	23	0.012	0.000288	0.0100	6.4	11.4	4.5	0.09	6.09	3.99	3.76	Q ok
P-170	DI-170	DI-171	2801	0	2801	0.06	0.95	0.06	0.37	6.0	6.09	6.14	**2.30**	18	68	0.012	0.000408	0.0100	6.4	**11.4**	4.8	0.23	6.32	3.26	2.58	Q ok
P-171	DI-171	DI-173	2811	0	2811	0.06	0.95	0.06	0.44	6.0	6.32	6.08	**2.65**	18	29	0.012	0.000543	0.0100	6.4	**11.4**	5.3	0.09	6.41	2.38	2.09	Q ok
P-173	DI-173	DI-174	2818	0	2818	0.06	0.95	0.06	0.77	6.0	6.41	6.06	**4.64**	24	46	0.012	0.000358	0.0100	7.8	**24.5**	5.9	0.13	6.54	1.89	1.43	Q ok
P-174	DI-174	DI-175	1817	0	1817	0.04	0.95	0.04	0.80	6.0	6.54	6.03	**4.85**	24	44	0.012	0.000392	0.0100	7.8	**24.5**	5.9	0.13	6.67	1.23	0.79	Q ok
P-175	DI-175	DI-211	3620	0	3620	0.08	0.95	0.08	1.17	6.0	6.67	5.98	**6.97**	24	29	0.012	0.000809	0.0100	7.8	**24.5**	6.6	0.07	6.74	0.59	0.30	Q ok
P-331	PARCEL M	DI-175	12913	0	12913	0.30	0.95	0.28	0.28	6.0	0.00	6.16	**1.74**	18	19	0.012	0.000233	0.0100	6.4	11.4	4.5	0.07	6.07	1.28	1.09	Q ok
P-328	PARCEL M	DI-172	9475	0	9475	0.22	0.95	0.21	0.21	6.0	0.00	6.16	**1.27**	18	22	0.012	0.000125	0.0100	6.4	11.4	3.9	0.09	6.09	3.49	3.27	Q ok
P-172	DI-172	DI-173	2798	0	2798	0.06	0.95	0.06	0.27	6.0	6.09	6.14	**1.64**	18	68	0.012	0.000208	0.0100	6.4	**11.4**	4.5	0.25	6.35	2.77	2.09	Q ok
P-169	DI-169	MH-210	2626	0	2626	0.06	0.95	0.06	0.06	6.0	0.00	6.16	**0.35**	18	7	0.012	0.000010	0.0100	6.4	**11.4**	3.2	0.04	6.04	1.64	1.57	Q ok
P-178	DI-178	DI-179	3573	0	3573	0.08	0.95	0.08	0.08	6.0	0.00	6.16	**0.48**	18	39	0.012	0.000018	0.0100	6.4	**11.4**	3.2	0.21	6.21	2.63	2.24	Q ok
P-179	DI-179	DI-180	1913	0	1913	0.04	0.95	0.04	0.12	6.0	0.00	6.16	**0.74**	18	34	0.012	0.000042	0.0100	6.4	**11.4**	3.2	0.18	6.18	2.04	1.70	Q ok
P-180	DI-180	DI-181	1165	0	1165	0.03	0.95	0.03	0.15	6.0	0.00	6.16	**0.89**	18	49	0.012	0.000062	0.0100	6.4	**11.4**	3.9	0.21	6.21	1.50	1.01	Q ok
P-181	DI-181	DI-212	1967	0	1967	0.05	0.95	0.04	0.19	6.0	0.00	6.16	**1.16**	18	23	0.012	0.000104	0.0100	6.4	**11.4**	3.9	0.10	6.10	0.81	0.58	Q ok
P-182	DI-182	DI-186	1887	0	1887	0.04	0.95	0.04	0.04	6.0	0.00	6.16	**0.25**	18	43	0.012	0.000005	0.0100	6.4	**11.4**	3.2	0.23	6.23	4.28	3.85	Q ok
P-338	PARCEL J	DI-185	10195	0	10195	0.23	0.95	0.22	0.22	6.0	0.00	6.16	**1.37**	18	23	0.012	0.000145	0.0100	6.4	11.4	3.9	0.10	6.10	3.86	3.63	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 10 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-183	DI-183	DI-184	2436	0	2436	0.06	0.95	0.05	0.05	6.0	0.00	6.16	**0.33**	18	59	0.012	0.000008	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.74	4.15	Q ok
P-184	DI-184	DI-185	2508	0	2508	0.06	0.95	0.05	0.11	6.0	0.00	6.16	**0.66**	18	62	0.012	0.000034	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.95	3.33	Q ok
P-185	DI-185	DI-186	3002	0	3002	0.07	0.95	0.07	0.40	6.0	0.00	6.16	**2.44**	18	108	0.012	0.000459	0.0100	6.4	**11.4**	4.8	0.37	6.37	3.13	2.05	Q ok
P-186	DI-186	DI-190	1354	0	1354	0.03	0.95	0.03	0.47	6.0	0.00	6.16	**2.87**	18	27	0.012	0.000638	0.0100	6.4	**11.4**	5.3	0.09	6.09	1.85	1.58	Q ok
check San x-ing																										
P-339	PARCEL K	DI-189	12930	0	12930	0.30	0.95	0.28	0.28	6.0	0.00	6.16	**1.74**	18	23	0.012	0.000233	0.0100	6.4	11.4	4.5	0.09	6.09	3.20	2.97	Q ok
P-187	DI-187	DI-188	2448	0	2448	0.06	0.95	0.05	0.05	6.0	0.00	6.16	**0.33**	18	59	0.012	0.000008	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.08	3.49	Q ok
P-188	DI-188	DI-189	2550	0	2550	0.06	0.95	0.06	0.11	6.0	0.00	6.16	**0.67**	18	62	0.012	0.000035	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.29	2.67	Q ok
P-189	DI-189	DI-190	3025	0	3025	0.07	0.95	0.07	0.46	6.0	0.00	6.16	**2.82**	18	119	0.012	0.000612	0.0100	6.4	**11.4**	5.3	0.38	6.38	2.47	1.28	Q ok
P-190	DI-190	DI-191	1765	0	1765	0.04	0.95	0.04	0.50	6.0	0.00	6.16	**3.05**	18	50	0.012	0.000720	0.0100	6.4	**11.4**	5.3	0.16	6.16	1.08	0.58	Q ok
P-341	PARCEL K	DI-195	13999	0	13999	0.32	0.95	0.31	0.31	6.0	0.00	6.16	**1.88**	18	53	0.012	0.000273	0.0100	6.4	11.4	4.5	0.20	6.20	3.96	3.43	Q ok
P-195	DI-195	A1-DI-214	**1887**	0	1887	0.04	0.95	0.04	0.35	6.0	6.20	6.11	**2.12**	18	43	0.012	0.000346	0.0100	6.4	**11.4**	4.8	0.15	6.34	2.43	2.00	Q ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	4.16	4.16	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.17	5.76	HGL ok
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.03	4.03	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	4.16	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	4.16	4.16	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.17	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	4.15	4.15	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.15	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	4.15	4.15	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	4.15	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	4.55	4.55	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	4.67	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	4.54	4.54	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.55	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	4.25	4.25	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	4.54	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	4.15	4.15	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	4.25	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.03	4.03	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	4.15	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	3.95	3.95	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	4.03	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.38	4.68	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.03	4.37	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	4.38	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.03	4.03	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	4.03	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	3.85	3.85	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	3.95	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.63	3.63	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	3.85	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.52	3.52	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	3.63	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.50	3.50	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	3.52	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.49	3.49	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	3.50	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.38	3.38	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	3.49	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.35	3.35	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	3.38	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.29	3.29	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	3.35	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.24	3.24	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	3.29	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.20**	**3.20**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**3.24**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	3.95	4.81	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.81	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	3.85	4.68	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	3.95	3.95	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	3.98	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	3.85	3.85	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	3.89	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.52	3.52	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.54	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.49	3.49	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.50	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.35	3.35	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.37	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.35	3.35	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.36	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.58	3.87	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.87	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.57	3.57	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	3.58	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.56	3.56	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	3.57	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.52	3.52	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	3.56	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.56	3.56	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.56	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	3.87	4.96	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	3.81	3.81	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	3.87	10.79	HGL ok
P-171	DI-171	DI-173	1.20	3.74	3.74	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	3.81	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.67	3.67	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	3.74	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.61	3.61	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	3.67	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.49	3.49	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	3.61	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.61	3.61	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.62	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	3.77	4.47	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.47	10.00	HGL ok
P-172	DI-172	DI-173	1.20	3.74	3.74	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	3.77	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.50	3.50	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.50	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.40	3.44	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.44	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.40	3.40	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	3.40	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.39	3.39	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	3.40	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.38	3.38	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	3.39	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.53	5.05	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.61	4.83	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.83	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.61	4.53	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.53	3.53	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	3.61	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.47	3.47	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	3.53	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.57	4.17	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.87	4.69	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.57	3.87	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.87	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.47	3.47	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	3.57	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.38	3.38	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	3.47	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.33	4.63	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	4.65	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.29	3.29	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	3.33	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	4.36	4.36	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.37	5.76	HGL ok
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.23	4.23	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	4.36	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	4.36	4.36	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.37	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	4.35	4.35	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.35	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	4.35	4.35	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	4.35	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	4.75	4.75	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	4.87	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	4.74	4.74	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.75	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	4.45	4.45	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	4.74	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	4.35	4.35	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	4.45	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.23	4.23	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	4.35	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.15	4.15	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	4.23	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.38	4.68	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.23	4.37	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	4.38	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.23	4.23	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	4.23	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.05	4.05	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	4.15	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.83	3.83	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	4.05	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.72	3.72	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	3.83	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.70	3.70	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	3.72	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.69	3.69	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	3.70	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.58	3.58	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	3.69	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.55	3.55	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	3.58	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.49	3.49	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	3.55	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.44	3.44	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	3.49	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.40**	**3.40**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**3.44**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.15	4.81	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.81	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.05	4.68	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.15	4.15	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	4.18	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.05	4.05	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	4.09	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.72	3.72	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.74	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.69	3.69	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.70	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.55	3.55	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.57	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.55	3.55	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.56	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.78	3.87	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.87	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.77	3.77	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	3.78	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.76	3.76	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	3.77	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.72	3.72	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	3.76	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.76	3.76	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.76	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.07	4.96	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.01	4.01	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	4.07	10.79	HGL ok
P-171	DI-171	DI-173	1.20	3.94	3.94	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	4.01	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.87	3.87	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	3.94	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.81	3.81	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	3.87	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.69	3.69	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	3.81	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.81	3.81	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.82	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	3.97	4.47	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.47	10.00	HGL ok
P-172	DI-172	DI-173	1.20	3.94	3.94	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	3.97	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.70	3.70	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.70	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.60	3.60	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.60	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.60	3.60	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	3.60	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.59	3.59	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	3.60	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.58	3.58	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	3.59	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.73	5.05	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.81	4.83	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.83	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.81	4.53	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.73	3.73	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	3.81	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.67	3.67	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	3.73	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.77	4.17	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.87	4.69	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.77	3.87	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.87	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.67	3.67	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	3.77	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.58	3.58	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	3.67	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.53	4.63	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	4.65	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.49	3.49	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	3.53	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.86	7.86	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.87	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.73	7.73	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	7.86	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.86	7.86	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.87	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.85	7.85	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.85	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.85	7.85	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	7.85	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.25	8.25	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	8.37	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.24	8.24	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.25	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.95	7.95	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	8.24	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.85	7.85	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	7.95	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.73	7.73	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	7.85	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.65	7.65	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	7.73	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.74	7.74	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.74	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.73	7.73	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	7.74	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.73	7.73	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	7.73	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.55	7.55	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	7.65	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.33	7.33	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	7.55	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.22	7.22	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	7.33	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.20	7.20	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	7.22	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.19	7.19	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	7.20	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.08	7.08	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	7.19	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.05	7.05	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	7.08	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	6.99	6.99	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	7.05	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.94	6.94	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	6.99	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**6.90**	**6.90**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**6.94**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.65	7.65	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.65	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.55	7.55	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	7.56	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.65	7.65	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	7.68	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.55	7.55	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	7.59	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.22	7.22	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.24	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.19	7.19	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.20	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.05	7.05	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.07	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.05	7.05	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.06	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.28	7.28	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.28	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.27	7.27	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	7.28	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.26	7.26	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	7.27	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.22	7.22	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	7.26	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.26	7.26	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.26	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.57	7.57	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.58	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.51	7.51	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	7.57	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.44	7.44	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	7.51	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.37	7.37	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	7.44	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.31	7.31	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	7.37	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.19	7.19	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	7.31	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.31	7.31	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.32	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.47	7.47	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.44	7.44	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	7.47	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.20	7.20	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.20	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.10	7.10	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.10	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.10	7.10	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	7.10	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.09	7.09	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	7.10	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.08	7.08	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	7.09	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.23	7.23	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.23	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.31	7.31	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.31	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.31	7.31	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.31	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.31	7.31	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.31	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.23	7.23	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	7.31	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.17	7.17	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	7.23	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.27	7.27	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.28	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.28	7.28	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.28	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.27	7.27	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.28	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.17	7.17	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	7.27	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.08	7.08	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	7.17	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.03	7.03	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	7.05	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	6.99	6.99	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	7.03	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.36	8.36	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.37	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.23	8.23	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	8.36	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.36	8.36	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.37	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.35	8.35	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.35	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.35	8.35	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	8.35	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.75	8.75	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	8.87	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.74	8.74	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.75	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.45	8.45	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	8.74	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.35	8.35	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	8.45	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.23	8.23	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	8.35	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.15	8.15	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	8.23	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.24	8.24	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.24	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.23	8.23	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	8.24	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.23	8.23	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	8.23	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.05	8.05	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	8.15	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.83	7.83	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	8.05	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.72	7.72	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	7.83	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.70	7.70	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	7.72	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.69	7.69	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	7.70	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.58	7.58	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	7.69	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.55	7.55	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	7.58	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.49	7.49	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	7.55	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.44	7.44	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	7.49	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.40**	**7.40**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**7.44**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.15	8.15	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.15	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.05	8.05	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.06	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.15	8.15	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.18	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.05	8.05	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.09	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.72	7.72	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.74	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.69	7.69	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.70	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.55	7.55	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.57	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.55	7.55	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.56	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.78	7.78	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.78	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.77	7.77	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	7.78	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.76	7.76	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	7.77	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.72	7.72	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	7.76	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.76	7.76	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.76	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.07	8.07	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.08	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.01	8.01	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	8.07	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.94	7.94	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	8.01	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.87	7.87	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	7.94	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.81	7.81	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	7.87	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.69	7.69	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	7.81	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.81	7.81	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.82	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.97	7.97	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.98	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.94	7.94	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	7.97	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.70	7.70	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.70	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.60	7.60	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.60	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.60	7.60	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	7.60	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.59	7.59	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	7.60	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.58	7.58	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	7.59	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.73	7.73	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.73	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.81	7.81	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.81	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.81	7.81	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.81	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.81	7.81	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.81	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.73	7.73	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	7.81	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.67	7.67	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	7.73	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.77	7.77	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.78	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.78	7.78	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.78	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.77	7.77	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.78	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.67	7.67	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	7.77	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.58	7.58	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	7.67	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.53	7.53	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	7.55	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.49	7.49	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	7.53	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.76	8.76	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.77	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.63	8.63	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	8.76	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.76	8.76	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.77	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.75	8.75	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.75	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.75	8.75	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	8.75	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.15	9.15	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	9.27	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.14	9.14	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.15	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.85	8.85	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	9.14	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.75	8.75	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	8.85	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.63	8.63	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	8.75	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.55	8.55	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	8.63	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.64	8.64	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.64	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.63	8.63	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	8.64	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.63	8.63	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	8.63	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.45	8.45	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	8.55	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.23	8.23	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	8.45	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.12	8.12	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	8.23	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.10	8.10	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	8.12	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.09	8.09	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	8.10	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.98	7.98	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	8.09	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.95	7.95	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	7.98	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.89	7.89	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	7.95	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.84	7.84	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	7.89	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.80**	**7.80**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**7.84**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.55	8.55	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.55	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.45	8.45	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.46	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.55	8.55	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.58	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.45	8.45	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.49	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	8.12	8.12	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.14	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.09	8.09	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.10	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.95	7.95	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.97	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.95	7.95	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.96	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.18	8.18	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.18	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.17	8.17	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.18	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.16	8.16	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	8.17	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.12	8.12	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	8.16	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.16	8.16	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.16	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.47	8.47	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.48	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.41	8.41	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	8.47	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.34	8.34	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	8.41	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.27	8.27	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	8.34	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.21	8.21	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	8.27	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.09	8.09	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	8.21	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.21	8.21	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.22	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.37	8.37	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.38	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.34	8.34	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	8.37	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.10	8.10	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.10	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.00	8.00	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.00	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.00	8.00	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	8.00	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.99	7.99	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	8.00	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.98	7.98	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	7.99	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.13	8.13	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.13	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.21	8.21	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.21	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.21	8.21	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.21	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.21	8.21	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.21	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.13	8.13	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	8.21	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.07	8.07	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	8.13	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.17	8.17	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.18	8.18	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.18	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.17	8.17	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.18	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.07	8.07	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	8.17	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.98	7.98	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	8.07	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.93	7.93	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	7.95	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.89	7.89	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	7.93	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.26	9.26	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.27	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.13	9.13	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	9.26	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.26	9.26	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.27	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.25	9.25	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.25	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.25	9.25	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	9.25	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.65	9.65	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	9.77	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.64	9.64	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.65	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.35	9.35	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	9.64	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.25	9.25	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	9.35	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.13	9.13	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	9.25	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.05	9.05	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	9.13	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.14	9.14	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.14	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.13	9.13	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	9.14	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.13	9.13	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	9.13	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.95	8.95	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	9.05	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.73	8.73	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	8.95	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.62	8.62	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	8.73	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.60	8.60	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	8.62	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.59	8.59	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	8.60	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.48	8.48	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	8.59	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.45	8.45	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	8.48	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	8.39	8.39	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	8.45	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	8.34	8.34	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	8.39	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**8.30**	**8.30**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**8.34**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.05	9.05	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.05	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.95	8.95	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.96	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.05	9.05	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.08	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.95	8.95	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.99	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	8.62	8.62	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.64	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.59	8.59	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.60	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.45	8.45	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.47	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.45	8.45	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.46	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.68	8.68	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.68	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.67	8.67	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.68	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.66	8.66	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	8.67	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.62	8.62	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	8.66	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.66	8.66	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.66	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.97	8.97	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.98	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.91	8.91	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	8.97	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.84	8.84	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	8.91	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.77	8.77	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	8.84	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.71	8.71	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	8.77	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.59	8.59	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	8.71	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.71	8.71	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.72	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.87	8.87	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.88	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.84	8.84	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	8.87	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.60	8.60	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.60	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.50	8.50	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.50	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.50	8.50	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	8.50	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.49	8.49	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	8.50	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.48	8.48	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	8.49	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.63	8.63	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.63	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.71	8.71	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.71	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.71	8.71	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.71	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.71	8.71	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.71	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.63	8.63	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	8.71	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.57	8.57	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	8.63	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.67	8.67	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.68	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.68	8.68	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.68	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.67	8.67	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.68	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.57	8.57	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	8.67	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.48	8.48	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	8.57	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.43	8.43	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	8.45	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	8.39	8.39	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	8.43	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.96	9.96	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.97	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.83	9.83	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	9.96	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.96	9.96	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.97	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.95	9.95	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.95	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.95	9.95	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	9.95	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.35	10.35	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	10.47	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.34	10.34	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.35	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.05	10.05	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	10.34	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.95	9.95	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	10.05	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.83	9.83	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	9.95	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.75	9.75	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	9.83	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.84	9.84	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.84	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.83	9.83	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	9.84	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.83	9.83	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	9.83	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.65	9.65	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	9.75	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.43	9.43	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	9.65	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.32	9.32	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	9.43	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.30	9.30	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	9.32	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.29	9.29	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	9.30	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.18	9.18	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	9.29	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.15	9.15	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	9.18	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.09	9.09	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	9.15	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.04	9.04	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	9.09	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.00**	**9.00**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**9.04**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.75	9.75	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.75	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.65	9.65	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.66	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.75	9.75	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.78	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.65	9.65	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.69	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.32	9.32	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.34	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.29	9.29	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.30	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.15	9.15	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.17	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.15	9.15	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.16	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.38	9.38	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.38	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.37	9.37	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.38	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.36	9.36	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	9.37	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.32	9.32	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	9.36	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.36	9.36	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.36	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	9.67	9.67	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.68	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.61	9.61	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	9.67	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.54	9.54	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	9.61	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.47	9.47	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	9.54	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.41	9.41	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	9.47	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.29	9.29	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	9.41	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.41	9.41	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.42	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.57	9.57	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.58	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.54	9.54	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	9.57	10.79	HGL ok
P-169	DI-169	MH-210	1.20	9.30	9.30	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.30	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.20	9.20	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.20	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.20	9.20	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	9.20	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.19	9.19	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	9.20	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.18	9.18	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	9.19	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.33	9.33	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.33	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.41	9.41	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.41	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.41	9.41	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.41	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.41	9.41	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.41	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.33	9.33	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	9.41	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.27	9.27	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	9.33	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.37	9.37	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.38	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.38	9.38	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.38	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.37	9.37	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.38	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.27	9.27	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	9.37	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.18	9.18	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	9.27	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.13	9.13	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	9.15	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.09	9.09	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	9.13	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.46	10.46	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.47	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.33	10.33	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	10.46	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.46	10.46	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.47	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.45	10.45	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.45	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.45	10.45	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.45	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.85	10.85	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	10.97	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.84	10.84	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.85	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.55	10.55	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	10.84	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.45	10.45	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	10.55	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.33	10.33	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	10.45	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.25	10.25	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	10.33	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.34	10.34	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.34	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.33	10.33	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	10.34	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.33	10.33	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	10.33	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.15	10.15	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	10.25	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.93	9.93	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	10.15	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.82	9.82	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	9.93	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.80	9.80	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	9.82	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.79	9.79	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	9.80	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.68	9.68	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	9.79	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.65	9.65	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	9.68	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.59	9.59	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	9.65	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.54	9.54	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	9.59	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.50**	**9.50**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**9.54**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.25	10.25	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.25	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.15	10.15	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.16	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.25	10.25	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.28	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.15	10.15	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.19	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.82	9.82	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.84	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.79	9.79	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.80	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.65	9.65	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.67	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.65	9.65	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.66	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.88	9.88	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.88	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.87	9.87	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.88	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.86	9.86	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	9.87	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.82	9.82	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	9.86	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.86	9.86	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.86	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.17	10.17	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.18	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.11	10.11	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	10.17	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.04	10.04	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	10.11	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.97	9.97	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	10.04	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.91	9.91	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	9.97	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.79	9.79	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	9.91	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.91	9.91	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.92	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.07	10.07	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.08	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.04	10.04	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	10.07	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.80	9.80	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.80	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.70	9.70	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.70	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.70	9.70	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	9.70	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.69	9.69	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	9.70	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.68	9.68	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	9.69	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.83	9.83	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.83	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.91	9.91	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.91	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.91	9.91	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.91	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.91	9.91	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.91	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.83	9.83	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	9.91	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.77	9.77	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	9.83	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.87	9.87	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.88	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.88	9.88	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.88	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.87	9.87	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.88	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.77	9.77	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	9.87	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.68	9.68	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	9.77	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.63	9.63	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	9.65	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.59	9.59	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	9.63	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.76	11.76	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.77	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.63	11.63	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	11.76	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.76	11.76	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.77	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.75	11.75	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.75	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.75	11.75	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.75	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.15	12.15	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	12.27	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.14	12.14	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.15	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.85	11.85	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	12.14	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.75	11.75	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	11.85	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.63	11.63	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	11.75	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.55	11.55	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	11.63	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.64	11.64	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.64	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.63	11.63	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	11.64	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.63	11.63	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	11.63	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.45	11.45	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	11.55	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.23	11.23	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	11.45	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.12	11.12	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	11.23	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.10	11.10	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	11.12	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.09	11.09	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	11.10	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.98	10.98	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	11.09	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.95	10.95	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	10.98	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.89	10.89	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	10.95	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.84	10.84	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	10.89	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.80**	**10.80**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**10.84**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.55	11.55	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.55	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.45	11.45	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.46	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.55	11.55	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.58	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.45	11.45	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.49	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.12	11.12	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.14	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.09	11.09	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.10	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.95	10.95	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.97	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.95	10.95	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.96	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.18	11.18	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.18	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.17	11.17	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.18	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.16	11.16	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.17	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.12	11.12	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	11.16	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.16	11.16	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.16	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.47	11.47	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.48	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.41	11.41	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	11.47	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.34	11.34	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	11.41	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.27	11.27	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	11.34	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.21	11.21	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	11.27	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.09	11.09	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	11.21	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.21	11.21	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.22	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.37	11.37	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.38	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.34	11.34	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	11.37	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.10	11.10	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.10	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.00	11.00	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.00	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.00	11.00	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	11.00	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	10.99	10.99	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	11.00	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	10.98	10.98	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	10.99	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.13	11.13	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.13	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.21	11.21	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.21	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.21	11.21	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.21	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.21	11.21	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.21	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.13	11.13	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	11.21	12.23	HGL ok
P-186	DI-186	DI-190	1.20	11.07	11.07	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	11.13	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.17	11.17	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.18	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.18	11.18	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.18	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.17	11.17	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.18	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.07	11.07	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	11.17	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.98	10.98	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	11.07	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.93	10.93	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	10.95	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.89	10.89	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	10.93	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	6.70	6.70	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.71	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	6.57	6.57	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	6.70	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	6.70	6.70	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.71	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	6.69	6.69	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.69	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	6.69	6.69	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	6.69	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	7.09	7.09	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	7.21	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	7.08	7.08	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.09	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	6.79	6.79	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	7.08	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	6.69	6.69	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	6.79	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	6.57	6.57	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	6.69	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	6.49	6.49	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	6.57	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	6.58	6.58	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.58	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	6.57	6.57	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	6.58	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	6.57	6.57	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	6.57	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.39	6.39	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	6.49	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.17	6.17	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	6.39	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.06	6.06	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	6.17	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.04	6.04	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	6.06	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.03	6.03	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	6.04	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	5.92	5.92	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	6.03	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	5.89	5.89	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	5.92	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.83	5.83	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	5.89	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.78	5.78	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	5.83	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.74**	**5.74**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**5.78**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.49	6.49	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.49	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.39	6.39	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	6.40	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.49	6.49	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	6.52	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.39	6.39	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.43	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.06	6.06	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.08	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.03	6.03	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.04	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	5.89	5.89	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	5.91	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	5.89	5.89	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	5.90	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.12	6.12	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.12	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.11	6.11	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	6.12	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.10	6.10	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	6.11	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.06	6.06	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	6.10	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.10	6.10	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.10	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.41	6.41	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.42	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.35	6.35	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	6.41	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.28	6.28	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	6.35	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.21	6.21	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	6.28	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.15	6.15	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	6.21	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.03	6.03	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	6.15	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.15	6.15	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.16	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.31	6.31	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.32	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.28	6.28	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	6.31	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.04	6.04	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.04	10.25	HGL ok
P-178	DI-178	DI-179	1.20	5.94	5.94	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.94	11.90	HGL ok
P-179	DI-179	DI-180	1.20	5.94	5.94	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	5.94	11.68	HGL ok
P-180	DI-180	DI-181	1.20	5.93	5.93	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	5.94	11.68	HGL ok
P-181	DI-181	DI-212	1.20	5.92	5.92	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	5.93	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.07	6.07	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.07	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.15	6.15	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.15	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.15	6.15	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.15	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.15	6.15	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	6.15	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.07	6.07	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	6.15	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.01	6.01	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	6.07	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.11	6.11	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.12	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.12	6.12	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.12	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.11	6.11	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	6.12	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.01	6.01	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	6.11	12.23	HGL ok
P-190	DI-190	DI-191	1.20	5.92	5.92	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	6.01	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	5.87	5.87	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	5.89	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.83	5.83	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	5.87	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	6.90	6.90	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.91	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	6.77	6.77	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	6.90	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	6.90	6.90	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.91	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	6.89	6.89	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.89	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	6.89	6.89	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	6.89	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	7.29	7.29	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	7.41	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	7.28	7.28	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.29	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	6.99	6.99	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	7.28	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	6.89	6.89	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	6.99	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	6.77	6.77	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	6.89	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	6.69	6.69	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	6.77	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	6.78	6.78	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.78	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	6.77	6.77	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	6.78	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	6.77	6.77	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	6.77	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.59	6.59	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	6.69	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.37	6.37	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	6.59	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.26	6.26	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	6.37	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.24	6.24	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	6.26	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.23	6.23	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	6.24	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.12	6.12	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	6.23	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.09	6.09	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	6.12	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	6.03	6.03	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	6.09	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.98	5.98	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	6.03	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.94**	**5.94**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**5.98**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.69	6.69	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.69	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.59	6.59	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	6.60	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.69	6.69	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	6.72	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.59	6.59	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.63	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.26	6.26	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.28	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.23	6.23	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.24	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.09	6.09	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.11	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.09	6.09	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.10	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.32	6.32	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.32	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.31	6.31	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	6.32	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.30	6.30	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	6.31	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.26	6.26	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	6.30	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.30	6.30	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.30	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.61	6.61	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.62	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.55	6.55	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	6.61	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.48	6.48	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	6.55	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.41	6.41	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	6.48	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.35	6.35	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	6.41	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.23	6.23	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	6.35	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.35	6.35	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.36	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.51	6.51	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.52	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.48	6.48	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	6.51	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.24	6.24	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.24	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.14	6.14	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.14	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.14	6.14	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	6.14	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.13	6.13	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	6.14	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.12	6.12	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	6.13	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.27	6.27	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.27	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.35	6.35	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.35	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.35	6.35	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.35	6.35	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	6.35	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.27	6.27	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	6.35	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.21	6.21	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	6.27	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.31	6.31	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.32	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.32	6.32	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.32	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.31	6.31	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	6.32	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.21	6.21	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	6.31	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.12	6.12	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	6.21	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.07	6.07	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	6.09	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	6.03	6.03	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	6.07	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	of
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077.001
Segment:	Jones Street Outfall	Design Freq.:	10	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.40	10.40	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.41	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.27	10.27	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	10.40	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.40	10.40	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.41	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.39	10.39	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.39	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.39	10.39	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.39	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.79	10.79	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	10.91	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.78	10.78	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.79	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.49	10.49	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	10.78	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.39	10.39	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	10.49	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.27	10.27	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	10.39	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.19	10.19	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	10.27	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.28	10.28	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.28	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.27	10.27	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	10.28	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.27	10.27	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	10.27	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.09	10.09	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	10.19	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.87	9.87	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	10.09	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.76	9.76	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	9.87	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.74	9.74	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	9.76	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.73	9.73	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	9.74	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.62	9.62	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	9.73	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.59	9.59	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	9.62	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.53	9.53	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	9.59	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.48	9.48	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	9.53	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.44**	**9.44**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**9.48**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.19	10.19	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.19	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.09	10.09	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.10	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.19	10.19	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.22	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.09	10.09	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.13	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.76	9.76	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.78	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.73	9.73	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.74	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.59	9.59	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.61	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.59	9.59	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.60	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.82	9.82	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.81	9.81	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.82	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.80	9.80	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	9.81	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.76	9.76	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	9.80	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.80	9.80	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.80	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.11	10.11	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.12	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.05	10.05	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	10.11	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	9.98	9.98	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	10.05	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.91	9.91	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	9.98	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.85	9.85	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	9.91	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.73	9.73	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	9.85	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.85	9.85	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.86	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.01	10.01	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.02	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.98	9.98	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	10.01	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.74	9.74	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.74	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.64	9.64	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.64	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.64	9.64	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	9.64	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.63	9.63	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	9.64	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.62	9.62	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	9.63	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.77	9.77	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.77	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.85	9.85	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.85	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.85	9.85	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.85	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.85	9.85	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.85	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.77	9.77	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	9.85	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.71	9.71	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	9.77	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.81	9.81	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.82	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.82	9.82	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.81	9.81	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.82	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.71	9.71	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	9.81	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.62	9.62	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	9.71	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.57	9.57	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	9.59	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.53	9.53	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	9.57	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.90	10.90	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.91	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.77	10.77	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	10.90	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.90	10.90	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.91	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.89	10.89	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.89	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.89	10.89	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.89	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.29	11.29	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	11.41	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.28	11.28	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.29	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.99	10.99	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	11.28	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.89	10.89	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	10.99	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.77	10.77	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	10.89	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.69	10.69	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	10.77	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.78	10.78	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.78	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.77	10.77	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	10.78	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.77	10.77	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	10.77	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.59	10.59	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	10.69	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.37	10.37	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	10.59	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.26	10.26	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	10.37	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.24	10.24	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	10.26	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.23	10.23	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	10.24	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.12	10.12	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	10.23	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.09	10.09	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	10.12	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.03	10.03	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	10.09	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.98	9.98	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	10.03	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.94**	**9.94**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**9.98**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.69	10.69	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.69	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.59	10.59	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.60	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.69	10.69	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.72	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.59	10.59	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.63	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.26	10.26	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.28	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.23	10.23	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.24	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.09	10.09	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.11	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.09	10.09	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.10	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.32	10.32	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.31	10.31	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.32	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.30	10.30	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	10.31	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.26	10.26	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	10.30	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.30	10.30	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.30	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.61	10.61	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.62	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.55	10.55	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	10.61	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.48	10.48	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	10.55	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.41	10.41	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	10.48	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.35	10.35	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	10.41	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.23	10.23	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	10.35	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.35	10.35	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.36	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.51	10.51	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.52	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.48	10.48	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	10.51	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.24	10.24	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.24	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.14	10.14	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.14	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.14	10.14	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.14	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.13	10.13	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	10.14	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.12	10.12	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	10.13	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.27	10.27	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.27	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.35	10.35	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.35	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.35	10.35	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.35	10.35	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.35	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.27	10.27	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	10.35	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.21	10.21	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	10.27	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.31	10.31	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.32	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.32	10.32	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.31	10.31	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.32	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.21	10.21	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	10.31	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.12	10.12	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	10.21	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.07	10.07	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	10.09	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.03	10.03	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	10.07	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.30	11.30	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.31	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.17	11.17	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	11.30	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.30	11.30	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.31	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.29	11.29	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.29	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.29	11.29	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.29	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.69	11.69	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	11.81	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.68	11.68	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.69	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.39	11.39	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	11.68	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.29	11.29	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	11.39	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.17	11.17	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	11.29	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.09	11.09	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	11.17	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.18	11.18	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.18	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.17	11.17	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	11.18	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.17	11.17	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	11.17	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.99	10.99	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	11.09	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.77	10.77	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	10.99	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.66	10.66	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	10.77	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.64	10.64	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	10.66	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.63	10.63	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	10.64	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.52	10.52	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	10.63	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.49	10.49	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	10.52	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.43	10.43	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	10.49	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.38	10.38	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	10.43	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.34**	**10.34**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**10.38**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.09	11.09	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.09	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.99	10.99	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.00	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.09	11.09	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.12	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.99	10.99	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.03	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.66	10.66	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.68	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.63	10.63	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.64	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.49	10.49	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.51	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.49	10.49	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.50	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.72	10.72	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.72	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.71	10.71	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.72	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.70	10.70	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	10.71	7.12	HGL Too High!

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County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.66	10.66	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	10.70	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.70	10.70	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.70	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.01	11.01	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.02	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.95	10.95	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	11.01	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.88	10.88	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	10.95	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.81	10.81	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	10.88	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.75	10.75	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	10.81	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.63	10.63	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	10.75	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.75	10.75	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.76	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.91	10.91	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.92	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.88	10.88	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	10.91	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.64	10.64	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.64	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.54	10.54	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.54	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.54	10.54	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	10.54	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.53	10.53	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	10.54	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.52	10.52	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	10.53	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.67	10.67	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.67	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.75	10.75	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.75	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.75	10.75	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	10.75	10.75	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.75	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.67	10.67	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	10.75	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.61	10.61	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	10.67	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.71	10.71	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.72	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.72	10.72	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.72	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	10.71	10.71	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.72	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.61	10.61	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	10.71	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.52	10.52	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	10.61	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.47	10.47	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	10.49	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.43	10.43	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	10.47	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.80	11.80	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.81	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.67	11.67	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	11.80	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.80	11.80	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.81	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.79	11.79	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.79	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.79	11.79	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.79	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.19	12.19	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	12.31	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.18	12.18	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.19	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.89	11.89	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	12.18	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.79	11.79	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	11.89	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.67	11.67	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	11.79	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.59	11.59	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	11.67	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.68	11.68	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.68	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.67	11.67	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	11.68	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.67	11.67	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	11.67	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.49	11.49	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	11.59	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.27	11.27	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	11.49	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.16	11.16	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	11.27	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.14	11.14	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	11.16	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.13	11.13	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	11.14	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.02	11.02	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	11.13	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.99	10.99	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	11.02	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.93	10.93	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	10.99	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.88	10.88	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	10.93	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.84**	**10.84**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**10.88**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.59	11.59	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.59	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.49	11.49	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.50	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.59	11.59	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.62	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.49	11.49	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.53	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.16	11.16	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.18	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.13	11.13	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.14	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.99	10.99	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.01	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.99	10.99	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.00	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.22	11.22	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.22	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.21	11.21	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.22	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.20	11.20	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.21	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.16	11.16	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	11.20	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.20	11.20	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.20	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.51	11.51	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.52	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.45	11.45	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	11.51	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.38	11.38	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	11.45	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.31	11.31	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	11.38	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.25	11.25	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	11.31	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.13	11.13	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	11.25	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.25	11.25	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.26	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.41	11.41	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.42	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.38	11.38	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	11.41	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.14	11.14	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.14	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.04	11.04	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.04	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.04	11.04	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	11.04	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.03	11.03	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	11.04	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.02	11.02	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	11.03	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.17	11.17	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.17	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.25	11.25	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.25	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.25	11.25	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.25	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.25	11.25	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.25	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.17	11.17	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	11.25	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.11	11.11	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	11.17	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.21	11.21	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.22	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.22	11.22	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.22	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.21	11.21	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.22	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.11	11.11	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	11.21	12.23	HGL ok
P-190	DI-190	DI-191	1.20	11.02	11.02	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	11.11	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.97	10.97	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	10.99	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.93	10.93	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	10.97	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.50	12.50	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.51	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.37	12.37	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	12.50	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.50	12.50	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.51	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.49	12.49	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.49	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.49	12.49	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	12.49	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.89	12.89	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	13.01	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.88	12.88	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.89	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.59	12.59	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	12.88	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.49	12.49	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	12.59	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.37	12.37	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	12.49	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.29	12.29	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	12.37	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.38	12.38	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.38	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.37	12.37	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	12.38	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.37	12.37	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	12.37	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.19	12.19	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	12.29	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.97	11.97	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	12.19	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.86	11.86	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	11.97	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.84	11.84	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	11.86	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.83	11.83	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	11.84	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.72	11.72	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	11.83	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.69	11.69	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	11.72	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.63	11.63	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	11.69	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	11.58	11.58	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	11.63	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**11.54**	**11.54**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**11.58**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.29	12.29	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.29	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.19	12.19	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	12.20	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.29	12.29	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.32	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.19	12.19	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.23	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.86	11.86	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.88	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.83	11.83	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.84	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.69	11.69	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.71	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.69	11.69	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.70	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.92	11.92	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.92	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.91	11.91	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.92	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.90	11.90	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.91	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.86	11.86	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	11.90	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.90	11.90	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.90	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.21	12.21	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.22	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.15	12.15	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	12.21	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.08	12.08	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	12.15	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.01	12.01	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	12.08	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.95	11.95	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	12.01	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.83	11.83	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	11.95	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.95	11.95	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.96	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.11	12.11	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.12	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.08	12.08	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	12.11	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.84	11.84	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.84	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.74	11.74	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.74	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.74	11.74	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	11.74	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.73	11.73	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	11.74	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.72	11.72	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	11.73	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.87	11.87	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.87	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.95	11.95	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.95	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.95	11.95	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.95	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.95	11.95	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.95	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.87	11.87	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	11.95	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.81	11.81	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	11.87	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.91	11.91	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.92	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.92	11.92	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.92	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.91	11.91	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.92	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.81	11.81	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	11.91	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.72	11.72	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	11.81	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.67	11.67	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	11.69	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.63	11.63	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	11.67	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.00	13.00	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.01	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.87	12.87	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	13.00	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.00	13.00	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.01	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.99	12.99	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.99	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.99	12.99	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	12.99	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.39	13.39	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	13.51	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.38	13.38	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.39	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.09	13.09	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	13.38	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.99	12.99	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	13.09	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.87	12.87	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	12.99	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.79	12.79	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	12.87	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.88	12.88	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.88	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.87	12.87	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	12.88	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.87	12.87	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	12.87	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.69	12.69	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	12.79	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.47	12.47	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	12.69	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.36	12.36	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	12.47	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	12.34	12.34	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	12.36	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	12.33	12.33	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	12.34	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	12.22	12.22	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	12.33	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	12.19	12.19	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	12.22	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	12.13	12.13	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	12.19	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	12.08	12.08	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	12.13	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**12.04**	**12.04**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**12.08**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.79	12.79	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.79	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.69	12.69	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	12.70	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.79	12.79	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.82	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.69	12.69	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.73	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.36	12.36	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.38	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	12.33	12.33	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.34	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	12.19	12.19	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.21	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	12.19	12.19	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.20	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.42	12.42	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.42	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.41	12.41	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	12.42	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.40	12.40	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	12.41	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.36	12.36	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	12.40	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.40	12.40	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.40	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.71	12.71	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.72	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.65	12.65	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	12.71	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.58	12.58	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	12.65	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.51	12.51	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	12.58	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.45	12.45	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	12.51	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	12.33	12.33	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	12.45	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.45	12.45	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.46	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.61	12.61	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.62	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.58	12.58	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	12.61	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	12.34	12.34	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.34	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	12.24	12.24	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.24	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	12.24	12.24	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	12.24	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	12.23	12.23	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	12.24	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	12.22	12.22	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	12.23	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.37	12.37	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.37	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.45	12.45	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.45	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.45	12.45	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.45	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.45	12.45	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	12.45	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.37	12.37	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	12.45	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.31	12.31	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	12.37	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.41	12.41	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.42	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.42	12.42	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.42	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.41	12.41	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	12.42	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.31	12.31	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	12.41	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	12.22	12.22	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	12.31	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	12.17	12.17	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	12.19	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	12.13	12.13	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	12.17	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	14.30	14.30	15	1.1	0.9	95	16	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.31	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	14.17	14.17	15	2.0	1.6	91	154	0.0008	0.13	0	0.00	0.01	0.7	0.9	0.0	0.9	0.0	95	0.01	0.02	1.0	0.5	0.01	0.14	14.30	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	14.30	14.30	15	0.9	0.8	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.31	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	14.29	14.29	15	0.5	0.4	109	16	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.29	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	14.29	14.29	15	0.5	0.4	104	18	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	14.29	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	14.69	14.69	12	1.8	2.3	0	47	0.0022	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	14.81	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	14.68	14.68	12	0.5	0.6	90	82.1	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.69	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	14.39	14.39	12	2.6	3.4	72	41	0.0047	0.19	0	0.00	0.04	0.3	4.1	0.0	2.3	0.0	0	0.00	0.07	1.3	1.0	0.09	0.29	14.68	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	14.29	14.29	18	2.6	1.5	77	26	0.0005	0.01	0	0.00	0.01	8.9	0.0	0.0	3.4	0.1	72	0.11	0.18	1.0	0.5	0.09	0.10	14.39	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	14.17	14.17	18	3.1	1.8	90	129	0.0007	0.10	0	0.00	0.01	3.9	0.2	0.0	1.5	0.0	77	0.02	0.05	1.0	0.5	0.02	0.12	14.29	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	14.09	14.09	18	5.8	3.3	3	14	0.0026	0.04	0	0.00	0.04	5.4	0.4	3.3	1.8	0.0	90	0.03	0.09	1.0	0.5	0.05	0.08	14.17	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	14.18	14.18	15	0.5	0.4	70	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.18	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	14.17	14.17	15	0.9	0.7	22	5	0.0002	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	70	0.00	0.00	1.3	1.0	0.01	0.01	14.18	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	14.17	14.17	18	0.9	0.5	2	25	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	22	0.00	0.01	1.0	0.5	0.00	0.00	14.17	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	13.99	13.99	24	6.7	2.1	4	60	0.0008	0.05	0	0.00	0.02	18.9	0.5	0.2	3.3	0.1	3	0.02	0.09	1.0	0.5	0.05	0.09	14.09	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	13.77	13.77	24	10.6	3.4	4	82	0.0019	0.15	0	0.00	0.04	14.3	7.9	0.0	2.1	0.0	4	0.01	0.08	1.0	1.0	0.08	0.23	13.99	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	13.66	13.66	36	10.8	1.5	7	59	0.0002	0.01	0	0.00	0.01	35.6	0.0	0.0	3.4	0.1	4	0.02	0.09	1.0	1.0	0.09	0.10	13.77	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	13.64	13.64	48	13.6	1.1	3	54	0.0001	0.00	0	0.00	0.00	16.5	4.7	5.1	1.5	0.0	7	0.00	0.02	1.0	1.0	0.02	0.03	13.66	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	13.63	13.63	48	13.8	1.1	3	68	0.0001	0.01	0	0.00	0.00	14.8	0.1	0.0	1.1	0.0	3	0.00	0.01	1.0	0.5	0.01	0.01	13.64	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	13.52	13.52	48	15.8	1.3	4	180	0.0001	0.02	0	0.00	0.01	15.2	15.5	2.0	2.2	0.0	88	0.05	0.09	1.0	1.0	0.09	0.11	13.63	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	13.49	13.49	48	19.4	1.5	2	58	0.0002	0.01	0	0.00	0.01	19.9	0.8	5.3	1.3	0.0	4	0.00	0.02	1.0	1.0	0.02	0.03	13.52	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	13.43	13.43	48	24.6	2.0	0	158	0.0002	0.04	0	0.00	0.01	29.9	2.4	2.4	1.5	0.0	2	0.00	0.03	1.0	1.0	0.03	0.07	13.49	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	13.38	13.38	48	25.9	2.1	16	35	0.0003	0.01	0	0.00	0.02	48.0	2.5	0.0	2.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.05	13.43	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**13.34**	**13.34**	**48**	**25.8**	**2.1**	**0**	**48**	**0.0003**	**0.01**	**0**	**0.00**	**0.02**	**53.5**	**0.0**	**0.0**	**2.1**	**0.0**	**16**	**0.01**	**0.05**	**1.0**	**0.5**	**0.03**	**0.04**	**13.38**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	14.09	14.09	15	0.5	0.4	0	44	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.09	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	13.99	13.99	15	0.8	0.6	88	25	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	14.00	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	14.09	14.09	8	0.2	0.7	93	96	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	14.12	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	13.99	13.99	18	3.7	2.1	90	23	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	14.03	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	13.66	13.66	18	2.9	1.6	90	19	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.68	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	13.63	13.63	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.64	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	13.49	13.49	18	2.1	1.2	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.51	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	13.49	13.49	18	2.1	1.2	90	18	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.50	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	13.72	13.72	18	1.0	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.72	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	13.71	13.71	18	1.3	0.7	0	54	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	13.72	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	13.70	13.70	24	1.7	0.6	90	91	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	13.71	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	13.66	13.66	24	4.0	1.3	94	33	0.0003	0.01	0	0.00	0.01	1.0	1.4	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.03	13.70	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	13.70	13.70	18	1.5	0.9	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.70	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	14.01	14.01	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.02	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	13.95	13.95	18	2.3	1.3	90	68	0.0004	0.03	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.03	0.06	14.01	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	13.88	13.88	18	2.7	1.5	79	29	0.0005	0.02	0	0.00	0.01	3.0	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	13.95	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	13.81	13.81	24	4.6	1.5	69	46	0.0004	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	79	0.02	0.04	1.3	1.0	0.06	0.07	13.88	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	13.75	13.75	24	4.9	1.5	80	44	0.0004	0.02	0	0.00	0.01	6.8	0.0	0.0	1.5	0.0	69	0.02	0.04	1.0	1.0	0.04	0.06	13.81	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	13.63	13.63	24	7.0	2.2	88	29	0.0008	0.02	0	0.00	0.02	7.5	15.5	0.0	2.2	0.0	88	0.05	0.10	1.0	1.0	0.10	0.12	13.75	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	13.75	13.75	18	1.7	1.0	90	19	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.76	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	13.91	13.91	18	1.3	0.7	90	22	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.92	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	13.88	13.88	18	1.6	0.9	12	68	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	90	0.01	0.01	1.3	1.0	0.02	0.03	13.91	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	13.64	13.64	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.64	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	13.54	13.54	18	0.5	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.54	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	13.54	13.54	18	0.7	0.4	80	34	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.00	13.54	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	13.53	13.53	18	0.9	0.5	12	49	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	80	0.00	0.00	1.3	1.0	0.00	0.01	13.54	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	13.52	13.52	18	1.2	0.7	98	23	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	12	0.00	0.00	1.3	1.0	0.00	0.01	13.53	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	13.67	13.67	18	0.3	0.1	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.67	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	13.75	13.75	18	1.4	0.8	90	23	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.75	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	13.75	13.75	18	0.3	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.75	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	13.75	13.75	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	13.75	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	13.67	13.67	18	2.4	1.4	70	108	0.0005	0.05	0	0.00	0.01	0.2	1.1	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.07	13.75	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	13.61	13.61	18	2.9	1.6	57	27	0.0006	0.02	0	0.00	0.01	3.4	0.0	0.0	1.4	0.0	70	0.02	0.04	1.3	1.0	0.05	0.07	13.67	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	13.71	13.71	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.72	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	13.72	13.72	18	0.3	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.72	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	13.71	13.71	18	0.7	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	13.72	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	13.61	13.61	18	2.8	1.6	14	119	0.0006	0.07	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	13.71	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	13.52	13.52	18	3.1	1.7	67	50	0.0007	0.04	0	0.00	0.01	4.5	4.7	0.0	1.6	0.0	57	0.02	0.05	1.0	1.0	0.05	0.08	13.61	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	13.47	13.47	18	1.9	1.1	105	53	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	13.49	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	13.43	13.43	18	2.1	1.2	90	43	0.0003	0.01	0	0.00	0.01	2.0	0.0	0.0	1.1	0.0	105	0.01	0.02	1.3	1.0	0.03	0.05	13.47	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 25 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
CRB Network STA 109+25 to 111+75																										
CRB-P72	CRB-DI72	CRB-MH-74	7961	0	7961	0.18	1.00	0.18	0.18	6.0	0.00	6.84	1.3	15	16	0.012	0.0003	0.019	7.8	9.6	5.5	0.05	6.05	2.60	2.30	Q ok
CRB-P74	CRB-MH-74	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.34	6.0	6.19	6.78	2.3	15	154	0.012	0.0011	0.005	4.1	5.1	4.0	0.64	6.83	1.65	0.84	Q ok
CRB-P73	CRB-DI73	CRB-MH-74	7042	0	7042	0.16	1.00	0.16	0.16	6.0	0.00	6.84	1.1	15	34	0.012	0.0002	0.005	4.0	4.9	3.0	0.19	6.19	1.92	1.75	Q ok
MSS Network Sta 111+75 to 114+00																										
P-162	DI-162	EXMH-201	3794	0	3794	0.09	1.00	0.09	0.09	6.0	0.00	6.84	**0.60**	15	16	0.011	0.000061	0.0200	8.8	**10.8**	4.3	0.06	6.06	2.50	2.18	Q ok
P-201	EXMH-201	A1-MH-203	1	0	1	0.00	1.00	0.00	0.09	6.0	6.06	6.81	**0.59**	15	18	0.012	0.000072	0.0200	8.1	**9.9**	3.9	0.08	6.14	1.98	1.62	Q ok
Ploener Property																										
EX-P LOT	EXDI LOT	DI-MSS-41	13430	0	13430	0.31	1.00	0.31	0.31	6.0	0.00	6.84	**2.11**	12	47	0.012	0.002985	0.0074	4.2	**3.3**	4.5	0.17	6.17	2.50	2.15	Q ok
P-MSS-48	DI-MSS-40	DI-MSS-41	3590	0	3590	0.08	1.00	0.08	0.08	6.0	0.00	6.84	**0.56**	12	82	0.012	0.000213	0.0050	3.5	**2.7**	2.6	0.53	6.53	2.56	2.15	Q ok
P-MSS-48A	DI-MSS-41	EX-MH	3072	0	3072	0.07	1.00	0.07	0.46	6.0	6.53	6.70	**3.09**	12	41	0.012	0.006401	0.0051	3.5	**2.8**	2.9	0.24	6.76	2.05	1.84	Undersized!
A1-P-202	EX-MH	A1-MH-203	1	0	1	0.00	1.00	0.00	0.46	6.0	6.76	6.61	**3.05**	18	26	0.012	0.000717	0.0046	4.4	**7.7**	4.0	0.11	6.87	1.74	1.62	Q ok
A1-P-204	A1-MH-204	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.55	6.0	6.87	6.58	**3.61**	18	129	0.012	0.001005	0.0052	4.6	**8.2**	4.5	0.48	7.35	1.52	0.85	Q ok
A1-P-205	CRB-MH-67	CMH-1	1	0	1	0.00	1.00	0.00	1.05	6.0	7.35	6.46	**6.79**	18	14	0.012	0.003559	0.0057	4.9	**8.6**	5.5	0.04	7.39	0.75	0.67	Q ok
MSS Network Sta 111+75 to 114+00																										
MSS-P2	MSS-DI2	MSS-DI1	3846	1139	4985	0.11	0.85	0.10	0.10	6.0	0.00	6.84	0.7	15	70	0.012	0.0001	0.005	4.0	4.9	2.8	0.42	6.42	4.03	3.68	Q ok
MSS-P1	MSS-DI1	EXMH	2301	1082	3383	0.08	0.77	0.06	0.16	6.0	6.42	6.72	1.1	15	5	0.012	0.0002	0.003	3.3	4.0	2.7	0.03	6.45	3.39	3.37	Q ok
A1-P-203	EX MH	MH-CRB-67	1	0	1	0.00	1.00	0.00	0.16	6.0	6.45	6.72	**1.06**	18	25	0.012	0.000087	0.0050	4.6	**8.0**	3.2	0.13	6.58	0.92	0.84	Q ok
Jones Street Constructed Under Area 1																										
A1-P-206	CMH-1	A1-DI-207	1	0	1	0.00	1.00	0.00	1.23	6.0	7.39	6.43	**7.93**	24	60	0.012	0.001047	0.0035	4.6	**14.5**	4.7	0.21	7.60	0.57	0.36	Q ok
A1-P-207	A1-DI-207	A1-DI-208	3414	0	3414	0.08	1.00	0.08	1.95	6.0	7.60	6.38	**12.44**	24	82	0.012	0.002576	0.0040	4.9	**15.5**	5.5	0.25	7.85	0.36	0.03	Q ok
A1-P-208	A1-DI-208	A1-DI-209	2490	0	2490	0.06	1.00	0.06	2.01	6.0	7.85	6.32	**12.69**	36	59	0.012	0.000308	0.0041	6.5	**46.1**	5.5	0.18	8.03	0.03	-0.21	Q ok
A1-P-209	A1-DI-209	A1-MH-210	2433	0	2433	0.06	1.00	0.06	2.56	6.0	8.03	6.26	**16.02**	48	54	0.012	0.000106	0.0041	7.9	**99.3**	5.5	0.16	8.19	-0.21	-0.43	Q ok
A1-P-210	A1-MH-210	A1-DI-211	1	0	1	0.00	1.00	0.00	2.62	6.0	8.19	6.20	**16.24**	48	68	0.012	0.000109	0.0040	7.8	**98.1**	5.5	0.21	8.40	-0.43	-0.70	Q ok
A1-P-211	A1-DI-211	A1-DI-212	3353	0	3353	0.08	1.00	0.08	3.02	6.0	8.40	6.14	**18.56**	48	180	0.012	0.000142	0.0040	7.8	**98.4**	5.9	0.51	8.91	-0.70	-1.42	Q ok
A1-P-212	A1-DI-212	A1-DI-213	1885	0	1885	0.04	1.00	0.04	3.78	6.0	8.91	6.00	**22.69**	48	58	0.012	0.000213	0.0040	7.8	**98.0**	6.4	0.15	9.06	-1.42	-1.65	Q ok
A1-P-213	A1-DI-213	A1-DI-214	15288	0	15288	0.35	1.00	0.35	4.84	6.0	9.06	5.94	**28.74**	48	158	0.012	0.000341	0.0040	7.8	**98.3**	6.6	0.40	9.46	-1.65	-2.28	Q ok
A1-P-214	A1-DI-214	A1-DI-215	**1**	0	1	0.00	1.00	0.00	5.20	6.0	9.46	5.83	**30.30**	48	35	0.012	0.000379	0.0040	7.8	**98.4**	6.7	0.09	9.54	-2.28	-2.42	Q ok
A1-P-215	A1-DI-215	A1-MH-216	**1**	0	1	0.00	1.00	0.00	5.20	6.0	9.54	5.83	**30.30**	48	48	0.012	0.000379	0.0040	7.8	**97.9**	6.6	0.12	9.66	-2.42	-2.61	Q ok
MSS-P3 A	MSS-DI14	DI-161	3612	330	3942	0.09	0.97	0.09	0.09	6.0	0.00	6.84	0.6	15	44	0.012	0.0001	0.005	4.0	4.9	2.4	0.30	6.30	4.03	3.81	Q ok
MSS-P3 B	DI-161	MSS-DI13	2062	222	2284	0.05	0.96	0.05	0.14	6.0	6.30	6.75	0.9	15	25	0.012	0.0002	0.005	4.1	5.0	3.0	0.14	6.44	3.81	3.68	Q ok
	DOGHOUSE																									
P-160	DI-160	CMH-1	1768	257	2025	0.05	0.94	0.04	0.04	6.0	0.00	6.84	**0.30**	8	96	0.011	0.000436	0.0200	5.8	**2.0**	4.1	0.40	6.40	2.99	1.07	Q ok
A1 P-200	PARCEL J	A1-DI-207	27861	0	27861	0.64	1.00	0.64	0.64	6.0	0.00	6.84	**4.37**	18	23	0.012	0.001478	0.0100	6.4	11.4	5.9	0.06	6.06	1.59	1.36	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/2023 | Sheet No.: 1 of 1
County: New Castle | Checked by: TMC | Date: 3/23/2023 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Storm Frequency: 25 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-336	PARCEL J	A1-DI-209	21549	0	21549	0.49	1.00	0.49	0.49	6.0	0.00	6.84	**3.38**	18	19	0.012	0.000884	0.0100	6.4	11.4	5.5	0.06	6.06	1.48	1.29	Q ok
P-337	PARCEL J	A1-DI-211	14148	0	14148	0.32	1.00	0.32	0.32	6.0	0.00	6.84	**2.22**	18	23	0.012	0.000381	0.0100	6.4	11.4	4.8	0.08	6.08	1.53	1.30	Q ok
P-335	PARCEL N	A1-DI-213	15379	0	15379	0.35	1.00	0.35	0.35	6.0	0.00	6.84	**2.41**	18	56	0.012	0.000450	0.0100	6.4	11.4	4.8	0.19	6.19	1.91	1.35	Q ok
P-340	PARCEL K	A1-DI-213	15267	0	15267	0.35	1.00	0.35	0.35	6.0	0.00	6.84	**2.40**	18	18	0.012	0.000444	0.0100	6.4	11.4	4.8	0.06	6.06	1.53	1.35	Q ok
P-165	DI-165	DI-166	7237	0	7237	0.17	1.00	0.17	0.17	6.0	0.00	6.84	**1.14**	18	28	0.012	0.000100	0.0100	6.4	**11.4**	3.9	0.12	6.12	2.95	2.67	Q ok
P-166	DI-166	DI-167	2265	0	2265	0.05	1.00	0.05	0.22	6.0	6.12	6.81	**1.49**	18	54	0.012	0.000170	0.0100	6.4	**11.4**	4.5	0.20	6.32	2.47	1.93	Q ok
P-167	DI-167	DI-168	3648	0	3648	0.08	1.00	0.08	0.30	6.0	6.32	6.75	**2.04**	24	91	0.012	0.000069	0.0100	7.8	**24.5**	4.7	0.32	6.64	1.73	0.82	Q ok
P-168	DI-168	DI-209	6136	0	6136	0.14	1.00	0.14	0.71	6.0	6.64	6.67	**4.71**	24	33	0.012	0.000370	0.0100	7.8	**24.5**	5.9	0.09	6.74	0.62	0.29	Q ok
P-327	PARCEL L	DI-168	11517	0	11517	0.26	1.00	0.26	0.26	6.0	0.00	6.84	**1.81**	18	19	0.012	0.000253	0.0100	6.4	11.4	4.5	0.07	6.07	1.31	1.12	Q ok
P-326	PARCEL L	DI-170	14378	0	14378	0.33	1.00	0.33	0.33	6.0	0.00	6.84	**2.26**	18	23	0.012	0.000394	0.0100	6.4	11.4	4.8	0.08	6.08	3.99	3.76	Q ok
P-170	DI-170	DI-171	2801	0	2801	0.06	1.00	0.06	0.39	6.0	6.08	6.81	**2.69**	18	68	0.012	0.000557	0.0100	6.4	**11.4**	5.3	0.21	6.29	3.26	2.58	Q ok
P-171	DI-171	DI-173	2811	0	2811	0.06	1.00	0.06	0.46	6.0	6.29	6.75	**3.10**	18	29	0.012	0.000742	0.0100	6.4	**11.4**	5.3	0.09	6.39	2.38	2.09	Q ok
P-173	DI-173	DI-174	2818	0	2818	0.06	1.00	0.06	0.81	6.0	6.39	6.72	**5.42**	24	46	0.012	0.000488	0.0100	7.8	**24.5**	5.9	0.13	6.52	1.89	1.43	Q ok
P-174	DI-174	DI-175	1817	0	1817	0.04	1.00	0.04	0.85	6.0	6.52	6.70	**5.67**	24	44	0.012	0.000535	0.0100	7.8	**24.5**	6.4	0.11	6.63	1.23	0.79	Q ok
P-175	DI-175	DI-211	3620	0	3620	0.08	1.00	0.08	1.23	6.0	6.63	6.67	**8.18**	24	29	0.012	0.001113	0.0100	7.8	**24.5**	7.0	0.07	6.70	0.59	0.30	Q ok
P-331	PARCEL M	DI-175	12913	0	12913	0.30	1.00	0.30	0.30	6.0	0.00	6.84	**2.03**	18	19	0.012	0.000317	0.0100	6.4	11.4	4.8	0.07	6.07	1.28	1.09	Q ok
P-328	PARCEL M	DI-172	9475	0	9475	0.22	1.00	0.22	0.22	6.0	0.00	6.84	**1.49**	18	22	0.012	0.000171	0.0100	6.4	11.4	4.5	0.08	6.08	3.49	3.27	Q ok
P-172	DI-172	DI-173	2798	0	2798	0.06	1.00	0.06	0.28	6.0	6.08	6.81	**1.92**	18	68	0.012	0.000284	0.0100	6.4	**11.4**	4.5	0.25	6.33	2.77	2.09	Q ok
P-169	DI-169	MH-210	2626	0	2626	0.06	1.00	0.06	0.06	6.0	0.00	6.84	**0.41**	18	7	0.012	0.000013	0.0100	6.4	**11.4**	3.2	0.04	6.04	1.64	1.57	Q ok
P-178	DI-178	DI-179	3573	0	3573	0.08	1.00	0.08	0.08	6.0	0.00	6.84	**0.56**	18	39	0.012	0.000024	0.0100	6.4	**11.4**	3.2	0.21	6.21	2.63	2.24	Q ok
P-179	DI-179	DI-180	1913	0	1913	0.04	1.00	0.04	0.13	6.0	0.00	6.84	**0.86**	18	34	0.012	0.000057	0.0100	6.4	**11.4**	3.9	0.15	6.15	2.04	1.70	Q ok
P-180	DI-180	DI-181	1165	0	1165	0.03	1.00	0.03	0.15	6.0	0.00	6.84	**1.04**	18	49	0.012	0.000084	0.0100	6.4	**11.4**	3.9	0.21	6.21	1.50	1.01	Q ok
P-181	DI-181	DI-212	1967	0	1967	0.05	1.00	0.05	0.20	6.0	0.00	6.84	**1.35**	18	23	0.012	0.000141	0.0100	6.4	**11.4**	3.9	0.10	6.10	0.81	0.58	Q ok
P-182	DI-182	DI-186	1887	0	1887	0.04	1.00	0.04	0.04	6.0	0.00	6.84	**0.30**	18	43	0.012	0.000007	0.0100	6.4	**11.4**	3.2	0.23	6.23	4.28	3.85	Q ok
P-338	PARCEL J	DI-185	10195	0	10195	0.23	1.00	0.23	0.23	6.0	0.00	6.84	**1.60**	18	23	0.012	0.000198	0.0100	6.4	11.4	4.5	0.09	6.09	3.86	3.63	Q ok

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Segment: Jones Street Outfall Storm Frequency: 25 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-183	DI-183	DI-184	2436	0	2436	0.06	1.00	0.06	0.06	6.0	0.00	6.84	**0.38**	18	59	0.012	0.000011	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.74	4.15	Q ok
P-184	DI-184	DI-185	2508	0	2508	0.06	1.00	0.06	0.11	6.0	0.00	6.84	**0.78**	18	62	0.012	0.000047	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.95	3.33	Q ok
P-185	DI-185	DI-186	3002	0	3002	0.07	1.00	0.07	0.42	6.0	0.00	6.84	**2.85**	18	108	0.012	0.000627	0.0100	6.4	**11.4**	5.3	0.34	6.34	3.13	2.05	Q ok
P-186	DI-186	DI-190	1354	0	1354	0.03	1.00	0.03	0.49	6.0	0.00	6.84	**3.36**	18	27	0.012	0.000871	0.0100	6.4	**11.4**	5.5	0.08	6.08	1.85	1.58	Q ok
check San x-ing																										
P-339	PARCEL K	DI-189	12930	0	12930	0.30	1.00	0.30	0.30	6.0	0.00	6.84	**2.03**	18	23	0.012	0.000318	0.0100	6.4	11.4	4.8	0.08	6.08	3.20	2.97	Q ok
P-187	DI-187	DI-188	2448	0	2448	0.06	1.00	0.06	0.06	6.0	0.00	6.84	**0.38**	18	59	0.012	0.000011	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.08	3.49	Q ok
P-188	DI-188	DI-189	2550	0	2550	0.06	1.00	0.06	0.11	6.0	0.00	6.84	**0.78**	18	62	0.012	0.000048	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.29	2.67	Q ok
P-189	DI-189	DI-190	3025	0	3025	0.07	1.00	0.07	0.48	6.0	0.00	6.84	**3.29**	18	119	0.012	0.000836	0.0100	6.4	**11.4**	5.5	0.36	6.36	2.47	1.28	Q ok
P-190	DI-190	DI-191	1765	0	1765	0.04	1.00	0.04	0.52	6.0	0.00	6.84	**3.57**	18	50	0.012	0.000983	0.0100	6.4	**11.4**	5.5	0.15	6.15	1.08	0.58	Q ok
P-341	PARCEL K	DI-195	13999	0	13999	0.32	1.00	0.32	0.32	6.0	0.00	6.84	**2.20**	18	53	0.012	0.000373	0.0100	6.4	11.4	4.8	0.18	6.18	3.96	3.43	Q ok
P-195	DI-195	A1-DI-214	**1887**	0	1887	0.04	1.00	0.04	0.36	6.0	6.18	6.78	**2.47**	18	43	0.012	0.000472	0.0100	6.4	**11.4**	4.8	0.15	6.33	2.43	2.00	Q ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	4.53	4.53	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.54	5.76	HGL ok
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.34	4.34	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	4.53	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	4.53	4.53	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.54	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	4.51	4.51	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.51	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	4.50	4.50	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	4.51	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	5.05	5.05	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	5.22	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	5.03	5.03	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.05	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	4.64	4.64	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	5.03	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	4.50	4.50	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	4.64	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.34	4.34	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	4.50	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.23	4.23	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	4.34	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.38	4.68	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.35	4.37	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	4.38	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.34	4.34	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	4.35	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.10	4.10	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	4.23	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.79	3.79	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	4.10	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.65	3.65	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	3.79	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.61	3.61	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	3.65	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.59	3.59	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	3.61	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.45	3.45	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	3.59	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.41	3.41	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	3.45	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.32	3.32	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	3.41	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.25	3.25	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	3.32	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.20**	**3.20**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**3.25**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.23	4.81	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.81	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.10	4.68	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.23	4.23	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	4.27	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.10	4.10	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	4.15	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.65	3.65	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.67	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.59	3.59	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.61	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.41	3.41	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	3.44	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.41	3.41	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.42	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.72	3.87	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.87	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.70	3.70	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	3.72	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.69	3.69	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	3.70	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.65	3.65	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	3.69	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.69	3.69	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.70	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.11	4.96	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.03	4.03	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	4.11	10.79	HGL ok
P-171	DI-171	DI-173	1.20	3.94	3.94	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	4.03	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.84	3.84	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	3.94	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.76	3.76	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	3.84	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.59	3.59	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	3.76	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.76	3.76	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.77	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	3.98	4.47	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	3.94	3.94	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	3.98	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.61	3.61	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.61	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.48	3.48	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.48	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.47	3.47	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.48	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.46	3.46	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	3.47	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.45	3.45	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	3.46	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.66	5.05	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.75	4.83	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.75	4.53	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.66	3.66	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	3.75	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.56	3.56	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	3.66	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.71	4.17	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.87	4.69	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.71	3.87	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.87	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.56	3.56	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	3.71	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.45	3.45	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	3.56	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.38	4.63	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.65	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.32	3.32	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	3.38	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	4.73	4.73	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.74	5.76	HGL ok
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.54	4.54	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	4.73	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	4.73	4.73	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.74	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	4.71	4.71	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.71	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	4.70	4.70	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	4.71	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	5.25	5.25	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	5.42	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	5.23	5.23	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.25	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	4.84	4.84	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	5.23	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	4.70	4.70	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	4.84	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.54	4.54	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	4.70	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.43	4.43	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	4.54	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.56	4.68	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.55	4.55	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	4.56	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.54	4.54	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	4.55	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.30	4.30	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	4.43	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.99	3.99	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	4.30	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.85	3.85	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	3.99	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.81	3.81	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	3.85	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.79	3.79	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	3.81	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.65	3.65	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	3.79	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.61	3.61	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	3.65	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.52	3.52	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	3.61	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.45	3.45	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	3.52	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.40**	**3.40**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**3.45**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.43	4.81	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.81	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.30	4.68	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.43	4.43	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	4.47	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.30	4.30	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	4.35	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.85	3.85	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.87	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.79	3.79	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.81	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.61	3.61	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	3.64	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.61	3.61	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.62	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.92	3.92	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.92	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.90	3.90	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	3.92	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.89	3.89	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	3.90	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.85	3.85	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	3.89	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.89	3.89	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.90	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.31	4.96	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.23	4.23	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	4.31	10.79	HGL ok
P-171	DI-171	DI-173	1.20	4.14	4.14	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	4.23	10.30	HGL ok
P-173	DI-173	DI-174	1.60	4.04	4.04	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	4.14	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.96	3.96	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	4.04	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.79	3.79	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	3.96	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.96	3.96	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.97	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	4.18	4.47	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	4.14	4.14	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	4.18	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.81	3.81	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.81	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.68	3.68	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.68	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.67	3.67	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.68	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.66	3.66	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	3.67	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.65	3.65	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	3.66	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.86	5.05	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.95	4.83	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.95	4.53	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.86	3.86	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	3.95	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.76	3.76	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	3.86	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.91	4.17	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.91	4.69	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.91	3.91	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.91	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.76	3.76	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	3.91	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.65	3.65	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	3.76	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.58	4.63	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.65	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.52	3.52	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	3.58	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.23	8.23	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.24	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.04	8.04	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	8.23	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.23	8.23	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.24	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.21	8.21	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.21	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.20	8.20	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	8.21	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.75	8.75	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	8.92	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.73	8.73	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.75	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.34	8.34	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	8.73	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.20	8.20	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	8.34	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.04	8.04	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	8.20	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.93	7.93	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	8.04	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.06	8.06	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.07	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.05	8.05	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	8.06	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.04	8.04	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	8.05	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.80	7.80	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	7.93	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.49	7.49	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	7.80	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.35	7.35	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	7.49	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.31	7.31	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	7.35	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.29	7.29	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	7.31	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.15	7.15	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	7.29	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.11	7.11	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	7.15	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.02	7.02	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	7.11	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.95	6.95	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	7.02	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**6.90**	**6.90**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**6.95**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.93	7.93	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.93	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.80	7.80	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	7.81	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.93	7.93	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	7.97	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.80	7.80	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	7.85	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.35	7.35	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.37	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.29	7.29	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.31	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.11	7.11	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.14	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.11	7.11	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.12	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.42	7.42	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.42	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.40	7.40	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	7.42	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.39	7.39	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	7.40	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.35	7.35	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	7.39	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.39	7.39	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.40	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.81	7.81	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.83	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.73	7.73	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	7.81	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.64	7.64	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	7.73	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.54	7.54	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	7.64	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.46	7.46	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	7.54	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.29	7.29	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	7.46	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.46	7.46	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.47	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.68	7.68	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.69	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.64	7.64	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	7.68	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.31	7.31	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.31	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.18	7.18	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.18	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.17	7.17	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.18	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.16	7.16	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	7.17	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.15	7.15	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	7.16	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.36	7.36	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.36	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.45	7.45	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.46	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.46	7.46	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.46	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.45	7.45	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.46	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.36	7.36	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	7.45	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.26	7.26	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	7.36	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.41	7.41	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.42	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.41	7.41	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.41	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.41	7.41	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.41	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.26	7.26	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	7.41	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.15	7.15	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	7.26	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.08	7.08	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.10	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.02	7.02	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	7.08	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.73	8.73	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.74	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.54	8.54	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	8.73	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.73	8.73	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.74	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.71	8.71	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.71	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.70	8.70	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	8.71	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.25	9.25	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	9.42	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.23	9.23	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.25	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.84	8.84	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	9.23	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.70	8.70	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	8.84	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.54	8.54	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	8.70	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.43	8.43	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	8.54	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.56	8.56	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.57	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.55	8.55	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	8.56	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.54	8.54	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	8.55	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.30	8.30	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	8.43	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.99	7.99	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	8.30	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.85	7.85	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	7.99	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.81	7.81	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	7.85	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.79	7.79	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	7.81	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.65	7.65	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	7.79	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.61	7.61	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	7.65	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.52	7.52	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	7.61	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.45	7.45	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	7.52	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.40**	**7.40**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**7.45**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.43	8.43	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.43	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.30	8.30	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	8.31	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.43	8.43	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	8.47	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.30	8.30	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	8.35	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.85	7.85	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.87	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.79	7.79	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.81	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.61	7.61	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.64	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.61	7.61	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.62	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.92	7.92	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.92	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.90	7.90	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	7.92	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.89	7.89	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	7.90	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.85	7.85	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	7.89	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.89	7.89	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.90	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.31	8.31	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.33	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.23	8.23	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	8.31	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.14	8.14	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	8.23	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.04	8.04	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	8.14	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.96	7.96	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	8.04	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.79	7.79	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	7.96	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.96	7.96	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.97	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.18	8.18	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.19	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.14	8.14	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	8.18	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.81	7.81	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.81	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.68	7.68	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.68	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.67	7.67	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.68	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.66	7.66	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	7.67	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.65	7.65	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	7.66	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.86	7.86	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.86	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.95	7.95	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.96	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.96	7.96	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.96	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.95	7.95	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.96	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.86	7.86	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	7.95	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.76	7.76	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	7.86	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.91	7.91	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.92	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.91	7.91	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.91	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.91	7.91	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.91	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.76	7.76	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	7.91	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.65	7.65	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	7.76	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.58	7.58	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.60	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.52	7.52	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	7.58	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.13	9.13	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.14	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.94	8.94	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	*0.5*	0.02	0.19	9.13	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.13	9.13	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.14	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.11	9.11	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.11	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.10	9.10	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	*0.5*	0.00	0.00	9.11	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.65	9.65	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	9.82	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.63	9.63	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.65	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.24	9.24	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	*1.3*	1.0	0.13	0.39	9.63	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.10	9.10	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	*0.5*	0.12	0.14	9.24	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.94	8.94	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	*0.5*	0.03	0.16	9.10	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.83	8.83	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	*0.5*	0.06	0.11	8.94	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.96	8.96	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.97	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.95	8.95	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	*1.3*	1.0	0.01	0.01	8.96	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.94	8.94	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	*0.5*	0.00	0.01	8.95	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.70	8.70	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	*0.5*	0.06	0.13	8.83	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.39	8.39	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	8.70	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.25	8.25	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	8.39	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.21	8.21	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	8.25	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.19	8.19	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	*0.5*	0.01	0.02	8.21	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.05	8.05	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	8.19	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.01	8.01	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	8.05	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.92	7.92	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	8.01	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.85	7.85	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	7.92	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.80**	**7.80**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	***0.5***	**0.04**	**0.05**	**7.85**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.83	8.83	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.83	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.70	8.70	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	*1.3*	1.0	0.00	0.01	8.71	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.83	8.83	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	8.87	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.70	8.70	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.05	8.75	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	8.25	8.25	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.01	0.02	8.27	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.19	8.19	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	8.21	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.01	8.01	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.03	8.04	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.01	8.01	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	8.02	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.32	8.32	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.32	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.30	8.30	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	*1.3*	1.0	0.01	0.02	8.32	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.29	8.29	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	*1.3*	1.0	0.01	0.01	8.30	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.25	8.25	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	8.29	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.29	8.29	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.30	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.71	8.71	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.73	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.63	8.63	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	8.71	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.54	8.54	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	8.63	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.44	8.44	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	8.54	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.36	8.36	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	8.44	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.19	8.19	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	8.36	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.36	8.36	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.37	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.58	8.58	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.59	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.54	8.54	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	8.58	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.21	8.21	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.21	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.08	8.08	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.08	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.07	8.07	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.08	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.06	8.06	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	8.07	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.05	8.05	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	8.06	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.26	8.26	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.26	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.35	8.35	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.36	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.36	8.36	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.36	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.35	8.35	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.36	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.26	8.26	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	8.35	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.16	8.16	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	8.26	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.31	8.31	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.32	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.31	8.31	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.31	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.31	8.31	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.31	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.16	8.16	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	8.31	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.05	8.05	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	8.16	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.98	7.98	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.00	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.92	7.92	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	7.98	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.63	9.63	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.64	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.44	9.44	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	9.63	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.63	9.63	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.64	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.61	9.61	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.61	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.60	9.60	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	9.61	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.15	10.15	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	10.32	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.13	10.13	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.15	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.74	9.74	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	10.13	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.60	9.60	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	9.74	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.44	9.44	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	9.60	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.33	9.33	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	9.44	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.46	9.46	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.47	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.45	9.45	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	9.46	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.44	9.44	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	9.45	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.20	9.20	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	9.33	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.89	8.89	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	9.20	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.75	8.75	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	8.89	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.71	8.71	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	8.75	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.69	8.69	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	8.71	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.55	8.55	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	8.69	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.51	8.51	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	8.55	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	8.42	8.42	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	8.51	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	8.35	8.35	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	8.42	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**8.30**	**8.30**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**8.35**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.33	9.33	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.33	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.20	9.20	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.21	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.33	9.33	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	9.37	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.20	9.20	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	9.25	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	8.75	8.75	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.77	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.69	8.69	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.71	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.51	8.51	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.54	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.51	8.51	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.52	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.82	8.82	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.82	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.80	8.80	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	8.82	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.79	8.79	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	8.80	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.75	8.75	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	8.79	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.79	8.79	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.80	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	9.21	9.21	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.23	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.13	9.13	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	9.21	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.04	9.04	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	9.13	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.94	8.94	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	9.04	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.86	8.86	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	8.94	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.69	8.69	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	8.86	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.86	8.86	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.87	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	9.08	9.08	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.09	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.04	9.04	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	9.08	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.71	8.71	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.71	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.58	8.58	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.58	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.57	8.57	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.58	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.56	8.56	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	8.57	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.55	8.55	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	8.56	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.76	8.76	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.76	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.85	8.85	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.86	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.86	8.86	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.86	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.85	8.85	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.86	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.76	8.76	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	8.85	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.66	8.66	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	8.76	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.81	8.81	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.82	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.81	8.81	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.81	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.81	8.81	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.81	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.66	8.66	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	8.81	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.55	8.55	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	8.66	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.48	8.48	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.50	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	8.42	8.42	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	8.48	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.33	10.33	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.34	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.14	10.14	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	10.33	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.33	10.33	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.34	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.31	10.31	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.31	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.30	10.30	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.31	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.85	10.85	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	11.02	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.83	10.83	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.85	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.44	10.44	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	10.83	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.30	10.30	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	10.44	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.14	10.14	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	10.30	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.03	10.03	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	10.14	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.16	10.16	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.17	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.15	10.15	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	10.16	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.14	10.14	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	10.15	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.90	9.90	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	10.03	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.59	9.59	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	9.90	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.45	9.45	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	9.59	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.41	9.41	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	9.45	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.39	9.39	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	9.41	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.25	9.25	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	9.39	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.21	9.21	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	9.25	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.12	9.12	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	9.21	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.05	9.05	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	9.12	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.00**	**9.00**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**9.05**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.03	10.03	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.03	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.90	9.90	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	9.91	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.03	10.03	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	10.07	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.90	9.90	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	9.95	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.45	9.45	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.47	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.39	9.39	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.41	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.21	9.21	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.24	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.21	9.21	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.22	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.52	9.52	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.52	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.50	9.50	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	9.52	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.49	9.49	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	9.50	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	$Q*V$ for determining controlling inflow pipe	$Q*V$ for determining controlling inflow pipe	$Q*V$ for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.45	9.45	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	9.49	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.49	9.49	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.50	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	9.91	9.91	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.93	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.83	9.83	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	9.91	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	9.74	9.74	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	9.83	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.64	9.64	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	9.74	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.56	9.56	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	9.64	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.39	9.39	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	9.56	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.56	9.56	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.57	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.78	9.78	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.79	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.74	9.74	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	9.78	10.79	HGL ok
P-169	DI-169	MH-210	1.20	9.41	9.41	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.41	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.28	9.28	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.28	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.27	9.27	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.28	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.26	9.26	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	9.27	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.25	9.25	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	9.26	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.46	9.46	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.46	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.55	9.55	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.56	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.56	9.56	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.56	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.55	9.55	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.56	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.46	9.46	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	9.55	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.36	9.36	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	9.46	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.51	9.51	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.52	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.51	9.51	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.51	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.51	9.51	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.51	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.36	9.36	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	9.51	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.25	9.25	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	9.36	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.18	9.18	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.20	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.12	9.12	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	9.18	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.83	10.83	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.84	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.64	10.64	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	10.83	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.83	10.83	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.84	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.81	10.81	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.81	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.80	10.80	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.81	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.35	11.35	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	11.52	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.33	11.33	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.35	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.94	10.94	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	11.33	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.80	10.80	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	10.94	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.64	10.64	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	10.80	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.53	10.53	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	10.64	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.66	10.66	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.67	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.65	10.65	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	10.66	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.64	10.64	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	10.65	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.40	10.40	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	10.53	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.09	10.09	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	10.40	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.95	9.95	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	10.09	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.91	9.91	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	9.95	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.89	9.89	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	9.91	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.75	9.75	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	9.89	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.71	9.71	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	9.75	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.62	9.62	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	9.71	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.55	9.55	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	9.62	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.50**	**9.50**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**9.55**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.53	10.53	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.53	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.40	10.40	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.41	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.53	10.53	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	10.57	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.40	10.40	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	10.45	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.95	9.95	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.97	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.89	9.89	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.91	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.71	9.71	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.74	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.71	9.71	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.72	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.02	10.02	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.02	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.00	10.00	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	10.02	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.99	9.99	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	10.00	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.95	9.95	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	9.99	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.99	9.99	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.00	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.41	10.41	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.43	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.33	10.33	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	10.41	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.24	10.24	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	10.33	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.14	10.14	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	10.24	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.06	10.06	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	10.14	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.89	9.89	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	10.06	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.06	10.06	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.07	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.28	10.28	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.29	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.24	10.24	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	10.28	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.91	9.91	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.91	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.78	9.78	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.78	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.77	9.77	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.78	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.76	9.76	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	9.77	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.75	9.75	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	9.76	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.96	9.96	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.96	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.05	10.05	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.06	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.06	10.06	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.06	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.05	10.05	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.06	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.96	9.96	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	10.05	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.86	9.86	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	9.96	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.01	10.01	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.02	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.01	10.01	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.01	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.01	10.01	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.01	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.86	9.86	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	10.01	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.75	9.75	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	9.86	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.68	9.68	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.70	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.62	9.62	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	9.68	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.13	12.13	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.14	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.94	11.94	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	12.13	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.13	12.13	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.14	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.11	12.11	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.11	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.10	12.10	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	12.11	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.65	12.65	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	12.82	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.63	12.63	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.65	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.24	12.24	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	12.63	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.10	12.10	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	12.24	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.94	11.94	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	12.10	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.83	11.83	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	11.94	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.96	11.96	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.97	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.95	11.95	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	11.96	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.94	11.94	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	11.95	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.70	11.70	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	11.83	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.39	11.39	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	11.70	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.25	11.25	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	11.39	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.21	11.21	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	11.25	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.19	11.19	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	11.21	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.05	11.05	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	11.19	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.01	11.01	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	11.05	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.92	10.92	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	11.01	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.85	10.85	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	10.92	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.80**	**10.80**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**10.85**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.83	11.83	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.83	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.70	11.70	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.71	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.83	11.83	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	11.87	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.70	11.70	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	11.75	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.25	11.25	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.27	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.19	11.19	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.21	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.01	11.01	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.04	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.01	11.01	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.02	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.32	11.32	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.32	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.30	11.30	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	11.32	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.29	11.29	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	11.30	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.25	11.25	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	11.29	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.29	11.29	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.30	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.71	11.71	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.73	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.63	11.63	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	11.71	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.54	11.54	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	11.63	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.44	11.44	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	11.54	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.36	11.36	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	11.44	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.19	11.19	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	11.36	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.36	11.36	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.37	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.58	11.58	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.59	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.54	11.54	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	11.58	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.21	11.21	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.21	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.08	11.08	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.08	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.07	11.07	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.08	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.06	11.06	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	11.07	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.05	11.05	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	11.06	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.26	11.26	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.26	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.35	11.35	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.36	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.36	11.36	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.36	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.35	11.35	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.36	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.26	11.26	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	11.35	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.16	11.16	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	11.26	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.31	11.31	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.32	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.31	11.31	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.31	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.31	11.31	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.31	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.16	11.16	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	11.31	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.05	11.05	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	11.16	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.98	10.98	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.00	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.92	10.92	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	10.98	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.07	7.07	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.08	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	6.88	6.88	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	7.07	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.07	7.07	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.08	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.05	7.05	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.05	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.04	7.04	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	7.05	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	7.59	7.59	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	7.76	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	7.57	7.57	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.59	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.18	7.18	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	7.57	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.04	7.04	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	7.18	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	6.88	6.88	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	7.04	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	6.77	6.77	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	6.88	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	6.90	6.90	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.91	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	6.89	6.89	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	6.90	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	6.88	6.88	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	6.89	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.64	6.64	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	6.77	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.33	6.33	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	6.64	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.19	6.19	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	6.33	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.15	6.15	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	6.19	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.13	6.13	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	6.15	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	5.99	5.99	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	6.13	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	5.95	5.95	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	5.99	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.86	5.86	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	5.95	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.79	5.79	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	5.86	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.74**	**5.74**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**5.79**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.77	6.77	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.77	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.64	6.64	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	6.65	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.77	6.77	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	6.81	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.64	6.64	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	6.69	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.19	6.19	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.21	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.13	6.13	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.15	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	5.95	5.95	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	5.98	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	5.95	5.95	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	5.96	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.26	6.26	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.26	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.24	6.24	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	6.26	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.23	6.23	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	6.24	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.19	6.19	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	6.23	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.23	6.23	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.24	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.65	6.65	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.67	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.57	6.57	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	6.65	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.48	6.48	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	6.57	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.38	6.38	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	6.48	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.30	6.30	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	6.38	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.13	6.13	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	6.30	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.30	6.30	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.31	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.52	6.52	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.53	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.48	6.48	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	6.52	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.15	6.15	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.15	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.02	6.02	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.02	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.01	6.01	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.02	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.00	6.00	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	6.01	11.68	HGL ok
P-181	DI-181	DI-212	1.20	5.99	5.99	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	6.00	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.20	6.20	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.20	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.29	6.29	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.30	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.30	6.30	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.30	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.29	6.29	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	6.30	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.20	6.20	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	6.29	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.10	6.10	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	6.20	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.25	6.25	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.26	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.25	6.25	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.25	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.25	6.25	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	6.25	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.10	6.10	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	6.25	12.23	HGL ok
P-190	DI-190	DI-191	1.20	5.99	5.99	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	6.10	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	5.92	5.92	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	5.94	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.86	5.86	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	5.92	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.27	7.27	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.28	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.08	7.08	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	7.27	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.27	7.27	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.28	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.25	7.25	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.25	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.24	7.24	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	7.25	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	7.79	7.79	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	7.96	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	7.77	7.77	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.79	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.38	7.38	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	7.77	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.24	7.24	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	7.38	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.08	7.08	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	7.24	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	6.97	6.97	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	7.08	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.10	7.10	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.11	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.09	7.09	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	7.10	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.08	7.08	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	7.09	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.84	6.84	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	6.97	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.53	6.53	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	6.84	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.39	6.39	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	6.53	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.35	6.35	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	6.39	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.33	6.33	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	6.35	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.19	6.19	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	6.33	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.15	6.15	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	6.19	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	6.06	6.06	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	6.15	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.99	5.99	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	6.06	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.94**	**5.94**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**5.99**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.97	6.97	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.97	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.84	6.84	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	6.85	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.97	6.97	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	7.01	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.84	6.84	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	6.89	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.39	6.39	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.41	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.33	6.33	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.35	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.15	6.15	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	6.18	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.15	6.15	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.16	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.46	6.46	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.46	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.44	6.44	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	6.46	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.43	6.43	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	6.44	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.39	6.39	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	6.43	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.43	6.43	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.44	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.85	6.85	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.87	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.77	6.77	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	6.85	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.68	6.68	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	6.77	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.58	6.58	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	6.68	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.50	6.50	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	6.58	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.33	6.33	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	6.50	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.50	6.50	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.51	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.72	6.72	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.73	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.68	6.68	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	6.72	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.35	6.35	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.35	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.22	6.22	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.22	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.21	6.21	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.22	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.20	6.20	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	6.21	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.19	6.19	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	6.20	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.40	6.40	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.40	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.49	6.49	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.50	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.50	6.50	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.50	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.49	6.49	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	6.50	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.40	6.40	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	6.49	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.30	6.30	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	6.40	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.45	6.45	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.46	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.45	6.45	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.45	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.45	6.45	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	6.45	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.30	6.30	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	6.45	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.19	6.19	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	6.30	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.12	6.12	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.14	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	6.06	6.06	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	6.12	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.77	10.77	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.78	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.58	10.58	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	10.77	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.77	10.77	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.78	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.75	10.75	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.74	10.74	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	10.75	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.29	11.29	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	11.46	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.27	11.27	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.29	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.88	10.88	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	11.27	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.74	10.74	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	10.88	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.58	10.58	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	10.74	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.47	10.47	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	10.58	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.60	10.60	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.61	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.59	10.59	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	10.60	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.58	10.58	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	10.59	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.34	10.34	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	10.47	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.03	10.03	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	10.34	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.89	9.89	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	10.03	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.85	9.85	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	9.89	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.83	9.83	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	9.85	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.69	9.69	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	9.83	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.65	9.65	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	9.69	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.56	9.56	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	9.65	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.49	9.49	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	9.56	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.44**	**9.44**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**9.49**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.47	10.47	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.47	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.34	10.34	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.35	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.47	10.47	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	10.51	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.34	10.34	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	10.39	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.89	9.89	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.91	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.83	9.83	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.85	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.65	9.65	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.68	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.65	9.65	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.66	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.96	9.96	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.96	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.94	9.94	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	9.96	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.93	9.93	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	9.94	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	$Q*V$ for determining controlling inflow pipe	$Q*V$ for determining controlling inflow pipe	$Q*V$ for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.89	9.89	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	9.93	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.93	9.93	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.94	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.35	10.35	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.37	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.27	10.27	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	10.35	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.18	10.18	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	10.27	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.08	10.08	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	10.18	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.00	10.00	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	10.08	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.83	9.83	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	10.00	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.00	10.00	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.01	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.22	10.22	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.23	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.18	10.18	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	10.22	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.85	9.85	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.85	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.72	9.72	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.72	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.71	9.71	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.72	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.70	9.70	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	9.71	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.69	9.69	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	9.70	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.90	9.90	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.90	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.99	9.99	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.00	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.00	10.00	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.00	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.99	9.99	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.00	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.90	9.90	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	9.99	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.80	9.80	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	9.90	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.95	9.95	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.96	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.95	9.95	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.95	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.95	9.95	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.95	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.80	9.80	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	9.95	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.69	9.69	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	9.80	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.62	9.62	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.64	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.56	9.56	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	9.62	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.27	11.27	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.28	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.08	11.08	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	11.27	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.27	11.27	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.28	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.25	11.25	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.25	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.24	11.24	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.25	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.79	11.79	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	11.96	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.77	11.77	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.79	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.38	11.38	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	11.77	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.24	11.24	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	11.38	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.08	11.08	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	11.24	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.97	10.97	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	11.08	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.10	11.10	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.11	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.09	11.09	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	11.10	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.08	11.08	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	11.09	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.84	10.84	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	10.97	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.53	10.53	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	10.84	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.39	10.39	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	10.53	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.35	10.35	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	10.39	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.33	10.33	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	10.35	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.19	10.19	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	10.33	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.15	10.15	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	10.19	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.06	10.06	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	10.15	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.99	9.99	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	10.06	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.94**	**9.94**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**9.99**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.97	10.97	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.97	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.84	10.84	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	10.85	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.97	10.97	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	11.01	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.84	10.84	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	10.89	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.39	10.39	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.41	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.33	10.33	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.35	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.15	10.15	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.18	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.15	10.15	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.16	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.46	10.46	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.46	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.44	10.44	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	10.46	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.43	10.43	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	10.44	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.39	10.39	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	10.43	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.43	10.43	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.44	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.85	10.85	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.87	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.77	10.77	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	10.85	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.68	10.68	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	10.77	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.58	10.58	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	10.68	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.50	10.50	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	10.58	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.33	10.33	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	10.50	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.50	10.50	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.51	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.72	10.72	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.73	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.68	10.68	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	10.72	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.35	10.35	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.35	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.22	10.22	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.22	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.21	10.21	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.22	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.20	10.20	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	10.21	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.19	10.19	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	10.20	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.40	10.40	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.40	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.49	10.49	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.50	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.50	10.50	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.50	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.49	10.49	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.50	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.40	10.40	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	10.49	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.30	10.30	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	10.40	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.45	10.45	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.46	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.45	10.45	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.45	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.45	10.45	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.45	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.30	10.30	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	10.45	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.19	10.19	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	10.30	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.12	10.12	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.14	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.06	10.06	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	10.12	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.67	11.67	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.68	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.48	11.48	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	11.67	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.67	11.67	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.68	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.65	11.65	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.65	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.64	11.64	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	11.65	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.19	12.19	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	12.36	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.17	12.17	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.19	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.78	11.78	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	12.17	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.64	11.64	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	11.78	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.48	11.48	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	11.64	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.37	11.37	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	11.48	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.50	11.50	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.51	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.49	11.49	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	11.50	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.48	11.48	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	11.49	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.24	11.24	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	11.37	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.93	10.93	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	11.24	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.79	10.79	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	10.93	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.75	10.75	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	10.79	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.73	10.73	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	10.75	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.59	10.59	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	10.73	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.55	10.55	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	10.59	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.46	10.46	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	10.55	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.39	10.39	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	10.46	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.34**	**10.34**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**10.39**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.37	11.37	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.37	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.24	11.24	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.25	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.37	11.37	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	11.41	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.24	11.24	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	11.29	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.79	10.79	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.81	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.73	10.73	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.75	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.55	10.55	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.58	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.55	10.55	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.56	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.86	10.86	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.86	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.84	10.84	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	10.86	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.83	10.83	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	10.84	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.79	10.79	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	10.83	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.83	10.83	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.84	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.25	11.25	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.27	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.17	11.17	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	11.25	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.08	11.08	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	11.17	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.98	10.98	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	11.08	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.90	10.90	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	10.98	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.73	10.73	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	10.90	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.90	10.90	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.91	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.12	11.12	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.13	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.08	11.08	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	11.12	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.75	10.75	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.62	10.62	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.62	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.61	10.61	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.62	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.60	10.60	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	10.61	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.59	10.59	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	10.60	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.80	10.80	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.80	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.89	10.89	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.90	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.90	10.90	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.90	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	10.89	10.89	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.90	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.80	10.80	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	10.89	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.70	10.70	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	10.80	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.85	10.85	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.86	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.85	10.85	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.85	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	10.85	10.85	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.85	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.70	10.70	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	10.85	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.59	10.59	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	10.70	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.52	10.52	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.54	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.46	10.46	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	10.52	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.17	12.17	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.18	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.98	11.98	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	12.17	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.17	12.17	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.18	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.15	12.15	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.15	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.14	12.14	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	12.15	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.69	12.69	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	12.86	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.67	12.67	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.69	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.28	12.28	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	12.67	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.14	12.14	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	12.28	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.98	11.98	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	12.14	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.87	11.87	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	11.98	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.00	12.00	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.01	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.99	11.99	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	12.00	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.98	11.98	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	11.99	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.74	11.74	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	11.87	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.43	11.43	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	11.74	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.29	11.29	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	11.43	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.25	11.25	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	11.29	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.23	11.23	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	11.25	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.09	11.09	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	11.23	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.05	11.05	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	11.09	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.96	10.96	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	11.05	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.89	10.89	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	10.96	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.84**	**10.84**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**10.89**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.87	11.87	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.87	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.74	11.74	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	11.75	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.87	11.87	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	11.91	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.74	11.74	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	11.79	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.29	11.29	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.31	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.23	11.23	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.25	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.05	11.05	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.08	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.05	11.05	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.06	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.36	11.36	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.36	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.34	11.34	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	11.36	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.33	11.33	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	11.34	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.29	11.29	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	11.33	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.33	11.33	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.34	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.75	11.75	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.77	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.67	11.67	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	11.75	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.58	11.58	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	11.67	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.48	11.48	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	11.58	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.40	11.40	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	11.48	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.23	11.23	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	11.40	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.40	11.40	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.41	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.62	11.62	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.63	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.58	11.58	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	11.62	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.25	11.25	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.25	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.12	11.12	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.12	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.11	11.11	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.12	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.10	11.10	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	11.11	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.09	11.09	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	11.10	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.30	11.30	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.30	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.39	11.39	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.40	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.40	11.40	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.40	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.39	11.39	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.40	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.30	11.30	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	11.39	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.20	11.20	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	11.30	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.35	11.35	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.36	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.35	11.35	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.35	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.35	11.35	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.35	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.20	11.20	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	11.35	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.09	11.09	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	11.20	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	11.02	11.02	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.04	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.96	10.96	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	11.02	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.87	12.87	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.88	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.68	12.68	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	12.87	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.87	12.87	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.88	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.85	12.85	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.85	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.84	12.84	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	12.85	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.39	13.39	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	13.56	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.37	13.37	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.39	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.98	12.98	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	13.37	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.84	12.84	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	12.98	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.68	12.68	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	12.84	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.57	12.57	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	12.68	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.70	12.70	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.71	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.69	12.69	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	12.70	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.68	12.68	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	12.69	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.44	12.44	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	12.57	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.13	12.13	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	12.44	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.99	11.99	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	12.13	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.95	11.95	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	11.99	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.93	11.93	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	11.95	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.79	11.79	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	11.93	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.75	11.75	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	11.79	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.66	11.66	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	11.75	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	11.59	11.59	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	11.66	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**11.54**	**11.54**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**11.59**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.57	12.57	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.57	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.44	12.44	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	12.45	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.57	12.57	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	12.61	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.44	12.44	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	12.49	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.99	11.99	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.01	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.93	11.93	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.95	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.75	11.75	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.78	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.75	11.75	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.76	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.06	12.06	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.06	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.04	12.04	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	12.06	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.03	12.03	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	12.04	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.99	11.99	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	12.03	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.03	12.03	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.04	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.45	12.45	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.47	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.37	12.37	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	12.45	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.28	12.28	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	12.37	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.18	12.18	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	12.28	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.10	12.10	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	12.18	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.93	11.93	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	12.10	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.10	12.10	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.11	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.32	12.32	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.33	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.28	12.28	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	12.32	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.95	11.95	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.95	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.82	11.82	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.82	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.81	11.81	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.82	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.80	11.80	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	11.81	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.79	11.79	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	11.80	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.00	12.00	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.00	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.09	12.09	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.10	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.10	12.10	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.10	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.09	12.09	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	12.10	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.00	12.00	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	12.09	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.90	11.90	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	12.00	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.05	12.05	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.06	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.05	12.05	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.05	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.05	12.05	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	12.05	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.90	11.90	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	12.05	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.79	11.79	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	11.90	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.72	11.72	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.74	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.66	11.66	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	11.72	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.37	13.37	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.38	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	13.18	13.18	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	13.37	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.37	13.37	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.38	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.35	13.35	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.35	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.34	13.34	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	13.35	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.89	13.89	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	14.06	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.87	13.87	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.89	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.48	13.48	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	13.87	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.34	13.34	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	13.48	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	13.18	13.18	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	13.34	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	13.07	13.07	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	13.18	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	13.20	13.20	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.21	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	13.19	13.19	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	13.20	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	13.18	13.18	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	13.19	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.94	12.94	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	13.07	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.63	12.63	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	12.94	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.49	12.49	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	12.63	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	12.45	12.45	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	12.49	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	12.43	12.43	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	12.45	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	12.29	12.29	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	12.43	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	12.25	12.25	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	12.29	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	12.16	12.16	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	12.25	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	12.09	12.09	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	12.16	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**12.04**	**12.04**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**12.09**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	13.07	13.07	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.07	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.94	12.94	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	12.95	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	13.07	13.07	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	13.11	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.94	12.94	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	12.99	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.49	12.49	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.51	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	12.43	12.43	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.45	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	12.25	12.25	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.28	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	12.25	12.25	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.26	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.56	12.56	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.56	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.54	12.54	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	12.56	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.53	12.53	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	12.54	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.49	12.49	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	12.53	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.53	12.53	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.54	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.95	12.95	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.97	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.87	12.87	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	12.95	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.78	12.78	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	12.87	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.68	12.68	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	12.78	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.60	12.60	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	12.68	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	12.43	12.43	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	12.60	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.60	12.60	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.61	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.82	12.82	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.83	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.78	12.78	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	12.82	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	12.45	12.45	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.45	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	12.32	12.32	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.32	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	12.31	12.31	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	12.32	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	12.30	12.30	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	12.31	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	12.29	12.29	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	12.30	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.50	12.50	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.50	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.59	12.59	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.60	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.60	12.60	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.60	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.59	12.59	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	12.60	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.50	12.50	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	12.59	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.40	12.40	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	12.50	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.55	12.55	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.56	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.55	12.55	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.55	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.55	12.55	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	12.55	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.40	12.40	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	12.55	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	12.29	12.29	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	12.40	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	12.22	12.22	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.24	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	12.16	12.16	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	12.22	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	14.67	14.67	15	1.3	1.0	95	16	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.68	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	14.48	14.48	15	2.3	1.9	91	154	0.0011	0.17	0	0.00	0.01	1.0	1.3	0.0	1.0	0.0	95	0.01	0.03	1.0	0.5	0.02	0.19	14.67	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	14.67	14.67	15	1.1	0.9	91	34	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.68	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	14.65	14.65	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.65	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	14.64	14.64	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.00	1.0	0.5	0.00	0.00	14.65	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	15.19	15.19	12	2.1	2.7	0	47	0.0030	0.14	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.17	15.36	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	15.17	15.17	12	0.6	0.7	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	15.19	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	14.78	14.78	12	3.1	3.9	72	41	0.0064	0.26	0	0.00	0.06	0.4	5.7	0.0	2.7	0.0	0	0.00	0.10	1.3	1.0	0.13	0.39	15.17	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	14.64	14.64	18	3.0	1.7	77	26	0.0007	0.02	0	0.00	0.01	12.1	0.0	0.0	3.9	0.1	72	0.15	0.24	1.0	0.5	0.12	0.14	14.78	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	14.48	14.48	18	3.6	2.0	90	129	0.0010	0.13	0	0.00	0.02	5.3	0.3	0.0	1.7	0.0	77	0.03	0.06	1.0	0.5	0.03	0.16	14.64	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	14.37	14.37	18	6.8	3.8	3	14	0.0036	0.05	0	0.00	0.06	7.4	0.6	4.4	2.0	0.0	90	0.05	0.13	1.0	0.5	0.06	0.11	14.48	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	14.50	14.50	15	0.7	0.5	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.51	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	14.49	14.49	15	1.1	0.9	22	5	0.0002	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	14.50	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	14.48	14.48	18	1.1	0.6	2	25	0.0001	0.00	0	0.00	0.00	0.9	0.0	0.0	0.9	0.0	22	0.00	0.01	1.0	0.5	0.00	0.01	14.49	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	14.24	14.24	24	7.9	2.5	4	60	0.0010	0.06	0	0.00	0.02	26.1	0.7	0.3	3.8	0.1	3	0.02	0.13	1.0	0.5	0.06	0.13	14.37	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	13.93	13.93	24	12.4	4.0	4	82	0.0026	0.21	0	0.00	0.06	20.0	10.8	0.0	2.5	0.0	4	0.01	0.11	1.0	1.0	0.11	0.32	14.24	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	13.79	13.79	36	12.7	1.8	7	59	0.0003	0.02	0	0.00	0.01	49.2	0.0	0.0	4.0	0.1	4	0.02	0.12	1.0	1.0	0.12	0.14	13.93	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	13.75	13.75	48	16.0	1.3	3	54	0.0001	0.01	0	0.00	0.01	22.8	6.5	7.1	1.8	0.0	7	0.01	0.03	1.0	1.0	0.03	0.03	13.79	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	13.73	13.73	48	16.2	1.3	3	68	0.0001	0.01	0	0.00	0.01	20.4	0.1	0.0	1.3	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	13.75	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	13.59	13.59	48	18.6	1.5	4	180	0.0001	0.03	0	0.00	0.01	21.0	21.3	2.8	2.6	0.0	88	0.07	0.12	1.0	1.0	0.12	0.14	13.73	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	13.55	13.55	48	22.7	1.8	2	58	0.0002	0.01	0	0.00	0.01	27.4	1.0	7.2	1.5	0.0	4	0.00	0.03	1.0	1.0	0.03	0.04	13.59	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	13.46	13.46	48	28.7	2.3	0	158	0.0003	0.05	0	0.00	0.02	41.0	3.3	3.3	1.8	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	13.55	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	13.39	13.39	48	30.3	2.4	16	35	0.0004	0.01	0	0.00	0.02	65.7	3.5	0.0	2.3	0.0	0	0.00	0.05	1.0	1.0	0.05	0.06	13.46	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**13.34**	**13.34**	**48**	**30.3**	**2.4**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.02**	**73.1**	**0.0**	**0.0**	**2.4**	**0.0**	**16**	**0.02**	**0.07**	**1.0**	**0.5**	**0.04**	**0.05**	**13.39**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	14.37	14.37	15	0.6	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.37	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	14.24	14.24	15	0.9	0.8	88	25	0.0002	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.00	0.01	14.25	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	14.37	14.37	8	0.3	0.9	93	96	0.0004	0.04	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.04	14.41	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	14.24	14.24	18	4.4	2.5	90	23	0.0015	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.05	14.29	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	13.79	13.79	18	3.4	1.9	90	19	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.81	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	13.73	13.73	18	2.2	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.75	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	13.55	13.55	18	2.4	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	13.58	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	13.55	13.55	18	2.4	1.4	90	18	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.56	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	13.86	13.86	18	1.1	0.6	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.86	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	13.84	13.84	18	1.5	0.8	0	54	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.02	13.86	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	13.83	13.83	24	2.0	0.6	90	91	0.0001	0.01	0	0.00	0.00	1.2	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	13.84	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	13.79	13.79	24	4.7	1.5	94	33	0.0004	0.01	0	0.00	0.01	1.3	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.05	13.83	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	13.83	13.83	18	1.8	1.0	90	19	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.84	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	14.25	14.25	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	14.27	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	14.17	14.17	18	2.7	1.5	90	68	0.0006	0.04	0	0.00	0.01	2.9	0.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.08	14.25	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	14.08	14.08	18	3.1	1.8	79	29	0.0007	0.02	0	0.00	0.01	4.1	0.0	0.0	1.5	0.0	90	0.03	0.05	1.3	1.0	0.06	0.09	14.17	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	13.98	13.98	24	5.4	1.7	69	46	0.0005	0.02	0	0.00	0.01	5.4	0.0	0.0	1.8	0.0	79	0.03	0.06	1.3	1.0	0.08	0.10	14.08	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	13.90	13.90	24	5.7	1.8	80	44	0.0005	0.02	0	0.00	0.01	9.3	0.0	0.0	1.7	0.0	69	0.03	0.06	1.0	1.0	0.06	0.08	13.98	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	13.73	13.73	24	8.2	2.6	88	29	0.0011	0.03	0	0.00	0.03	10.2	21.3	0.0	2.6	0.0	88	0.07	0.14	1.0	1.0	0.14	0.17	13.90	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	13.90	13.90	18	2.0	1.1	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.91	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	14.12	14.12	18	1.5	0.8	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.13	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	14.08	14.08	18	1.9	1.1	12	68	0.0003	0.02	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	90	0.01	0.02	1.3	1.0	0.02	0.04	14.12	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	13.75	13.75	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.75	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	13.62	13.62	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.62	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	13.61	13.61	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	13.62	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	13.60	13.60	18	1.0	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	13.61	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	13.59	13.59	18	1.4	0.8	98	23	0.0001	0.00	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	12	0.00	0.00	1.3	1.0	0.01	0.01	13.60	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	13.80	13.80	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.80	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	13.89	13.89	18	1.6	0.9	90	23	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.90	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	13.90	13.90	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.90	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	13.89	13.89	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	13.90	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	13.80	13.80	18	2.8	1.6	70	108	0.0006	0.07	0	0.00	0.01	0.3	1.5	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.03	0.10	13.89	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	13.70	13.70	18	3.4	1.9	57	27	0.0009	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	70	0.02	0.05	1.3	1.0	0.07	0.09	13.80	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	13.85	13.85	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.86	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	13.85	13.85	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.85	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	13.85	13.85	18	0.8	0.4	2	62	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	13.85	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	13.70	13.70	18	3.3	1.9	14	119	0.0008	0.10	0	0.00	0.01	0.3	2.3	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.05	0.14	13.85	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	13.59	13.59	18	3.6	2.0	67	50	0.0010	0.05	0	0.00	0.02	6.1	6.4	0.0	1.9	0.0	57	0.03	0.07	1.0	1.0	0.07	0.11	13.70	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	13.52	13.52	18	2.2	1.2	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.54	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	13.46	13.46	18	2.5	1.4	90	43	0.0005	0.02	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	105	0.02	0.03	1.3	1.0	0.04	0.06	13.52	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 50 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
CRB Network STA 109+25 to 111+75																										
CRB-P72	CRB-DI72	CRB-MH-74	7961	0	7961	0.18	1.00	0.18	0.18	6.0	0.00	7.29	1.3	15	16	0.012	0.0004	0.019	7.8	9.6	5.5	0.05	6.05	2.60	2.30	Q ok
CRB-P74	CRB-MH-74	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.34	6.0	6.17	7.23	2.5	15	154	0.012	0.0013	0.005	4.1	5.1	4.1	0.63	6.80	1.65	0.84	Q ok
CRB-P73	CRB-DI73	CRB-MH-74	7042	0	7042	0.16	1.00	0.16	0.16	6.0	0.00	7.29	1.2	15	34	0.012	0.0003	0.005	4.0	4.9	3.3	0.17	6.17	1.92	1.75	Q ok
MSS Network Sta 111+75 to 114+00																										
P-162	DI-162	EXMH-201	3794	0	3794	0.09	1.00	0.09	0.09	6.0	0.00	7.29	**0.63**	15	16	0.011	0.000069	0.0200	8.8	**10.8**	4.3	0.06	6.06	2.50	2.18	Q ok
P-201	EXMH-201	A1-MH-203	1	0	1	0.00	1.00	0.00	0.09	6.0	6.06	7.26	**0.63**	15	18	0.012	0.000082	0.0200	8.1	**9.9**	3.9	0.08	6.14	1.98	1.62	Q ok
Ploener Property																										
EX-P LOT	EXDI LOT	DI-MSS-41	13430	0	13430	0.31	1.00	0.31	0.31	6.0	0.00	7.29	**2.25**	12	47	0.012	0.003391	0.0074	4.2	**3.3**	4.5	0.17	6.17	2.50	2.15	Q ok
P-MSS-48	DI-MSS-40	DI-MSS-41	3590	0	3590	0.08	1.00	0.08	0.08	6.0	0.00	7.29	**0.60**	12	82	0.012	0.000242	0.0050	3.5	**2.7**	2.6	0.53	6.53	2.56	2.15	Q ok
P-MSS-48A	DI-MSS-41	EX-MH	3072	0	3072	0.07	1.00	0.07	0.46	6.0	6.53	7.14	**3.29**	12	41	0.012	0.007270	0.0051	3.5	**2.8**	2.9	0.24	6.76	2.05	1.84	Undersized!
A1-P-202	EX-MH	A1-MH-203	1	0	1	0.00	1.00	0.00	0.46	6.0	6.76	7.04	**3.25**	18	26	0.012	0.000815	0.0046	4.4	**7.7**	4.0	0.11	6.87	1.74	1.62	Q ok
A1-P-204	A1-MH-204	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.55	6.0	6.87	7.01	**3.84**	18	129	0.012	0.001142	0.0052	4.6	**8.2**	4.5	0.48	7.35	1.52	0.85	Q ok
A1-P-205	CRB-MH-67	CMH-1	1	0	1	0.00	1.00	0.00	1.06	6.0	7.35	6.89	**7.33**	18	14	0.012	0.004153	0.0057	4.9	**8.6**	5.5	0.04	7.39	0.75	0.67	Q ok
MSS Network Sta 111+75 to 114+00																										
MSS-P2	MSS-DI2	MSS-DI1	3846	1139	4985	0.11	0.93	0.11	0.11	6.0	0.00	7.29	0.8	15	70	0.012	0.0001	0.005	4.0	4.9	2.8	0.42	6.42	4.03	3.68	Q ok
MSS-P1	MSS-DI1	EXMH	2301	1082	3383	0.08	0.84	0.07	0.17	6.0	6.42	7.17	1.2	15	5	0.012	0.0003	0.003	3.3	4.0	2.8	0.03	6.45	3.39	3.37	Q ok
A1-P-203	EX MH	MH-CRB-67	1	0	1	0.00	1.00	0.00	0.17	6.0	6.45	7.17	**1.23**	18	25	0.012	0.000117	0.0050	4.6	**8.0**	3.2	0.13	6.58	0.92	0.84	Q ok
Jones Street Constructed Under Area 1																										
A1-P-206	CMH-1	A1-DI-207	1	0	1	0.00	1.00	0.00	1.25	6.0	7.39	6.86	**8.60**	24	60	0.012	0.001231	0.0035	4.6	**14.5**	4.8	0.21	7.60	0.57	0.36	Q ok
A1-P-207	A1-DI-207	A1-DI-208	3414	0	3414	0.08	1.00	0.08	1.97	6.0	7.60	6.79	**13.40**	24	82	0.012	0.002989	0.0040	4.9	**15.5**	5.6	0.24	7.84	0.36	0.03	Q ok
A1-P-208	A1-DI-208	A1-DI-209	2490	0	2490	0.06	1.00	0.06	2.03	6.0	7.84	6.73	**13.66**	36	59	0.012	0.000357	0.0041	6.5	**46.1**	5.5	0.18	8.02	0.03	-0.21	Q ok
A1-P-209	A1-DI-209	A1-MH-210	2433	0	2433	0.06	1.00	0.06	2.58	6.0	8.02	6.67	**17.21**	48	54	0.012	0.000122	0.0041	7.9	**99.3**	5.5	0.16	8.18	-0.21	-0.43	Q ok
A1-P-210	A1-MH-210	A1-DI-211	1	0	1	0.00	1.00	0.00	2.64	6.0	8.18	6.61	**17.45**	48	68	0.012	0.000126	0.0040	7.8	**98.1**	5.9	0.19	8.37	-0.43	-0.70	Q ok
A1-P-211	A1-DI-211	A1-DI-212	3353	0	3353	0.08	1.00	0.08	3.04	6.0	8.37	6.55	**19.91**	48	180	0.012	0.000164	0.0040	7.8	**98.4**	5.9	0.51	8.89	-0.70	-1.42	Q ok
A1-P-212	A1-DI-212	A1-DI-213	1885	0	1885	0.04	1.00	0.04	3.80	6.0	8.89	6.39	**24.32**	48	58	0.012	0.000244	0.0040	7.8	**98.0**	6.4	0.15	9.04	-1.42	-1.65	Q ok
A1-P-213	A1-DI-213	A1-DI-214	15288	0	15288	0.35	1.00	0.35	4.86	6.0	9.04	6.36	**30.90**	48	158	0.012	0.000394	0.0040	7.8	**98.3**	6.6	0.40	9.43	-1.65	-2.28	Q ok
A1-P-214	A1-DI-214	A1-DI-215	**1**	0	1	0.00	1.00	0.00	5.22	6.0	9.43	6.24	**32.58**	48	35	0.012	0.000438	0.0040	7.8	**98.4**	7.0	0.08	9.52	-2.28	-2.42	Q ok
A1-P-215	A1-DI-215	A1-MH-216	**1**	0	1	0.00	1.00	0.00	5.22	6.0	9.52	6.21	**32.41**	48	48	0.012	0.000434	0.0040	7.8	**97.9**	7.0	0.11	9.63	-2.42	-2.61	Q ok
MSS-P3 A	MSS-DI14	DI-161	3612	330	3942	0.09	1.00	0.09	0.09	6.0	0.00	7.29	0.7	15	44	0.012	0.0001	0.005	4.0	4.9	2.8	0.26	6.26	4.03	3.81	Q ok
MSS-P3 B	DI-161	MSS-DI13	2062	222	2284	0.05	1.00	0.05	0.14	6.0	6.26	7.20	1.0	15	25	0.012	0.0002	0.005	4.1	5.0	3.0	0.14	6.40	3.81	3.68	Q ok
	DOGHOUSE																									
P-160	DI-160	CMH-1	1768	257	2025	0.05	1.00	0.05	0.05	6.0	0.00	7.29	**0.34**	8	96	0.011	0.000563	0.0200	5.8	**2.0**	4.1	0.40	6.40	2.99	1.07	Q ok
A1 P-200	PARCEL J	A1-DI-207	27861	0	27861	0.64	1.00	0.64	0.64	6.0	0.00	7.29	**4.66**	18	23	0.012	0.001679	0.0100	6.4	11.4	5.9	0.06	6.06	1.59	1.36	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 50 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-336	PARCEL J	A1-DI-209	21549	0	21549	0.49	1.00	0.49	0.49	6.0	0.00	7.29	**3.61**	18	19	0.012	0.001004	0.0100	6.4	11.4	5.5	0.06	6.06	1.48	1.29	Q ok
P-337	PARCEL J	A1-DI-211	14148	0	14148	0.32	1.00	0.32	0.32	6.0	0.00	7.29	**2.37**	18	23	0.012	0.000433	0.0100	6.4	11.4	4.8	0.08	6.08	1.53	1.30	Q ok
P-335	PARCEL N	A1-DI-213	15379	0	15379	0.35	1.00	0.35	0.35	6.0	0.00	7.29	**2.57**	18	56	0.012	0.000512	0.0100	6.4	11.4	5.3	0.18	6.18	1.91	1.35	Q ok
P-340	PARCEL K	A1-DI-213	15267	0	15267	0.35	1.00	0.35	0.35	6.0	0.00	7.29	**2.56**	18	18	0.012	0.000504	0.0100	6.4	11.4	4.8	0.06	6.06	1.53	1.35	Q ok
P-165	DI-165	DI-166	7237	0	7237	0.17	1.00	0.17	0.17	6.0	0.00	7.29	**1.21**	18	28	0.012	0.000113	0.0100	6.4	**11.4**	3.9	0.12	6.12	2.95	2.67	Q ok
P-166	DI-166	DI-167	2265	0	2265	0.05	1.00	0.05	0.22	6.0	6.12	7.26	**1.58**	18	54	0.012	0.000194	0.0100	6.4	**11.4**	4.5	0.20	6.32	2.47	1.93	Q ok
P-167	DI-167	DI-168	3648	0	3648	0.08	1.00	0.08	0.30	6.0	6.32	7.20	**2.17**	24	91	0.012	0.000079	0.0100	7.8	**24.5**	4.7	0.32	6.64	1.73	0.82	Q ok
P-168	DI-168	DI-209	6136	0	6136	0.14	1.00	0.14	0.71	6.0	6.64	7.10	**5.02**	24	33	0.012	0.000420	0.0100	7.8	**24.5**	5.9	0.09	6.74	0.62	0.29	Q ok
P-327	PARCEL L	DI-168	11517	0	11517	0.26	1.00	0.26	0.26	6.0	0.00	7.29	**1.93**	18	19	0.012	0.000287	0.0100	6.4	11.4	4.5	0.07	6.07	1.31	1.12	Q ok
P-326	PARCEL L	DI-170	14378	0	14378	0.33	1.00	0.33	0.33	6.0	0.00	7.29	**2.41**	18	23	0.012	0.000447	0.0100	6.4	11.4	4.8	0.08	6.08	3.99	3.76	Q ok
P-170	DI-170	DI-171	2801	0	2801	0.06	1.00	0.06	0.39	6.0	6.08	7.26	**2.86**	18	68	0.012	0.000633	0.0100	6.4	**11.4**	5.3	0.21	6.29	3.26	2.58	Q ok
P-171	DI-171	DI-173	2811	0	2811	0.06	1.00	0.06	0.46	6.0	6.29	7.20	**3.30**	18	29	0.012	0.000842	0.0100	6.4	**11.4**	5.5	0.09	6.38	2.38	2.09	Q ok
P-173	DI-173	DI-174	2818	0	2818	0.06	1.00	0.06	0.81	6.0	6.38	7.17	**5.77**	24	46	0.012	0.000555	0.0100	7.8	**24.5**	6.4	0.12	6.50	1.89	1.43	Q ok
P-174	DI-174	DI-175	1817	0	1817	0.04	1.00	0.04	0.85	6.0	6.50	7.14	**6.04**	24	44	0.012	0.000608	0.0100	7.8	**24.5**	6.4	0.11	6.62	1.23	0.79	Q ok
P-175	DI-175	DI-211	3620	0	3620	0.08	1.00	0.08	1.23	6.0	6.62	7.10	**8.71**	24	29	0.012	0.001264	0.0100	7.8	**24.5**	7.0	0.07	6.69	0.59	0.30	Q ok
P-331	PARCEL M	DI-175	12913	0	12913	0.30	1.00	0.30	0.30	6.0	0.00	7.29	**2.16**	18	19	0.012	0.000361	0.0100	6.4	11.4	4.8	0.07	6.07	1.28	1.09	Q ok
P-328	PARCEL M	DI-172	9475	0	9475	0.22	1.00	0.22	0.22	6.0	0.00	7.29	**1.59**	18	22	0.012	0.000194	0.0100	6.4	11.4	4.5	0.08	6.08	3.49	3.27	Q ok
P-172	DI-172	DI-173	2798	0	2798	0.06	1.00	0.06	0.28	6.0	6.08	7.26	**2.05**	18	68	0.012	0.000323	0.0100	6.4	**11.4**	4.8	0.23	6.32	2.77	2.09	Q ok
P-169	DI-169	MH-210	2626	0	2626	0.06	1.00	0.06	0.06	6.0	0.00	7.29	**0.44**	18	7	0.012	0.000015	0.0100	6.4	**11.4**	3.2	0.04	6.04	1.64	1.57	Q ok
P-178	DI-178	DI-179	3573	0	3573	0.08	1.00	0.08	0.08	6.0	0.00	7.29	**0.60**	18	39	0.012	0.000028	0.0100	6.4	**11.4**	3.2	0.21	6.21	2.63	2.24	Q ok
P-179	DI-179	DI-180	1913	0	1913	0.04	1.00	0.04	0.13	6.0	0.00	7.29	**0.92**	18	34	0.012	0.000065	0.0100	6.4	**11.4**	3.9	0.15	6.15	2.04	1.70	Q ok
P-180	DI-180	DI-181	1165	0	1165	0.03	1.00	0.03	0.15	6.0	0.00	7.29	**1.11**	18	49	0.012	0.000096	0.0100	6.4	**11.4**	3.9	0.21	6.21	1.50	1.01	Q ok
P-181	DI-181	DI-212	1967	0	1967	0.05	1.00	0.05	0.20	6.0	0.00	7.29	**1.44**	18	23	0.012	0.000161	0.0100	6.4	**11.4**	4.5	0.09	6.09	0.81	0.58	Q ok
P-182	DI-182	DI-186	1887	0	1887	0.04	1.00	0.04	0.04	6.0	0.00	7.29	**0.32**	18	43	0.012	0.000008	0.0100	6.4	**11.4**	3.2	0.23	6.23	4.28	3.85	Q ok
P-338	PARCEL J	DI-185	10195	0	10195	0.23	1.00	0.23	0.23	6.0	0.00	7.29	**1.71**	18	23	0.012	0.000225	0.0100	6.4	11.4	4.5	0.09	6.09	3.86	3.63	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 50 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-183	DI-183	DI-184	2436	0	2436	0.06	1.00	0.06	0.06	6.0	0.00	7.29	**0.41**	18	59	0.012	0.000013	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.74	4.15	Q ok
P-184	DI-184	DI-185	2508	0	2508	0.06	1.00	0.06	0.11	6.0	0.00	7.29	**0.83**	18	62	0.012	0.000053	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.95	3.33	Q ok
P-185	DI-185	DI-186	3002	0	3002	0.07	1.00	0.07	0.42	6.0	0.00	7.29	**3.04**	18	108	0.012	0.000712	0.0100	6.4	**11.4**	5.3	0.34	6.34	3.13	2.05	Q ok
P-186	DI-186	DI-190	1354	0	1354	0.03	1.00	0.03	0.49	6.0	0.00	7.29	**3.58**	18	27	0.012	0.000989	0.0100	6.4	**11.4**	5.5	0.08	6.08	1.85	1.58	Q ok
check San x-ing																										
P-339	PARCEL K	DI-189	12930	0	12930	0.30	1.00	0.30	0.30	6.0	0.00	7.29	**2.16**	18	23	0.012	0.000362	0.0100	6.4	11.4	4.8	0.08	6.08	3.20	2.97	Q ok
P-187	DI-187	DI-188	2448	0	2448	0.06	1.00	0.06	0.06	6.0	0.00	7.29	**0.41**	18	59	0.012	0.000013	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.08	3.49	Q ok
P-188	DI-188	DI-189	2550	0	2550	0.06	1.00	0.06	0.11	6.0	0.00	7.29	**0.84**	18	62	0.012	0.000054	0.0100	6.4	**11.4**	3.2	0.33	6.33	3.29	2.67	Q ok
P-189	DI-189	DI-190	3025	0	3025	0.07	1.00	0.07	0.48	6.0	0.00	7.29	**3.51**	18	119	0.012	0.000950	0.0100	6.4	**11.4**	5.5	0.36	6.36	2.47	1.28	Q ok
P-190	DI-190	DI-191	1765	0	1765	0.04	1.00	0.04	0.52	6.0	0.00	7.29	**3.80**	18	50	0.012	0.001116	0.0100	6.4	**11.4**	5.8	0.14	6.14	1.08	0.58	Q ok
P-341	PARCEL K	DI-195	13999	0	13999	0.32	1.00	0.32	0.32	6.0	0.00	7.29	**2.34**	18	53	0.012	0.000424	0.0100	6.4	11.4	4.8	0.18	6.18	3.96	3.43	Q ok
P-195	DI-195	A1-DI-214	**1887**	0	1887	0.04	1.00	0.04	0.36	6.0	6.18	7.23	**2.64**	18	43	0.012	0.000537	0.0100	6.4	**11.4**	5.3	0.14	6.32	2.43	2.00	Q ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	4.62	4.62	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.63	5.76	HGL ok
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.41	4.41	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	4.62	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	4.62	4.62	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.64	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	4.60	4.60	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.60	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	4.59	4.59	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	4.60	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	5.22	5.22	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	5.41	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	5.20	5.20	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.22	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	4.75	4.75	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	5.20	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	4.59	4.59	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	4.75	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.41	4.41	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	4.59	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.28	4.28	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	4.41	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.43	4.68	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.42	4.42	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	4.43	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.41	4.41	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	4.42	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.13	4.13	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	4.28	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.76	3.76	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	4.13	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.60	3.60	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	3.76	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.56	3.56	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	3.60	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.54	3.54	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	3.56	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.49	3.49	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	3.54	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.44	3.44	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	3.49	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.34	3.34	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	3.44	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.26	3.26	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	3.34	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.20**	**3.20**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**3.26**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.28	4.81	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.82	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.13	4.68	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.28	4.28	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	4.34	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.13	4.13	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	4.18	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.60	3.60	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	3.63	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.54	3.54	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.55	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.44	3.44	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	3.48	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.44	3.44	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.46	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.69	3.87	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.87	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.67	3.67	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.69	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.65	3.65	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.67	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.60	3.60	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	3.65	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.65	3.65	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.66	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.13	4.96	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.04	4.04	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	4.13	10.79	HGL ok
P-171	DI-171	DI-173	1.20	3.94	3.94	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	4.04	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.82	3.82	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	3.94	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.73	3.73	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	3.82	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.54	3.54	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	3.73	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.73	3.73	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.74	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	3.98	4.47	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	3.94	3.94	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	3.98	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.56	3.56	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.56	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.52	3.52	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.52	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.51	3.51	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.52	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.50	3.50	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	3.51	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.49	3.49	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	3.50	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.72	5.05	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.83	4.83	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.83	4.53	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.72	3.72	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	3.83	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.62	3.62	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	3.72	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.78	4.17	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.87	4.69	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.78	3.87	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.87	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.62	3.62	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	3.78	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.49	3.49	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	3.62	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.41	4.63	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	4.66	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.34	3.34	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	3.41	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	4.82	4.82	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.83	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.61	4.61	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	4.82	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	4.82	4.82	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.84	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	4.80	4.80	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.80	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	4.79	4.79	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	4.80	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	5.42	5.42	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	5.61	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	5.40	5.40	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.42	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	4.95	4.95	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	5.40	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	4.79	4.79	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	4.95	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.61	4.61	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	4.79	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.48	4.48	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	4.61	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.63	4.68	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.69	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.62	4.62	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	4.63	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.61	4.61	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	4.62	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.33	4.33	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	4.48	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.96	3.96	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	4.33	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.80	3.80	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	3.96	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.76	3.76	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	3.80	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.74	3.74	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	3.76	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.69	3.69	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	3.74	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.64	3.64	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	3.69	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.54	3.54	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	3.64	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.46	3.46	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	3.54	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.40**	**3.40**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**3.46**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.48	4.81	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.82	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.33	4.68	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	4.69	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.48	4.48	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	4.54	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.33	4.33	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	4.38	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.80	3.80	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	3.83	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.74	3.74	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.75	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.64	3.64	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	3.68	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.64	3.64	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.66	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.89	3.89	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.89	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.87	3.87	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.89	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.85	3.85	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.87	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.80	3.80	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	3.85	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.85	3.85	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.86	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.33	4.96	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.24	4.24	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	4.33	10.79	HGL ok
P-171	DI-171	DI-173	1.20	4.14	4.14	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	4.24	10.30	HGL ok
P-173	DI-173	DI-174	1.60	4.02	4.02	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	4.14	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.93	3.93	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	4.02	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.74	3.74	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	3.93	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.93	3.93	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.94	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	4.18	4.47	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	4.14	4.14	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	4.18	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.76	3.76	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.76	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.72	3.72	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.72	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.71	3.71	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.72	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.70	3.70	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	3.71	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.69	3.69	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	3.70	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.92	5.05	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	4.03	4.83	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.53	5.35	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	4.03	4.53	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	4.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.92	3.92	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	4.03	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.82	3.82	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	3.92	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.98	4.17	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.99	4.69	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.98	3.98	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.99	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.82	3.82	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	3.98	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.69	3.69	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	3.82	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.61	4.63	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	4.66	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.54	3.54	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	3.61	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.32	8.32	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.33	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.11	8.11	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	8.32	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.32	8.32	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.34	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.30	8.30	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.30	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.29	8.29	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	8.30	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.92	8.92	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	9.11	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.90	8.90	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.92	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.45	8.45	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	8.90	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.29	8.29	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	8.45	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.11	8.11	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	8.29	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.98	7.98	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	8.11	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.13	8.13	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.14	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.12	8.12	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	8.13	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.11	8.11	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	8.12	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.83	7.83	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	7.98	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.46	7.46	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	7.83	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.30	7.30	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	7.46	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.26	7.26	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	7.30	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.24	7.24	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	7.26	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.19	7.19	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	7.24	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.14	7.14	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	7.19	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.04	7.04	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	7.14	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.96	6.96	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	7.04	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**6.90**	**6.90**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**6.96**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.98	7.98	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.98	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.83	7.83	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	7.84	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.98	7.98	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	8.04	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.83	7.83	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	7.88	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.30	7.30	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	7.33	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.24	7.24	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.25	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.14	7.14	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.18	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.14	7.14	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.16	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.39	7.39	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.39	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.37	7.37	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.39	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.35	7.35	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.37	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.30	7.30	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	7.35	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.35	7.35	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.36	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.83	7.83	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.85	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.74	7.74	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	7.83	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.64	7.64	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	7.74	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.52	7.52	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	7.64	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.43	7.43	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	7.52	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.24	7.24	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	7.43	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.43	7.43	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.44	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.68	7.68	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.69	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.64	7.64	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	7.68	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.26	7.26	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.26	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.22	7.22	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.22	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.21	7.21	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.22	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.20	7.20	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	7.21	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.19	7.19	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	7.20	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.42	7.42	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.42	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.53	7.53	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.54	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.54	7.54	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.54	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.53	7.53	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	7.54	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.42	7.42	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	7.53	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.32	7.32	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	7.42	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.48	7.48	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.49	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.49	7.49	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.49	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.48	7.48	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.49	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.32	7.32	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	7.48	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.19	7.19	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	7.32	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.11	7.11	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.13	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.04	7.04	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	7.11	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	of
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077.001
Segment:	Jones Street Outfall	Design Freq.:	50	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.82	8.82	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.83	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.61	8.61	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	8.82	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.82	8.82	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.84	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.80	8.80	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.80	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.79	8.79	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	8.80	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.42	9.42	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	9.61	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.40	9.40	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.42	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.95	8.95	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	9.40	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.79	8.79	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	8.95	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.61	8.61	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	8.79	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.48	8.48	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	8.61	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.63	8.63	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.64	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.62	8.62	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	8.63	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.61	8.61	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	8.62	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.33	8.33	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	8.48	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.96	7.96	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	8.33	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.80	7.80	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	7.96	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.76	7.76	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	7.80	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.74	7.74	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	7.76	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.69	7.69	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	7.74	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.64	7.64	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	7.69	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.54	7.54	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	7.64	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.46	7.46	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	7.54	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.40**	**7.40**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**7.46**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.48	8.48	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.48	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.33	8.33	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	8.34	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.48	8.48	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	8.54	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.33	8.33	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	8.38	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.80	7.80	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	7.83	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.74	7.74	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.75	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.64	7.64	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.68	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.64	7.64	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.66	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.89	7.89	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.89	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.87	7.87	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.89	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.85	7.85	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.87	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.80	7.80	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	7.85	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.85	7.85	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.86	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.33	8.33	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.35	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.24	8.24	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	8.33	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.14	8.14	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	8.24	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.02	8.02	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	8.14	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.93	7.93	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	8.02	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.74	7.74	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	7.93	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.93	7.93	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.94	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.18	8.18	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.19	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.14	8.14	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	8.18	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.76	7.76	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.76	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.72	7.72	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.72	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.71	7.71	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.72	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.70	7.70	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	7.71	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.69	7.69	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	7.70	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.92	7.92	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.92	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.03	8.03	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.04	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.04	8.04	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.04	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.03	8.03	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.04	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.92	7.92	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	8.03	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.82	7.82	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	7.92	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.98	7.98	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.99	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.99	7.99	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.99	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.98	7.98	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.99	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.82	7.82	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	7.98	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.69	7.69	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	7.82	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.61	7.61	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.63	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.54	7.54	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	7.61	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.22	9.22	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.23	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.01	9.01	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	9.22	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.22	9.22	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.24	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.20	9.20	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.20	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.19	9.19	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	9.20	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.82	9.82	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	10.01	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.80	9.80	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.82	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.35	9.35	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	9.80	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.19	9.19	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	9.35	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.01	9.01	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	9.19	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.88	8.88	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	9.01	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.03	9.03	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.04	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.02	9.02	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	9.03	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.01	9.01	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	9.02	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.73	8.73	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	8.88	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.36	8.36	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	8.73	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.20	8.20	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	8.36	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.16	8.16	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	8.20	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.14	8.14	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	8.16	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.09	8.09	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	8.14	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.04	8.04	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	8.09	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.94	7.94	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	8.04	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.86	7.86	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	7.94	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.80**	**7.80**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**7.86**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.88	8.88	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.88	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.73	8.73	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	8.74	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.88	8.88	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	8.94	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.73	8.73	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	8.78	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	8.20	8.20	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.23	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.14	8.14	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.15	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.04	8.04	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.08	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.04	8.04	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.06	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.29	8.29	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.29	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.27	8.27	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.29	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.25	8.25	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.27	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.20	8.20	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	8.25	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.25	8.25	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.26	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.73	8.73	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.75	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.64	8.64	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	8.73	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.54	8.54	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	8.64	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.42	8.42	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	8.54	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.33	8.33	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	8.42	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.14	8.14	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	8.33	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.33	8.33	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.34	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.58	8.58	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.59	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.54	8.54	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	8.58	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.16	8.16	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.16	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.12	8.12	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.12	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.11	8.11	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.12	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.10	8.10	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	8.11	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.09	8.09	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	8.10	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.32	8.32	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.32	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.43	8.43	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.44	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.44	8.44	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.44	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.43	8.43	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.44	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.32	8.32	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	8.43	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.22	8.22	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	8.32	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.38	8.38	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.39	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.39	8.39	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.39	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.38	8.38	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.39	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.22	8.22	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	8.38	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.09	8.09	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	8.22	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.01	8.01	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.03	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.94	7.94	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	8.01	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: ____ of ____
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077.001
Segment:	Jones Street Outfall	Design Freq.:	50	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.72	9.72	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.73	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.51	9.51	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	9.72	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.72	9.72	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.74	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.70	9.70	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.70	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.69	9.69	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	9.70	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.32	10.32	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	10.51	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.30	10.30	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.32	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.85	9.85	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	10.30	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.69	9.69	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	9.85	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.51	9.51	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	9.69	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.38	9.38	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	9.51	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.53	9.53	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.54	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.52	9.52	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	9.53	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.51	9.51	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	9.52	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.23	9.23	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	9.38	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.86	8.86	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	9.23	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.70	8.70	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	8.86	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.66	8.66	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	8.70	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.64	8.64	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	8.66	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.59	8.59	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	8.64	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.54	8.54	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	8.59	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	8.44	8.44	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	8.54	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	8.36	8.36	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	8.44	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**8.30**	**8.30**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**8.36**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.38	9.38	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.38	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.23	9.23	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	9.24	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.38	9.38	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	9.44	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.23	9.23	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	9.28	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	8.70	8.70	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.73	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.64	8.64	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.65	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.54	8.54	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.58	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.54	8.54	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.56	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.79	8.79	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.79	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.77	8.77	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.79	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.75	8.75	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.77	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.70	8.70	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	8.75	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.75	8.75	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.76	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	9.23	9.23	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.25	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.14	9.14	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	9.23	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.04	9.04	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	9.14	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.92	8.92	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	9.04	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.83	8.83	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	8.92	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.64	8.64	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	8.83	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.83	8.83	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.84	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	9.08	9.08	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.09	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.04	9.04	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	9.08	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.66	8.66	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.66	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.62	8.62	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.62	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.61	8.61	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.62	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.60	8.60	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	8.61	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.59	8.59	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	8.60	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.82	8.82	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.82	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.93	8.93	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.94	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.94	8.94	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.94	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.93	8.93	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	8.94	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.82	8.82	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	8.93	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.72	8.72	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	8.82	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.88	8.88	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.89	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.89	8.89	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.89	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.88	8.88	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.89	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.72	8.72	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	8.88	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.59	8.59	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	8.72	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.51	8.51	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.53	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	8.44	8.44	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	8.51	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.42	10.42	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.43	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.21	10.21	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	*0.5*	0.02	0.21	10.42	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.42	10.42	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.44	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.40	10.40	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.40	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.39	10.39	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	*0.5*	0.00	0.00	10.40	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.02	11.02	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	11.21	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.00	11.00	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.02	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.55	10.55	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	*1.3*	1.0	0.15	0.44	11.00	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.39	10.39	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	*0.5*	0.14	0.16	10.55	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.21	10.21	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	*0.5*	0.04	0.18	10.39	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.08	10.08	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	*0.5*	0.07	0.13	10.21	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.23	10.23	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.24	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.22	10.22	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	*1.3*	1.0	0.01	0.01	10.23	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.21	10.21	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	*0.5*	0.01	0.01	10.22	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.93	9.93	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	*0.5*	0.07	0.15	10.08	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.56	9.56	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	9.93	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.40	9.40	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	9.56	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.36	9.36	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	9.40	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.34	9.34	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	*0.5*	0.01	0.02	9.36	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.29	9.29	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	9.34	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.24	9.24	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	9.29	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.14	9.14	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	9.24	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.06	9.06	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	9.14	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.00**	**9.00**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	*0.5*	**0.04**	**0.06**	**9.06**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.08	10.08	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.08	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.93	9.93	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	*1.3*	1.0	0.01	0.01	9.94	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.08	10.08	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	10.14	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.93	9.93	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	*0.5*	0.01	0.05	9.98	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.40	9.40	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.03	9.43	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.34	9.34	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	9.35	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.24	9.24	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.03	9.28	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.24	9.24	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	9.26	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.49	9.49	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.49	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.47	9.47	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	*1.3*	1.0	0.01	0.02	9.49	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.45	9.45	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	*1.3*	1.0	0.01	0.02	9.47	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.40	9.40	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	9.45	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.45	9.45	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.46	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	9.93	9.93	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.95	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.84	9.84	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	9.93	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	9.74	9.74	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	9.84	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.62	9.62	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	9.74	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.53	9.53	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	9.62	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.34	9.34	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	9.53	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.53	9.53	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.54	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.78	9.78	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.79	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.74	9.74	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	9.78	10.79	HGL ok
P-169	DI-169	MH-210	1.20	9.36	9.36	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.36	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.32	9.32	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.32	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.31	9.31	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.32	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.30	9.30	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	9.31	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.29	9.29	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.30	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.52	9.52	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.52	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.63	9.63	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.64	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.64	9.64	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.64	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.63	9.63	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	9.64	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.52	9.52	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	9.63	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.42	9.42	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	9.52	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.58	9.58	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.59	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.59	9.59	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.59	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.58	9.58	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.59	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.42	9.42	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	9.58	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.29	9.29	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	9.42	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.21	9.21	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.23	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.14	9.14	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	9.21	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.92	10.92	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.93	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.71	10.71	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	10.92	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.92	10.92	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.94	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.90	10.90	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.90	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.89	10.89	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	10.90	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.52	11.52	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	11.71	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.50	11.50	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.52	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.05	11.05	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	11.50	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.89	10.89	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	11.05	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.71	10.71	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	10.89	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.58	10.58	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	10.71	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.73	10.73	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.74	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.72	10.72	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	10.73	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.71	10.71	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	10.72	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.43	10.43	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	10.58	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.06	10.06	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	10.43	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.90	9.90	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	10.06	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.86	9.86	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	9.90	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.84	9.84	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	9.86	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.79	9.79	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	9.84	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.74	9.74	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	9.79	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.64	9.64	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	9.74	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.56	9.56	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	9.64	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.50**	**9.50**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**9.56**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.58	10.58	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.58	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.43	10.43	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	10.44	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.58	10.58	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	10.64	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.43	10.43	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	10.48	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.90	9.90	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.93	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.84	9.84	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.85	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.74	9.74	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.78	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.74	9.74	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.76	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.99	9.99	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.99	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.97	9.97	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.99	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.95	9.95	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.97	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.90	9.90	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	9.95	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.95	9.95	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.96	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.43	10.43	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.45	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.34	10.34	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	10.43	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.24	10.24	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	10.34	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.12	10.12	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	10.24	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.03	10.03	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	10.12	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.84	9.84	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	10.03	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.03	10.03	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.04	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.28	10.28	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.29	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.24	10.24	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	10.28	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.86	9.86	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.86	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.82	9.82	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.81	9.81	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.82	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.80	9.80	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	9.81	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.79	9.79	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.80	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.02	10.02	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.02	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.13	10.13	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.14	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.14	10.14	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.14	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.13	10.13	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.14	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.02	10.02	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	10.13	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.92	9.92	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	10.02	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.08	10.08	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.09	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.09	10.09	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.09	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.08	10.08	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.09	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.92	9.92	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	10.08	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.79	9.79	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	9.92	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.71	9.71	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.73	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.64	9.64	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	9.71	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.22	12.22	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.23	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.01	12.01	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	12.22	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.22	12.22	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.24	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.20	12.20	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.20	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.19	12.19	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	12.20	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.82	12.82	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	13.01	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.80	12.80	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.82	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.35	12.35	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	12.80	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.19	12.19	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	12.35	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.01	12.01	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	12.19	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.88	11.88	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	12.01	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.03	12.03	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.04	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.02	12.02	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	12.03	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.01	12.01	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	12.02	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.73	11.73	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	11.88	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.36	11.36	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	11.73	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.20	11.20	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	11.36	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.16	11.16	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	11.20	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.14	11.14	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	11.16	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.09	11.09	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	11.14	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.04	11.04	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	11.09	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.94	10.94	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	11.04	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.86	10.86	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	10.94	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.80**	**10.80**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**10.86**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.88	11.88	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.88	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.73	11.73	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.74	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.88	11.88	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	11.94	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.73	11.73	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	11.78	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.20	11.20	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.23	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.14	11.14	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.15	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.04	11.04	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.08	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.04	11.04	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.06	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.29	11.29	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.29	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.27	11.27	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.29	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.25	11.25	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.27	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.20	11.20	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	11.25	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.25	11.25	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.26	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.73	11.73	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.75	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.64	11.64	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	11.73	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.54	11.54	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	11.64	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.42	11.42	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	11.54	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.33	11.33	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	11.42	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.14	11.14	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	11.33	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.33	11.33	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.34	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.58	11.58	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.59	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.54	11.54	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	11.58	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.16	11.16	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.16	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.12	11.12	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.12	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.11	11.11	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.12	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.10	11.10	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	11.11	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.09	11.09	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.10	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.32	11.32	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.32	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.43	11.43	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.44	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.44	11.44	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.44	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.43	11.43	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.44	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.32	11.32	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	11.43	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.22	11.22	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	11.32	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.38	11.38	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.39	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.39	11.39	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.39	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.38	11.38	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.39	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.22	11.22	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	11.38	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.09	11.09	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	11.22	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	11.01	11.01	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.03	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.94	10.94	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	11.01	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ____ of ____
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077.001
Segment: Jones Street Outfall — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.16	7.16	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.17	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	6.95	6.95	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	7.16	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.16	7.16	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.18	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.14	7.14	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.14	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.13	7.13	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	7.14	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	7.76	7.76	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	7.95	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	7.74	7.74	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.76	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.29	7.29	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	7.74	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.13	7.13	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	7.29	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	6.95	6.95	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	7.13	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	6.82	6.82	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	6.95	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	6.97	6.97	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.98	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	6.96	6.96	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	6.97	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	6.95	6.95	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	6.96	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.67	6.67	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	6.82	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.30	6.30	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	6.67	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.14	6.14	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	6.30	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.10	6.10	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	6.14	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.08	6.08	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	6.10	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.03	6.03	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	6.08	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	5.98	5.98	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	6.03	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.88	5.88	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	5.98	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.80	5.80	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	5.88	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.74**	**5.74**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**5.80**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.82	6.82	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.82	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.67	6.67	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	6.68	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.82	6.82	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	6.88	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.67	6.67	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	6.72	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.14	6.14	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.17	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.08	6.08	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.09	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	5.98	5.98	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	6.02	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	5.98	5.98	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.00	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.23	6.23	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.23	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.21	6.21	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.23	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.19	6.19	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.21	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.14	6.14	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	6.19	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.19	6.19	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.20	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.67	6.67	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.69	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.58	6.58	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	6.67	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.48	6.48	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	6.58	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.36	6.36	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	6.48	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.27	6.27	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	6.36	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.08	6.08	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	6.27	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.27	6.27	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.28	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.52	6.52	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.53	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.48	6.48	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	6.52	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.10	6.10	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.10	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.06	6.06	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.06	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.05	6.05	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.06	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.04	6.04	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	6.05	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.03	6.03	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	6.04	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.26	6.26	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.26	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.37	6.37	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.38	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.38	6.38	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.38	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.37	6.37	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	6.38	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.26	6.26	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	6.37	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.16	6.16	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	6.26	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.32	6.32	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.33	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.33	6.33	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.33	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.32	6.32	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	6.33	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.16	6.16	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	6.32	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.03	6.03	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	6.16	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	5.95	5.95	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	5.97	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.88	5.88	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	5.95	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.36	7.36	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.37	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.15	7.15	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	7.36	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.36	7.36	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.38	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.34	7.34	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.34	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.33	7.33	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	7.34	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	7.96	7.96	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	8.15	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	7.94	7.94	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.96	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.49	7.49	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	7.94	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.33	7.33	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	7.49	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.15	7.15	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	7.33	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.02	7.02	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	7.15	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.17	7.17	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.18	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.16	7.16	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	7.17	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.15	7.15	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	7.16	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.87	6.87	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	7.02	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.50	6.50	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	6.87	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.34	6.34	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	6.50	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.30	6.30	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	6.34	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.28	6.28	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	6.30	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.23	6.23	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	6.28	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.18	6.18	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	6.23	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	6.08	6.08	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	6.18	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.00	6.00	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	6.08	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.94**	**5.94**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**6.00**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.02	7.02	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.02	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.87	6.87	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	6.88	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.02	7.02	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	7.08	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.87	6.87	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	6.92	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.34	6.34	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.37	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.28	6.28	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.29	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.18	6.18	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	6.22	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.18	6.18	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.20	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.43	6.43	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.43	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.41	6.41	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.43	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.39	6.39	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.41	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.34	6.34	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	6.39	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.39	6.39	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.40	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.87	6.87	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.89	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.78	6.78	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	6.87	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.68	6.68	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	6.78	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.56	6.56	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	6.68	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.47	6.47	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	6.56	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.28	6.28	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	6.47	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.47	6.47	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.48	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.72	6.72	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.73	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.68	6.68	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	6.72	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.30	6.30	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.30	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.26	6.26	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.26	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.25	6.25	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.26	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.24	6.24	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	6.25	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.23	6.23	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	6.24	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.46	6.46	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.46	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.57	6.57	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.58	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.58	6.58	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.58	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.57	6.57	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	6.58	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.46	6.46	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	6.57	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.36	6.36	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	6.46	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.52	6.52	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.53	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.53	6.53	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.53	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.52	6.52	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	6.53	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.36	6.36	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	6.52	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.23	6.23	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	6.36	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.15	6.15	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	6.17	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	6.08	6.08	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	6.15	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.86	10.86	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.87	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.65	10.65	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	10.86	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.86	10.86	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.88	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.84	10.84	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.84	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.83	10.83	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	10.84	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.46	11.46	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	11.65	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.44	11.44	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.46	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.99	10.99	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	11.44	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.83	10.83	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	10.99	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.65	10.65	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	10.83	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.52	10.52	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	10.65	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.67	10.67	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.68	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.66	10.66	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	10.67	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.65	10.65	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	10.66	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.37	10.37	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	10.52	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.00	10.00	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	10.37	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.84	9.84	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	10.00	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.80	9.80	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	9.84	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.78	9.78	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	9.80	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.73	9.73	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	9.78	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.68	9.68	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	9.73	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.58	9.58	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	9.68	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.50	9.50	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	9.58	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.44**	**9.44**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**9.50**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.52	10.52	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.52	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.37	10.37	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	10.38	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.52	10.52	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	10.58	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.37	10.37	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	10.42	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.84	9.84	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.87	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.78	9.78	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.79	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.68	9.68	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.72	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.68	9.68	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.70	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.93	9.93	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.93	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.91	9.91	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.93	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.89	9.89	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.91	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.84	9.84	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	9.89	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.89	9.89	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.90	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.37	10.37	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.39	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.28	10.28	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	10.37	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.18	10.18	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	10.28	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.06	10.06	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	10.18	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.97	9.97	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	10.06	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.78	9.78	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	9.97	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.97	9.97	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.98	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.22	10.22	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.23	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.18	10.18	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	10.22	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.80	9.80	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.80	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.76	9.76	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.76	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.75	9.75	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.76	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.74	9.74	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	9.75	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.73	9.73	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.74	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.96	9.96	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.96	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.07	10.07	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.08	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.08	10.08	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.08	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.07	10.07	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.08	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.96	9.96	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	10.07	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.86	9.86	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	9.96	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.02	10.02	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.03	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.03	10.03	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.03	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.02	10.02	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.03	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.86	9.86	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	10.02	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.73	9.73	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	9.86	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.65	9.65	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.67	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.58	9.58	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	9.65	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.36	11.36	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.37	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.15	11.15	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	11.36	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.36	11.36	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.38	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.34	11.34	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.34	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.33	11.33	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	11.34	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.96	11.96	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	12.15	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.94	11.94	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.96	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.49	11.49	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	11.94	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.33	11.33	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	11.49	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.15	11.15	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	11.33	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.02	11.02	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	11.15	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.17	11.17	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.18	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.16	11.16	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	11.17	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.15	11.15	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	11.16	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.87	10.87	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	11.02	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.50	10.50	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	10.87	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.34	10.34	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	10.50	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.30	10.30	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	10.34	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.28	10.28	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	10.30	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.23	10.23	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	10.28	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.18	10.18	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	10.23	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.08	10.08	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	10.18	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.00	10.00	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	10.08	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.94**	**9.94**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**10.00**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.02	11.02	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.02	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.87	10.87	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	10.88	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.02	11.02	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	11.08	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.87	10.87	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	10.92	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.34	10.34	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.37	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.28	10.28	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.29	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.18	10.18	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.22	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.18	10.18	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.20	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.43	10.43	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.43	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.41	10.41	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.43	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.39	10.39	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.41	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.34	10.34	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	10.39	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.39	10.39	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.40	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.87	10.87	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.89	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.78	10.78	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	10.87	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.68	10.68	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	10.78	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.56	10.56	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	10.68	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.47	10.47	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	10.56	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.28	10.28	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	10.47	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.47	10.47	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.48	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.72	10.72	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.73	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.68	10.68	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	10.72	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.30	10.30	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.30	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.26	10.26	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.26	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.25	10.25	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.26	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.24	10.24	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	10.25	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.23	10.23	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	10.24	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.46	10.46	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.46	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.57	10.57	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.58	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.58	10.58	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.58	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	10.57	10.57	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.58	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.46	10.46	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	10.57	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.36	10.36	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	10.46	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.52	10.52	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.53	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.53	10.53	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.53	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.52	10.52	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.53	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.36	10.36	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	10.52	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.23	10.23	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	10.36	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.15	10.15	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.17	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.08	10.08	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	10.15	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.76	11.76	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.77	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.55	11.55	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	11.76	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.76	11.76	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.78	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.74	11.74	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.74	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.73	11.73	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	11.74	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.36	12.36	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	12.55	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.34	12.34	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.36	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.89	11.89	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	12.34	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.73	11.73	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	11.89	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.55	11.55	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	11.73	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.42	11.42	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	11.55	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.57	11.57	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.58	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.56	11.56	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	11.57	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.55	11.55	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	11.56	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.27	11.27	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	11.42	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.90	10.90	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	11.27	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.74	10.74	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	10.90	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.70	10.70	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	10.74	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.68	10.68	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	10.70	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.63	10.63	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	10.68	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.58	10.58	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	10.63	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.48	10.48	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	10.58	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.40	10.40	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	10.48	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.34**	**10.34**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**10.40**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.42	11.42	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.42	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.27	11.27	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.28	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.42	11.42	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	11.48	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.27	11.27	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	11.32	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.74	10.74	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.77	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.68	10.68	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.69	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.58	10.58	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.62	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.58	10.58	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.60	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.83	10.83	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.83	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.81	10.81	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.83	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.79	10.79	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.81	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.74	10.74	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	10.79	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.79	10.79	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.80	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.27	11.27	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.29	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.18	11.18	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	11.27	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.08	11.08	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	11.18	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.96	10.96	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	11.08	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.87	10.87	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	10.96	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.68	10.68	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	10.87	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.87	10.87	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.88	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.12	11.12	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.13	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.08	11.08	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	11.12	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.70	10.70	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.70	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.66	10.66	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.66	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.65	10.65	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.66	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.64	10.64	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	10.65	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.63	10.63	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	10.64	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.86	10.86	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.86	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.97	10.97	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.98	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.98	10.98	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.98	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	10.97	10.97	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	10.98	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	10.86	10.86	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	10.97	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.76	10.76	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	10.86	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.92	10.92	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.93	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.93	10.93	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.93	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	10.92	10.92	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.93	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	10.76	10.76	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	10.92	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.63	10.63	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	10.76	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.55	10.55	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.57	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.48	10.48	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	10.55	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.26	12.26	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.27	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.05	12.05	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	12.26	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.26	12.26	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.28	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.24	12.24	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.24	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.23	12.23	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	12.24	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.86	12.86	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	13.05	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.84	12.84	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.86	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.39	12.39	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	12.84	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.23	12.23	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	12.39	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.05	12.05	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	12.23	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.92	11.92	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	12.05	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.07	12.07	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.08	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.06	12.06	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	12.07	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.05	12.05	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	12.06	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.77	11.77	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	11.92	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.40	11.40	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	11.77	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.24	11.24	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	11.40	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.20	11.20	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	11.24	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.18	11.18	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	11.20	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.13	11.13	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	11.18	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.08	11.08	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	11.13	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.98	10.98	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	11.08	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.90	10.90	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	10.98	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.84**	**10.84**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**10.90**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.92	11.92	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.92	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.77	11.77	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.78	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.92	11.92	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	11.98	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.77	11.77	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	11.82	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.24	11.24	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.27	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.18	11.18	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.19	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.08	11.08	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.12	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.08	11.08	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.10	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.33	11.33	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.33	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.31	11.31	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.33	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.29	11.29	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.31	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.24	11.24	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	11.29	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.29	11.29	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.30	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.77	11.77	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.79	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.68	11.68	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	11.77	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.58	11.58	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	11.68	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.46	11.46	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	11.58	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.37	11.37	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	11.46	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.18	11.18	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	11.37	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.37	11.37	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.38	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.62	11.62	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.63	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.58	11.58	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	11.62	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.20	11.20	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.20	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.16	11.16	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.16	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.15	11.15	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.16	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.14	11.14	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	11.15	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.13	11.13	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.14	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.36	11.36	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.36	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.47	11.47	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.48	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.48	11.48	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.48	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.47	11.47	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	11.48	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.36	11.36	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	11.47	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.26	11.26	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	11.36	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.42	11.42	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.43	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.43	11.43	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.43	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.42	11.42	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.43	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.26	11.26	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	11.42	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.13	11.13	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	11.26	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	11.05	11.05	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.07	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.98	10.98	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	11.05	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.96	12.96	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.97	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.75	12.75	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	12.96	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.96	12.96	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.98	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.94	12.94	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.94	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.93	12.93	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	12.94	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.56	13.56	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	13.75	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.54	13.54	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.56	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.09	13.09	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	13.54	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.93	12.93	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	13.09	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.75	12.75	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	12.93	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.62	12.62	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	12.75	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.77	12.77	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.78	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.76	12.76	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	12.77	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.75	12.75	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	12.76	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.47	12.47	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	12.62	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.10	12.10	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	12.47	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.94	11.94	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	12.10	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.90	11.90	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	11.94	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.88	11.88	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	11.90	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.83	11.83	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	11.88	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.78	11.78	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	11.83	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.68	11.68	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	11.78	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	11.60	11.60	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	11.68	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**11.54**	**11.54**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**11.60**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.62	12.62	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.62	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.47	12.47	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	12.48	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.62	12.62	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	12.68	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.47	12.47	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	12.52	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.94	11.94	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.97	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.88	11.88	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.89	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.78	11.78	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.82	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.78	11.78	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.80	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.03	12.03	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.03	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.01	12.01	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.03	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.99	11.99	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.01	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.94	11.94	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	11.99	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.99	11.99	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.00	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.47	12.47	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.49	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.38	12.38	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	12.47	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.28	12.28	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	12.38	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.16	12.16	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	12.28	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.07	12.07	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	12.16	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.88	11.88	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	12.07	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.07	12.07	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.08	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.32	12.32	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.33	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.28	12.28	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	12.32	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.90	11.90	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.90	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.86	11.86	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.86	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.85	11.85	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.86	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.84	11.84	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	11.85	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.83	11.83	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.84	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.06	12.06	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.06	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.17	12.17	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.18	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.18	12.18	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.18	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.17	12.17	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	12.18	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.06	12.06	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	12.17	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.96	11.96	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	12.06	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.12	12.12	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.13	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.13	12.13	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.13	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.12	12.12	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	12.13	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.96	11.96	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	12.12	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.83	11.83	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	11.96	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.75	11.75	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.77	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.68	11.68	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	11.75	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.46	13.46	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.47	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	13.25	13.25	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	13.46	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.46	13.46	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.48	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.44	13.44	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.44	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.43	13.43	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	13.44	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	14.06	14.06	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	14.25	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	14.04	14.04	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	14.06	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.59	13.59	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	14.04	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.43	13.43	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	13.59	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	13.25	13.25	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	13.43	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	13.12	13.12	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	13.25	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	13.27	13.27	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.28	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	13.26	13.26	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	13.27	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	13.25	13.25	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	13.26	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.97	12.97	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	13.12	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.60	12.60	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	12.97	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.44	12.44	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	12.60	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	12.40	12.40	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	12.44	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	12.38	12.38	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	12.40	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	12.33	12.33	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	12.38	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	12.28	12.28	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	12.33	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	12.18	12.18	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	12.28	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	12.10	12.10	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	12.18	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**12.04**	**12.04**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**12.10**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	13.12	13.12	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.12	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.97	12.97	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	12.98	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	13.12	13.12	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	13.18	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.97	12.97	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	13.02	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.44	12.44	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.47	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	12.38	12.38	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.39	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	12.28	12.28	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.32	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	12.28	12.28	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.30	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.53	12.53	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.53	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.51	12.51	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.53	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.49	12.49	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.51	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.44	12.44	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	12.49	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.49	12.49	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.50	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.97	12.97	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.99	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.88	12.88	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	12.97	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.78	12.78	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	12.88	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.66	12.66	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	12.78	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.57	12.57	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	12.66	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	12.38	12.38	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	12.57	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.57	12.57	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.58	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.82	12.82	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.83	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.78	12.78	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	12.82	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	12.40	12.40	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.40	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	12.36	12.36	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	12.35	12.35	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	12.36	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	12.34	12.34	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	12.35	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	12.33	12.33	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	12.34	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.56	12.56	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.56	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.67	12.67	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.68	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.68	12.68	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.68	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.67	12.67	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	12.68	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.56	12.56	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	12.67	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.46	12.46	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	12.56	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.62	12.62	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.63	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.63	12.63	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.63	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.62	12.62	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	12.63	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.46	12.46	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	12.62	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	12.33	12.33	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	12.46	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	12.25	12.25	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.27	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	12.18	12.18	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	12.25	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	14.76	14.76	15	1.3	1.1	95	16	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.77	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	14.55	14.55	15	2.5	2.0	91	154	0.0013	0.19	0	0.00	0.02	1.1	1.4	0.0	1.1	0.0	95	0.01	0.04	1.0	0.5	0.02	0.21	14.76	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	14.76	14.76	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.78	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	14.74	14.74	15	0.6	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.74	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	14.73	14.73	15	0.6	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	14.74	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	15.36	15.36	12	2.2	2.9	0	47	0.0034	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.19	15.55	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	15.34	15.34	12	0.6	0.8	90	82.1	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	15.36	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	14.89	14.89	12	3.3	4.2	72	41	0.0073	0.30	0	0.00	0.07	0.5	6.4	0.0	2.9	0.0	0	0.00	0.11	1.3	1.0	0.15	0.44	15.34	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	14.73	14.73	18	3.2	1.8	77	26	0.0008	0.02	0	0.00	0.01	13.8	0.0	0.0	4.2	0.1	72	0.17	0.27	1.0	0.5	0.14	0.16	14.89	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	14.55	14.55	18	3.8	2.2	90	129	0.0011	0.15	0	0.00	0.02	6.0	0.3	0.0	1.8	0.0	77	0.03	0.07	1.0	0.5	0.04	0.18	14.73	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	14.42	14.42	18	7.3	4.1	3	14	0.0042	0.06	0	0.00	0.07	8.4	0.9	5.1	2.2	0.0	90	0.05	0.14	1.0	0.5	0.07	0.13	14.55	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	14.57	14.57	15	0.8	0.6	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.58	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	14.56	14.56	15	1.2	1.0	22	5	0.0003	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	70	0.00	0.01	1.3	1.0	0.01	0.01	14.57	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	14.55	14.55	18	1.2	0.7	2	25	0.0001	0.00	0	0.00	0.00	1.2	0.0	0.0	1.0	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	14.56	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	14.27	14.27	24	8.6	2.7	4	60	0.0012	0.07	0	0.00	0.03	30.4	0.9	0.3	4.1	0.1	3	0.03	0.15	1.0	0.5	0.07	0.15	14.42	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	13.90	13.90	24	13.4	4.3	4	82	0.0030	0.25	0	0.00	0.07	23.5	12.3	0.0	2.7	0.0	4	0.01	0.12	1.0	1.0	0.12	0.37	14.27	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	13.74	13.74	36	13.7	1.9	7	59	0.0004	0.02	0	0.00	0.01	57.1	0.0	0.0	4.3	0.1	4	0.03	0.14	1.0	1.0	0.14	0.16	13.90	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	13.70	13.70	48	17.2	1.4	3	54	0.0001	0.01	0	0.00	0.01	26.4	7.4	8.0	1.9	0.0	7	0.01	0.03	1.0	1.0	0.03	0.04	13.74	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	13.68	13.68	48	17.4	1.4	3	68	0.0001	0.01	0	0.00	0.01	23.6	0.1	0.0	1.4	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	13.70	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	13.63	13.63	48	19.9	1.6	4	180	0.0002	0.03	0	0.00	0.01	24.2	24.2	3.2	1.4	0.0	3	0.00	0.02	1.0	1.0	0.02	0.05	13.68	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	13.58	13.58	48	24.3	1.9	2	58	0.0002	0.01	0	0.00	0.01	31.6	1.2	8.2	1.6	0.0	4	0.00	0.03	1.0	1.0	0.03	0.05	13.63	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	13.48	13.48	48	30.9	2.5	0	158	0.0004	0.06	0	0.00	0.02	47.0	3.7	3.7	1.9	0.0	2	0.00	0.04	1.0	1.0	0.04	0.11	13.58	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	13.40	13.40	48	32.6	2.6	16	35	0.0004	0.02	0	0.00	0.03	76.0	3.9	0.0	2.5	0.0	0	0.00	0.06	1.0	1.0	0.06	0.07	13.48	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**13.34**	**13.34**	**48**	**32.4**	**2.6**	**0**	**48**	**0.0004**	**0.02**	**0**	**0.00**	**0.03**	**84.4**	**0.0**	**0.0**	**2.6**	**0.0**	**16**	**0.02**	**0.08**	**1.0**	**0.5**	**0.04**	**0.06**	**13.40**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	14.42	14.42	15	0.7	0.5	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.42	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	14.27	14.27	15	1.0	0.8	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	14.28	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	14.42	14.42	8	0.3	1.0	93	96	0.0006	0.05	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	14.48	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	14.27	14.27	18	4.7	2.6	90	23	0.0017	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.05	14.32	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	13.74	13.74	18	3.6	2.0	90	19	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.77	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	13.68	13.68	18	2.4	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.69	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	13.58	13.58	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	13.62	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	13.58	13.58	18	2.6	1.4	90	18	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.60	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	13.83	13.83	18	1.2	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.83	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	13.81	13.81	18	1.6	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	13.83	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	13.79	13.79	24	2.2	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.4	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	13.81	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	13.74	13.74	24	5.0	1.6	94	33	0.0004	0.01	0	0.00	0.01	1.5	2.1	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.05	13.79	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	13.79	13.79	18	1.9	1.1	90	19	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.80	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	14.27	14.27	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	14.29	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	14.18	14.18	18	2.9	1.6	90	68	0.0006	0.04	0	0.00	0.01	3.3	0.0	0.0	1.4	0.0	90	0.02	0.04	1.3	1.0	0.05	0.10	14.27	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	14.08	14.08	18	3.3	1.9	79	29	0.0008	0.02	0	0.00	0.01	4.6	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.10	14.18	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	13.96	13.96	24	5.8	1.8	69	46	0.0006	0.03	0	0.00	0.01	6.2	0.0	0.0	1.9	0.0	79	0.04	0.07	1.3	1.0	0.09	0.11	14.08	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	13.87	13.87	24	6.0	1.9	80	44	0.0006	0.03	0	0.00	0.01	10.6	0.0	0.0	1.8	0.0	69	0.03	0.06	1.0	1.0	0.06	0.09	13.96	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	13.68	13.68	24	8.7	2.8	88	29	0.0013	0.04	0	0.00	0.03	11.6	24.2	0.0	2.8	0.0	88	0.08	0.16	1.0	1.0	0.16	0.19	13.87	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	13.87	13.87	18	2.2	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.88	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	14.12	14.12	18	1.6	0.9	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.13	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	14.08	14.08	18	2.0	1.2	12	68	0.0003	0.02	0	0.00	0.01	1.4	0.0	0.0	0.9	0.0	90	0.01	0.02	1.3	1.0	0.02	0.05	14.12	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	13.70	13.70	18	0.4	0.2	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.70	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	13.66	13.66	18	0.6	0.3	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.66	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	13.65	13.65	18	0.9	0.5	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.3	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	13.66	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	13.64	13.64	18	1.1	0.6	12	49	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.5	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	13.65	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	13.63	13.63	18	1.4	0.8	98	23	0.0002	0.00	0	0.00	0.00	0.7	0.0	0.0	0.6	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	13.64	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	13.86	13.86	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.86	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	13.97	13.97	18	1.7	1.0	90	23	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.98	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	13.98	13.98	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.98	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	13.97	13.97	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.00	13.98	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	13.86	13.86	18	3.0	1.7	70	108	0.0007	0.08	0	0.00	0.01	0.4	1.6	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.11	13.97	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	13.76	13.76	18	3.6	2.0	57	27	0.0010	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	70	0.03	0.06	1.3	1.0	0.08	0.10	13.86	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	13.92	13.92	18	2.2	1.2	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.93	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	13.93	13.93	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.93	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	13.92	13.92	18	0.8	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	13.93	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	13.76	13.76	18	3.5	2.0	14	119	0.0009	0.11	0	0.00	0.02	0.4	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.16	13.92	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	13.63	13.63	18	3.8	2.2	67	50	0.0011	0.06	0	0.00	0.02	7.0	7.2	0.0	2.0	0.0	57	0.03	0.07	1.0	1.0	0.07	0.13	13.76	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	13.55	13.55	18	2.3	1.3	105	53	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	13.57	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	13.48	13.48	18	2.6	1.5	90	43	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	105	0.02	0.04	1.3	1.0	0.05	0.07	13.55	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 100 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
CRB Network STA 109+25 to 111+75																										
CRB-P72	CRB-DI72	CRB-MH-74	7961	0	7961	0.18	1.00	0.18	0.18	6.0	0.00	7.73	1.4	15	16	0.012	0.0004	0.019	7.8	9.6	5.5	0.05	6.05	2.60	2.30	Q ok
CRB-P74	CRB-MH-74	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.34	6.0	6.17	7.66	2.6	15	154	0.012	0.0014	0.005	4.1	5.1	4.1	0.63	6.80	1.65	0.84	Q ok
CRB-P73	CRB-DI73	CRB-MH-74	7042	0	7042	0.16	1.00	0.16	0.16	6.0	0.00	7.73	1.2	15	34	0.012	0.0003	0.005	4.0	4.9	3.3	0.17	6.17	1.92	1.75	Q ok
MSS Network Sta 111+75 to 114+00																										
P-162	DI-162	EXMH-201	3794	0	3794	0.09	1.00	0.09	0.09	6.0	0.00	7.73	**0.67**	15	16	0.011	0.000078	0.0200	8.8	**10.8**	4.3	0.06	6.06	2.50	2.18	Q ok
P-201	EXMH-201	A1-MH-203	1	0	1	0.00	1.00	0.00	0.09	6.0	6.06	7.69	**0.67**	15	18	0.012	0.000092	0.0200	8.1	**9.9**	3.9	0.08	6.14	1.98	1.62	Q ok
Ploener Property																										
EX-P LOT	EXDI LOT	DI-MSS-41	13430	0	13430	0.31	1.00	0.31	0.31	6.0	0.00	7.73	**2.38**	12	47	0.012	0.003811	0.0074	4.2	**3.3**	4.6	0.17	6.17	2.50	2.15	Q ok
P-MSS-48	DI-MSS-40	DI-MSS-41	3590	0	3590	0.08	1.00	0.08	0.08	6.0	0.00	7.73	**0.64**	12	82	0.012	0.000272	0.0050	3.5	**2.7**	2.8	0.48	6.48	2.56	2.15	Q ok
P-MSS-48A	DI-MSS-41	EX-MH	3072	0	3072	0.07	1.00	0.07	0.46	6.0	6.48	7.56	**3.49**	12	41	0.012	0.008166	0.0051	3.5	**2.8**	2.9	0.24	6.72	2.05	1.84	Undersized!
A1-P-202	EX-MH	A1-MH-203	1	0	1	0.00	1.00	0.00	0.46	6.0	6.72	7.50	**3.46**	18	26	0.012	0.000923	0.0046	4.4	**7.7**	4.2	0.10	6.82	1.74	1.62	Q ok
A1-P-204	A1-MH-204	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.55	6.0	6.82	7.46	**4.09**	18	129	0.012	0.001293	0.0052	4.6	**8.2**	4.6	0.47	7.29	1.52	0.85	Q ok
A1-P-205	CRB-MH-67	CMH-1	1	0	1	0.00	1.00	0.00	1.07	6.0	7.29	7.30	**7.82**	18	14	0.012	0.004724	0.0057	4.9	**8.6**	5.5	0.04	7.33	0.75	0.67	Q ok
MSS Network Sta 111+75 to 114+00																										
MSS-P2	MSS-DI2	MSS-DI1	3846	1139	4985	0.11	0.97	0.11	0.11	6.0	0.00	7.73	0.9	15	70	0.012	0.0001	0.005	4.0	4.9	2.8	0.42	6.42	4.03	3.68	Q ok
MSS-P1	MSS-DI1	EXMH	2301	1082	3383	0.08	0.88	0.07	0.18	6.0	6.42	7.60	1.4	15	5	0.012	0.0004	0.003	3.3	4.0	3.0	0.03	6.44	3.39	3.37	Q ok
A1-P-203	EX MH	MH-CRB-67	1	0	1	0.00	1.00	0.00	0.18	6.0	6.44	7.60	**1.36**	18	25	0.012	0.000143	0.0050	4.6	**8.0**	3.2	0.13	6.57	0.92	0.84	Q ok
Jones Street Constructed Under Area 1																										
A1-P-206	CMH-1	A1-DI-207	1	0	1	0.00	1.00	0.00	1.26	6.0	7.33	7.30	**9.20**	24	60	0.012	0.001410	0.0035	4.6	**14.5**	4.9	0.20	7.53	0.57	0.36	Q ok
A1-P-207	A1-DI-207	A1-DI-208	3414	0	3414	0.08	1.00	0.08	1.98	6.0	7.53	7.23	**14.31**	24	82	0.012	0.003410	0.0040	4.9	**15.5**	5.6	0.24	7.77	0.36	0.03	Q ok
A1-P-208	A1-DI-208	A1-DI-209	2490	0	2490	0.06	1.00	0.06	2.04	6.0	7.77	7.13	**14.52**	36	59	0.012	0.000404	0.0041	6.5	**46.1**	5.5	0.18	7.95	0.03	-0.21	Q ok
A1-P-209	A1-DI-209	A1-MH-210	2433	0	2433	0.06	1.00	0.06	2.59	6.0	7.95	7.06	**18.28**	48	54	0.012	0.000138	0.0041	7.9	**99.3**	5.9	0.15	8.10	-0.21	-0.43	Q ok
A1-P-210	A1-MH-210	A1-DI-211	1	0	1	0.00	1.00	0.00	2.65	6.0	8.10	7.03	**18.61**	48	68	0.012	0.000143	0.0040	7.8	**98.1**	5.9	0.19	8.30	-0.43	-0.70	Q ok
A1-P-211	A1-DI-211	A1-DI-212	3353	0	3353	0.08	1.00	0.08	3.05	6.0	8.30	6.96	**21.24**	48	180	0.012	0.000186	0.0040	7.8	**98.4**	5.9	0.51	8.81	-0.70	-1.42	Q ok
A1-P-212	A1-DI-212	A1-DI-213	1885	0	1885	0.04	1.00	0.04	3.81	6.0	8.81	6.80	**25.91**	48	58	0.012	0.000277	0.0040	7.8	**98.0**	6.4	0.15	8.96	-1.42	-1.65	Q ok
A1-P-213	A1-DI-213	A1-DI-214	15288	0	15288	0.35	1.00	0.35	4.87	6.0	8.96	6.73	**32.76**	48	158	0.012	0.000443	0.0040	7.8	**98.3**	7.0	0.37	9.33	-1.65	-2.28	Q ok
A1-P-214	A1-DI-214	A1-DI-215	**1**	0	1	0.00	1.00	0.00	5.23	6.0	9.33	6.63	**34.69**	48	35	0.012	0.000497	0.0040	7.8	**98.4**	7.0	0.08	9.42	-2.28	-2.42	Q ok
A1-P-215	A1-DI-215	A1-MH-216	**1**	0	1	0.00	1.00	0.00	5.23	6.0	9.42	6.60	**34.52**	48	48	0.012	0.000492	0.0040	7.8	**97.9**	7.0	0.11	9.53	-2.42	-2.61	Q ok
MSS-P3 A	MSS-DI14	DI-161	3612	330	3942	0.09	1.00	0.09	0.09	6.0	0.00	7.73	0.7	15	44	0.012	0.0001	0.005	4.0	4.9	2.8	0.26	6.26	4.03	3.81	Q ok
MSS-P3 B	DI-161	MSS-DI13	2062	222	2284	0.05	1.00	0.05	0.14	6.0	6.26	7.63	1.1	15	25	0.012	0.0002	0.005	4.1	5.0	3.0	0.14	6.40	3.81	3.68	Q ok
	DOGHOUSE																									
P-160	DI-160	CMH-1	1768	257	2025	0.05	1.00	0.05	0.05	6.0	0.00	7.73	**0.36**	8	96	0.011	0.000633	0.0200	5.8	**2.0**	4.3	0.37	6.37	2.99	1.07	Q ok
A1 P-200	PARCEL J	A1-DI-207	27861	0	27861	0.64	1.00	0.64	0.64	6.0	0.00	7.73	**4.94**	18	23	0.012	0.001887	0.0100	6.4	11.4	6.2	0.06	6.06	1.59	1.36	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 100 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to	Pervious Area, C = 0.18 to	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-336	PARCEL J	A1-DI-209	21549	0	21549	0.49	1.00	0.49	0.49	6.0	0.00	7.73	**3.82**	18	19	0.012	0.001129	0.0100	6.4	11.4	5.8	0.05	6.05	1.48	1.29	Q ok
P-337	PARCEL J	A1-DI-211	14148	0	14148	0.32	1.00	0.32	0.32	6.0	0.00	7.73	**2.51**	18	23	0.012	0.000487	0.0100	6.4	11.4	4.8	0.08	6.08	1.53	1.30	Q ok
P-335	PARCEL N	A1-DI-213	15379	0	15379	0.35	1.00	0.35	0.35	6.0	0.00	7.73	**2.73**	18	56	0.012	0.000575	0.0100	6.4	11.4	5.3	0.18	6.18	1.91	1.35	Q ok
P-340	PARCEL K	A1-DI-213	15267	0	15267	0.35	1.00	0.35	0.35	6.0	0.00	7.73	**2.71**	18	18	0.012	0.000567	0.0100	6.4	11.4	5.3	0.06	6.06	1.53	1.35	Q ok
P-165	DI-165	DI-166	7237	0	7237	0.17	1.00	0.17	0.17	6.0	0.00	7.73	**1.28**	18	28	0.012	0.000127	0.0100	6.4	**11.4**	3.9	0.12	6.12	2.95	2.67	Q ok
P-166	DI-166	DI-167	2265	0	2265	0.05	1.00	0.05	0.22	6.0	6.12	7.69	**1.68**	18	54	0.012	0.000218	0.0100	6.4	**11.4**	4.5	0.20	6.32	2.47	1.93	Q ok
P-167	DI-167	DI-168	3648	0	3648	0.08	1.00	0.08	0.30	6.0	6.32	7.63	**2.30**	24	91	0.012	0.000088	0.0100	7.8	**24.5**	4.7	0.32	6.64	1.73	0.82	Q ok
P-168	DI-168	DI-209	6136	0	6136	0.14	1.00	0.14	0.71	6.0	6.64	7.53	**5.32**	24	33	0.012	0.000472	0.0100	7.8	**24.5**	5.9	0.09	6.74	0.62	0.29	Q ok
P-327	PARCEL L	DI-168	11517	0	11517	0.26	1.00	0.26	0.26	6.0	0.00	7.73	**2.04**	18	19	0.012	0.000322	0.0100	6.4	11.4	4.8	0.07	6.07	1.31	1.12	Q ok
P-326	PARCEL L	DI-170	14378	0	14378	0.33	1.00	0.33	0.33	6.0	0.00	7.73	**2.55**	18	23	0.012	0.000502	0.0100	6.4	11.4	4.8	0.08	6.08	3.99	3.76	Q ok
P-170	DI-170	DI-171	2801	0	2801	0.06	1.00	0.06	0.39	6.0	6.08	7.69	**3.03**	18	68	0.012	0.000711	0.0100	6.4	**11.4**	5.3	0.21	6.29	3.26	2.58	Q ok
P-171	DI-171	DI-173	2811	0	2811	0.06	1.00	0.06	0.46	6.0	6.29	7.63	**3.50**	18	29	0.012	0.000946	0.0100	6.4	**11.4**	5.5	0.09	6.38	2.38	2.09	Q ok
P-173	DI-173	DI-174	2818	0	2818	0.06	1.00	0.06	0.81	6.0	6.38	7.60	**6.12**	24	46	0.012	0.000623	0.0100	7.8	**24.5**	6.4	0.12	6.50	1.89	1.43	Q ok
P-174	DI-174	DI-175	1817	0	1817	0.04	1.00	0.04	0.85	6.0	6.50	7.56	**6.41**	24	44	0.012	0.000683	0.0100	7.8	**24.5**	6.4	0.11	6.62	1.23	0.79	Q ok
P-175	DI-175	DI-211	3620	0	3620	0.08	1.00	0.08	1.23	6.0	6.62	7.53	**9.23**	24	29	0.012	0.001420	0.0100	7.8	**24.5**	7.2	0.07	6.68	0.59	0.30	Q ok
P-331	PARCEL M	DI-175	12913	0	12913	0.30	1.00	0.30	0.30	6.0	0.00	7.73	**2.29**	18	19	0.012	0.000405	0.0100	6.4	11.4	4.8	0.07	6.07	1.28	1.09	Q ok
P-328	PARCEL M	DI-172	9475	0	9475	0.22	1.00	0.22	0.22	6.0	0.00	7.73	**1.68**	18	22	0.012	0.000218	0.0100	6.4	11.4	4.5	0.08	6.08	3.49	3.27	Q ok
P-172	DI-172	DI-173	2798	0	2798	0.06	1.00	0.06	0.28	6.0	6.08	7.69	**2.17**	18	68	0.012	0.000363	0.0100	6.4	**11.4**	4.8	0.23	6.32	2.77	2.09	Q ok
P-169	DI-169	MH-210	2626	0	2626	0.06	1.00	0.06	0.06	6.0	0.00	7.73	**0.47**	18	7	0.012	0.000017	0.0100	6.4	**11.4**	3.2	0.04	6.04	1.64	1.57	Q ok
P-178	DI-178	DI-179	3573	0	3573	0.08	1.00	0.08	0.08	6.0	0.00	7.73	**0.63**	18	39	0.012	0.000031	0.0100	6.4	**11.4**	3.2	0.21	6.21	2.63	2.24	Q ok
P-179	DI-179	DI-180	1913	0	1913	0.04	1.00	0.04	0.13	6.0	0.00	7.73	**0.97**	18	34	0.012	0.000073	0.0100	6.4	**11.4**	3.9	0.15	6.15	2.04	1.70	Q ok
P-180	DI-180	DI-181	1165	0	1165	0.03	1.00	0.03	0.15	6.0	0.00	7.73	**1.18**	18	49	0.012	0.000108	0.0100	6.4	**11.4**	3.9	0.21	6.21	1.50	1.01	Q ok
P-181	DI-181	DI-212	1967	0	1967	0.05	1.00	0.05	0.20	6.0	0.00	7.73	**1.53**	18	23	0.012	0.000181	0.0100	6.4	**11.4**	4.5	0.09	6.09	0.81	0.58	Q ok
P-182	DI-182	DI-186	1887	0	1887	0.04	1.00	0.04	0.04	6.0	0.00	7.73	**0.33**	18	43	0.012	0.000009	0.0100	6.4	**11.4**	3.2	0.23	6.23	4.28	3.85	Q ok
P-338	PARCEL J	DI-185	10195	0	10195	0.23	1.00	0.23	0.23	6.0	0.00	7.73	**1.81**	18	23	0.012	0.000253	0.0100	6.4	11.4	4.5	0.09	6.09	3.86	3.63	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 100 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-183	DI-183	DI-184	2436	0	2436	0.06	1.00	0.06	0.06	6.0	0.00	7.73	**0.43**	18	59	0.012	0.000014	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.74	4.15	Q ok
P-184	DI-184	DI-185	2508	0	2508	0.06	1.00	0.06	0.11	6.0	0.00	7.73	**0.88**	18	62	0.012	0.000059	0.0100	6.4	**11.4**	3.9	0.27	6.27	3.95	3.33	Q ok
P-185	DI-185	DI-186	3002	0	3002	0.07	1.00	0.07	0.42	6.0	0.00	7.73	**3.22**	18	108	0.012	0.000800	0.0100	6.4	**11.4**	5.5	0.33	6.33	3.13	2.05	Q ok
P-186	DI-186	DI-190	1354	0	1354	0.03	1.00	0.03	0.49	6.0	0.00	7.73	**3.79**	18	27	0.012	0.001111	0.0100	6.4	**11.4**	5.8	0.08	6.08	1.85	1.58	Q ok
check San x-ing																										
P-339	PARCEL K	DI-189	12930	0	12930	0.30	1.00	0.30	0.30	6.0	0.00	7.73	**2.29**	18	23	0.012	0.000406	0.0100	6.4	11.4	4.8	0.08	6.08	3.20	2.97	Q ok
P-187	DI-187	DI-188	2448	0	2448	0.06	1.00	0.06	0.06	6.0	0.00	7.73	**0.43**	18	59	0.012	0.000015	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.08	3.49	Q ok
P-188	DI-188	DI-189	2550	0	2550	0.06	1.00	0.06	0.11	6.0	0.00	7.73	**0.89**	18	62	0.012	0.000061	0.0100	6.4	**11.4**	3.9	0.27	6.27	3.29	2.67	Q ok
P-189	DI-189	DI-190	3025	0	3025	0.07	1.00	0.07	0.48	6.0	0.00	7.73	**3.72**	18	119	0.012	0.001067	0.0100	6.4	**11.4**	5.8	0.34	6.34	2.47	1.28	Q ok
P-190	DI-190	DI-191	1765	0	1765	0.04	1.00	0.04	0.52	6.0	0.00	7.73	**4.03**	18	50	0.012	0.001254	0.0100	6.4	**11.4**	5.8	0.14	6.14	1.08	0.58	Q ok
P-341	PARCEL K	DI-195	13999	0	13999	0.32	1.00	0.32	0.32	6.0	0.00	7.73	**2.48**	18	53	0.012	0.000476	0.0100	6.4	11.4	4.8	0.18	6.18	3.96	3.43	Q ok
P-195	DI-195	A1-DI-214	**1887**	0	1887	0.04	1.00	0.04	0.36	6.0	6.18	7.66	**2.79**	18	43	0.012	0.000603	0.0100	6.4	**11.4**	5.3	0.14	6.32	2.43	2.00	Q ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	of
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077.001
Segment:	Jones Street Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	4.81	4.81	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	4.83	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.58	4.58	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	4.81	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	4.81	4.81	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.83	5.87	HGL ok
P-162	DI-162	EXMH-201	1.00	4.79	4.79	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.79	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	4.78	4.78	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	4.79	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	5.49	5.49	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	5.70	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	5.46	5.46	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.49	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	4.96	4.96	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	5.46	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	4.78	4.78	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	4.96	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.58	4.58	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	4.78	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.43	4.43	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	4.58	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.60	4.68	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.70	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.59	4.59	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	4.60	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.58	4.58	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	4.59	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.26	4.26	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	4.43	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.84	3.84	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	4.26	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.65	3.65	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	3.84	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.61	3.61	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	3.65	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.59	3.59	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	3.61	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.53	3.53	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	3.59	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.47	3.47	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	3.53	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.35	3.35	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	3.47	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.27	3.27	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	3.35	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.20**	**3.20**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**3.27**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.43	4.81	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.82	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.26	4.68	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	4.70	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.43	4.43	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	4.49	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.26	4.26	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	4.32	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.65	3.65	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	3.68	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.59	3.59	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.60	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.47	3.47	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	3.51	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.47	3.47	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.49	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.75	3.87	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.88	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.73	3.73	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.75	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.71	3.71	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.73	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.65	3.65	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	3.71	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.71	3.71	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.72	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.25	4.96	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.98	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.14	4.14	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	4.25	10.79	HGL ok
P-171	DI-171	DI-173	1.20	4.03	4.03	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	4.14	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.90	3.90	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	4.03	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.80	3.80	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	3.90	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.59	3.59	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	3.80	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.80	3.80	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.81	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	4.08	4.47	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	4.03	4.03	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	4.08	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.61	3.61	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.61	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.56	3.56	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.56	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.55	3.55	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.56	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.54	3.54	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	3.55	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.53	3.53	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	3.54	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.79	5.05	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.91	4.83	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.54	5.35	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.91	4.53	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	4.54	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.79	3.79	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	3.91	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.67	3.67	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	3.79	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.86	4.17	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.88	4.69	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.86	3.87	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	3.88	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.67	3.67	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	3.86	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.53	3.53	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	3.67	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.43	4.63	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	4.66	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.35	3.35	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	3.43	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	5.01	5.01	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	5.03	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.78	4.78	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	5.01	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	5.01	5.01	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.03	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	4.99	4.99	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.99	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	4.98	4.98	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	4.99	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	5.69	5.69	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	5.90	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	5.66	5.66	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.69	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	5.16	5.16	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	5.66	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	4.98	4.98	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	5.16	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.78	4.78	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	4.98	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.63	4.63	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	4.78	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.80	4.80	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.82	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.79	4.79	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	4.80	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.78	4.78	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	4.79	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.46	4.46	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	4.63	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	4.04	4.04	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	4.46	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.85	3.85	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	4.04	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.81	3.81	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	3.85	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.79	3.79	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	3.81	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.73	3.73	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	3.79	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.67	3.67	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	3.73	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.55	3.55	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	3.67	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.47	3.47	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	3.55	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.40**	**3.40**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**3.47**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.63	4.81	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.82	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.46	4.68	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	4.70	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.63	4.63	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	4.69	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.46	4.46	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	4.52	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.85	3.85	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	3.88	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.79	3.79	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.80	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.67	3.67	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	3.71	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.67	3.67	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.69	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.95	3.95	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.95	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.93	3.93	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.95	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.91	3.91	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.93	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.85	3.85	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	3.91	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.91	3.91	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.92	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.45	4.96	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.98	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.34	4.34	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	4.45	10.79	HGL ok
P-171	DI-171	DI-173	1.20	4.23	4.23	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	4.34	10.30	HGL ok
P-173	DI-173	DI-174	1.60	4.10	4.10	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	4.23	10.30	HGL ok
P-174	DI-174	DI-175	1.60	4.00	4.00	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	4.10	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.79	3.79	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	4.00	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	4.00	4.00	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.01	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	4.28	4.47	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	4.23	4.23	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	4.28	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.81	3.81	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.81	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.76	3.76	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.76	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.75	3.75	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.76	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.74	3.74	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	3.75	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.73	3.73	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	3.74	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.99	5.05	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	4.11	4.83	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.54	5.35	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	4.11	4.53	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	4.54	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.99	3.99	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	4.11	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.87	3.87	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	3.99	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	4.06	4.17	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	4.06	4.69	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	4.06	4.06	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	4.06	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.87	3.87	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	4.06	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.73	3.73	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	3.87	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.63	4.63	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	4.66	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.55	3.55	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	3.63	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

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Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.51	8.51	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	8.53	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.28	8.28	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	8.51	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.51	8.51	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.53	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.49	8.49	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.49	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.48	8.48	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	8.49	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.19	9.19	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	9.40	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.16	9.16	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.19	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.66	8.66	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	9.16	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.48	8.48	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	8.66	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.28	8.28	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	8.48	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.13	8.13	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	8.28	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.30	8.30	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.32	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.29	8.29	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	8.30	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.28	8.28	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	8.29	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.96	7.96	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	8.13	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.54	7.54	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	7.96	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.35	7.35	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	7.54	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.31	7.31	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	7.35	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.29	7.29	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	7.31	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.23	7.23	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	7.29	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.17	7.17	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	7.23	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.05	7.05	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	7.17	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.97	6.97	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	7.05	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**6.90**	**6.90**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**6.97**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.13	8.13	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.13	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.96	7.96	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	7.97	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.13	8.13	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	8.19	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.96	7.96	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	8.02	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.35	7.35	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	7.38	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.29	7.29	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.30	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.17	7.17	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	7.21	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.17	7.17	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.19	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.45	7.45	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.45	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.43	7.43	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.45	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.41	7.41	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.43	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.35	7.35	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	7.41	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.41	7.41	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.42	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.95	7.95	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.84	7.84	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	7.95	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.73	7.73	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	7.84	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.60	7.60	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	7.73	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.50	7.50	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	7.60	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.29	7.29	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	7.50	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.50	7.50	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.51	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.78	7.78	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.79	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.73	7.73	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	7.78	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.31	7.31	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.31	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.26	7.26	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.26	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.25	7.25	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.26	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.24	7.24	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	7.25	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.23	7.23	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	7.24	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.49	7.49	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.49	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.61	7.61	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.62	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.62	7.62	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.62	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.61	7.61	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	7.62	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.49	7.49	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	7.61	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.37	7.37	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	7.49	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.56	7.56	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.57	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.56	7.56	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.56	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.56	7.56	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	7.56	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.37	7.37	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	7.56	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.23	7.23	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	7.37	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.13	7.13	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.16	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.05	7.05	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	7.13	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.01	9.01	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	9.03	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.78	8.78	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	9.01	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.01	9.01	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.03	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.99	8.99	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.99	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.98	8.98	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	8.99	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.69	9.69	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	9.90	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.66	9.66	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.69	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.16	9.16	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	9.66	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.98	8.98	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	9.16	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.78	8.78	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	8.98	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.63	8.63	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	8.78	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.80	8.80	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.82	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.79	8.79	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	8.80	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.78	8.78	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	8.79	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.46	8.46	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	8.63	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.04	8.04	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	8.46	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.85	7.85	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	8.04	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.81	7.81	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	7.85	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.79	7.79	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	7.81	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.73	7.73	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	7.79	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.67	7.67	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	7.73	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.55	7.55	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	7.67	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.47	7.47	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	7.55	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.40**	**7.40**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**7.47**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.63	8.63	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.63	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.46	8.46	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	8.47	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.63	8.63	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	8.69	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.46	8.46	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	8.52	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.85	7.85	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	7.88	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.79	7.79	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.80	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.67	7.67	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	7.71	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.67	7.67	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.69	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.95	7.95	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.95	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.93	7.93	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.95	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.91	7.91	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.93	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.85	7.85	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	7.91	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.91	7.91	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.92	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.45	8.45	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.47	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.34	8.34	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	8.45	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.23	8.23	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	8.34	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.10	8.10	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	8.23	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.00	8.00	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	8.10	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.79	7.79	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	8.00	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.00	8.00	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.01	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.28	8.28	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.29	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.23	8.23	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	8.28	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.81	7.81	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.81	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.76	7.76	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.76	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.75	7.75	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.76	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.74	7.74	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	7.75	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.73	7.73	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	7.74	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.99	7.99	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.99	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.11	8.11	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.12	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.12	8.12	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.12	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.11	8.11	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	8.12	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.99	7.99	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	8.11	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.87	7.87	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	7.99	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.06	8.06	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.07	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.06	8.06	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.06	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.06	8.06	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.06	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.87	7.87	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	8.06	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.73	7.73	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	7.87	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.63	7.63	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.66	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.55	7.55	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	7.63	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.41	9.41	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	9.43	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.18	9.18	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	9.41	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.41	9.41	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.43	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.39	9.39	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.39	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.38	9.38	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	9.39	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.09	10.09	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	10.30	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.06	10.06	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.09	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.56	9.56	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	10.06	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.38	9.38	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	9.56	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.18	9.18	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	9.38	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.03	9.03	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	9.18	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.20	9.20	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.22	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.19	9.19	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	9.20	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.18	9.18	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	9.19	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.86	8.86	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	9.03	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.44	8.44	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	8.86	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.25	8.25	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	8.44	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.21	8.21	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	8.25	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.19	8.19	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	8.21	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.13	8.13	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	8.19	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.07	8.07	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	8.13	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.95	7.95	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	8.07	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.87	7.87	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	7.95	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.80**	**7.80**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**7.87**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.03	9.03	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.03	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.86	8.86	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	8.87	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.03	9.03	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	9.09	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.86	8.86	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	8.92	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	8.25	8.25	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.28	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.19	8.19	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.20	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.07	8.07	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	8.11	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.07	8.07	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.09	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.35	8.35	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.35	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.33	8.33	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.35	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.31	8.31	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.33	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.25	8.25	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	8.31	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.31	8.31	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.32	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.85	8.85	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.87	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.74	8.74	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	8.85	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.63	8.63	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	8.74	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.50	8.50	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	8.63	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.40	8.40	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	8.50	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.19	8.19	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	8.40	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.40	8.40	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.41	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.68	8.68	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.69	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.63	8.63	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	8.68	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.21	8.21	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.21	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.16	8.16	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.16	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.15	8.15	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.16	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.14	8.14	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	8.15	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.13	8.13	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	8.14	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.39	8.39	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.39	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.51	8.51	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.52	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.52	8.52	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.52	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.51	8.51	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	8.52	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.39	8.39	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	8.51	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.27	8.27	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	8.39	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.46	8.46	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.47	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.46	8.46	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.46	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.46	8.46	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.46	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.27	8.27	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	8.46	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.13	8.13	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	8.27	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.03	8.03	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.06	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.95	7.95	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	8.03	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.91	9.91	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	9.93	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.68	9.68	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	9.91	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.91	9.91	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.93	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.89	9.89	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.89	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.88	9.88	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	9.89	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.59	10.59	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	10.80	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.56	10.56	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.59	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.06	10.06	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	10.56	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.88	9.88	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	10.06	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.68	9.68	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	9.88	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.53	9.53	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	9.68	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.70	9.70	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.72	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.69	9.69	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	9.70	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.68	9.68	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	9.69	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.36	9.36	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	9.53	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.94	8.94	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	9.36	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.75	8.75	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	8.94	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.71	8.71	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	8.75	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.69	8.69	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	8.71	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.63	8.63	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	8.69	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.57	8.57	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	8.63	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	8.45	8.45	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	8.57	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	8.37	8.37	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	8.45	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**8.30**	**8.30**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**8.37**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.53	9.53	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.53	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.36	9.36	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	9.37	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.53	9.53	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	9.59	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.36	9.36	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	9.42	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	8.75	8.75	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.78	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.69	8.69	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.70	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.57	8.57	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	8.61	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.57	8.57	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.59	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.85	8.85	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.85	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.83	8.83	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.85	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.81	8.81	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.83	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.75	8.75	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	8.81	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.81	8.81	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.82	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	9.35	9.35	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.37	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.24	9.24	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	9.35	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.13	9.13	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	9.24	10.30	HGL ok
P-173	DI-173	DI-174	1.60	9.00	9.00	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	9.13	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.90	8.90	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	9.00	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.69	8.69	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	8.90	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.90	8.90	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.91	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	9.18	9.18	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.19	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.13	9.13	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	9.18	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.71	8.71	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.71	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.66	8.66	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.66	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.65	8.65	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.66	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.64	8.64	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	8.65	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.63	8.63	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	8.64	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.89	8.89	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.89	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.01	9.01	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.02	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.02	9.02	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.02	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.01	9.01	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	9.02	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.89	8.89	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	9.01	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.77	8.77	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	8.89	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.96	8.96	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.97	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.96	8.96	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.96	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.96	8.96	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.96	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.77	8.77	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	8.96	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.63	8.63	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	8.77	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.53	8.53	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.56	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	8.45	8.45	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	8.53	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ____ of ____
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077.001
Segment: Jones Street Outfall — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.61	10.61	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	10.63	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.38	10.38	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	10.61	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.61	10.61	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.63	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.59	10.59	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.59	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.58	10.58	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	10.59	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.29	11.29	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	11.50	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.26	11.26	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.29	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.76	10.76	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	11.26	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.58	10.58	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	10.76	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.38	10.38	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	10.58	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.23	10.23	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	10.38	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.40	10.40	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.42	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.39	10.39	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	10.40	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.38	10.38	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	10.39	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.06	10.06	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	10.23	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.64	9.64	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	10.06	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.45	9.45	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	9.64	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.41	9.41	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	9.45	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.39	9.39	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	9.41	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.33	9.33	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	9.39	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.27	9.27	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	9.33	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.15	9.15	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	9.27	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.07	9.07	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	9.15	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.00**	**9.00**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**9.07**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.23	10.23	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.23	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.06	10.06	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	10.07	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.23	10.23	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	10.29	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.06	10.06	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	10.12	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.45	9.45	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.48	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.39	9.39	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.40	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.27	9.27	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.31	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.27	9.27	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.29	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.55	9.55	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.55	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.53	9.53	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.55	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.51	9.51	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.53	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.45	9.45	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	9.51	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.51	9.51	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.52	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.05	10.05	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.07	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.94	9.94	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	10.05	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	9.83	9.83	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	9.94	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.70	9.70	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	9.83	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.60	9.60	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	9.70	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.39	9.39	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	9.60	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.60	9.60	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.61	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.88	9.88	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.89	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.83	9.83	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	9.88	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.41	9.41	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.41	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.36	9.36	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.36	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.35	9.35	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.36	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.34	9.34	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	9.35	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.33	9.33	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.34	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.59	9.59	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.59	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.71	9.71	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.72	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.72	9.72	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.72	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.71	9.71	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	9.72	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.59	9.59	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	9.71	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.47	9.47	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	9.59	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.66	9.66	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.67	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.66	9.66	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.66	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.66	9.66	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.66	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.47	9.47	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	9.66	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.33	9.33	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	9.47	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.23	9.23	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.26	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.15	9.15	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	9.23	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.11	11.11	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.13	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.88	10.88	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	11.11	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.11	11.11	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.13	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.09	11.09	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.09	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.08	11.08	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	11.09	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.79	11.79	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	12.00	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.76	11.76	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.79	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.26	11.26	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	11.76	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.08	11.08	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	11.26	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.88	10.88	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	11.08	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.73	10.73	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	10.88	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.90	10.90	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.92	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.89	10.89	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	10.90	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.88	10.88	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	10.89	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.56	10.56	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	10.73	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.14	10.14	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	10.56	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.95	9.95	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	10.14	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.91	9.91	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	9.95	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.89	9.89	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	9.91	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.83	9.83	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	9.89	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.77	9.77	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	9.83	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.65	9.65	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	9.77	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.57	9.57	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	9.65	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.50**	**9.50**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**9.57**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.73	10.73	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.73	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.56	10.56	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	10.57	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.73	10.73	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	10.79	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.56	10.56	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	10.62	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.95	9.95	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.98	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.89	9.89	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.90	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.77	9.77	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.81	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.77	9.77	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.79	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.05	10.05	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.05	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.03	10.03	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.05	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.01	10.01	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.03	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.95	9.95	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	10.01	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.01	10.01	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.02	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.55	10.55	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.57	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.44	10.44	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	10.55	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.33	10.33	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	10.44	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.20	10.20	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	10.33	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.10	10.10	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	10.20	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	9.89	9.89	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	10.10	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.10	10.10	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.11	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.38	10.38	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.39	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.33	10.33	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	10.38	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.91	9.91	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.91	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.86	9.86	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.86	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.85	9.85	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.86	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.84	9.84	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	9.85	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.83	9.83	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.84	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.09	10.09	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.09	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.21	10.21	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.22	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.22	10.22	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.22	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.21	10.21	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	10.22	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.09	10.09	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	10.21	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.97	9.97	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	10.09	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.16	10.16	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.17	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.16	10.16	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.16	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.16	10.16	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.16	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.97	9.97	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	10.16	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.83	9.83	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	9.97	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.73	9.73	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.76	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.65	9.65	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	9.73	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ____ of ____
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077.001
Segment: Jones Street Outfall — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.41	12.41	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.43	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.18	12.18	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	12.41	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.41	12.41	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.43	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.39	12.39	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.39	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.38	12.38	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	12.39	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.09	13.09	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	13.30	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.06	13.06	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.09	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.56	12.56	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	13.06	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.38	12.38	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	12.56	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.18	12.18	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	12.38	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.03	12.03	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	12.18	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.20	12.20	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.22	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.19	12.19	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	12.20	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.18	12.18	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	12.19	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.86	11.86	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	12.03	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.44	11.44	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	11.86	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.25	11.25	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	11.44	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.21	11.21	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	11.25	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.19	11.19	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	11.21	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.13	11.13	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	11.19	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.07	11.07	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	11.13	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.95	10.95	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	11.07	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.87	10.87	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	10.95	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.80**	**10.80**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**10.87**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.03	12.03	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.03	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.86	11.86	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.87	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.03	12.03	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	12.09	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.86	11.86	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	11.92	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.25	11.25	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.28	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.19	11.19	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.20	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.07	11.07	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.11	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.07	11.07	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.09	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.35	11.35	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.35	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.33	11.33	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.35	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.31	11.31	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.33	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.25	11.25	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	11.31	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.31	11.31	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.32	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.85	11.85	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.87	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.74	11.74	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	11.85	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.63	11.63	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	11.74	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.50	11.50	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	11.63	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.40	11.40	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	11.50	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.19	11.19	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	11.40	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.40	11.40	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.41	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.68	11.68	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.69	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.63	11.63	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	11.68	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.21	11.21	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.21	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.16	11.16	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.16	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.15	11.15	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.16	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.14	11.14	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	11.15	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.13	11.13	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.14	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.39	11.39	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.39	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.51	11.51	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.52	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.52	11.52	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.52	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.51	11.51	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	11.52	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.39	11.39	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	11.51	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.27	11.27	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	11.39	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.46	11.46	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.47	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.46	11.46	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.46	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.46	11.46	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.46	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.27	11.27	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	11.46	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.13	11.13	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	11.27	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	11.03	11.03	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.06	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.95	10.95	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	11.03	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.35	7.35	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	7.37	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.12	7.12	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	7.35	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.35	7.35	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.37	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.33	7.33	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.33	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.32	7.32	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	7.33	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.03	8.03	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	8.24	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.00	8.00	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.03	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.50	7.50	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	8.00	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.32	7.32	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	7.50	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.12	7.12	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	7.32	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	6.97	6.97	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	7.12	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.14	7.14	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.16	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.13	7.13	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	7.14	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.12	7.12	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	7.13	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.80	6.80	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	6.97	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.38	6.38	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	6.80	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.19	6.19	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	6.38	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.15	6.15	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	6.19	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.13	6.13	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	6.15	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.07	6.07	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	6.13	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.01	6.01	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	6.07	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.89	5.89	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	6.01	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.81	5.81	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	5.89	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.74**	**5.74**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**5.81**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	6.97	6.97	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.97	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.80	6.80	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	6.81	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	6.97	6.97	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	7.03	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.80	6.80	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	6.86	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.19	6.19	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.22	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.13	6.13	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.14	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.01	6.01	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	6.05	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.01	6.01	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.03	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.29	6.29	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.29	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.27	6.27	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.29	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.25	6.25	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.27	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.19	6.19	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	6.25	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.25	6.25	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.26	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.79	6.79	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.81	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.68	6.68	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	6.79	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.57	6.57	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	6.68	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.44	6.44	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	6.57	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.34	6.34	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	6.44	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.13	6.13	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	6.34	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.34	6.34	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.35	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.62	6.62	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.63	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.57	6.57	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	6.62	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.15	6.15	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.15	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.10	6.10	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.10	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.09	6.09	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.10	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.08	6.08	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	6.09	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.07	6.07	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	6.08	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.33	6.33	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.33	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.45	6.45	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.46	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.46	6.46	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.46	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.45	6.45	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	6.46	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.33	6.33	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	6.45	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.21	6.21	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	6.33	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.40	6.40	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.41	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.40	6.40	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.40	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.40	6.40	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.40	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.21	6.21	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	6.40	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.07	6.07	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	6.21	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	5.97	5.97	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	6.00	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.89	5.89	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	5.97	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.55	7.55	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	7.57	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.32	7.32	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	7.55	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.55	7.55	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.57	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.53	7.53	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.53	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.52	7.52	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	7.53	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.23	8.23	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	8.44	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.20	8.20	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.23	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.70	7.70	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	8.20	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.52	7.52	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	7.70	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.32	7.32	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	7.52	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.17	7.17	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	7.32	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.34	7.34	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.36	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.33	7.33	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	7.34	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.32	7.32	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	7.33	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.00	7.00	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	7.17	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.58	6.58	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	7.00	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.39	6.39	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	6.58	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.35	6.35	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	6.39	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.33	6.33	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	6.35	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.27	6.27	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	6.33	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.21	6.21	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	6.27	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	6.09	6.09	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	6.21	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.01	6.01	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	6.09	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.94**	**5.94**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**6.01**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.17	7.17	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.17	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.00	7.00	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	7.01	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.17	7.17	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	7.23	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.00	7.00	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	7.06	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.39	6.39	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.42	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.33	6.33	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.34	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.21	6.21	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	6.25	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.21	6.21	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.23	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.49	6.49	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.49	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.47	6.47	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.49	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.45	6.45	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.47	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.39	6.39	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	6.45	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.45	6.45	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.46	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.99	6.99	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.01	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.88	6.88	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	6.99	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.77	6.77	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	6.88	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.64	6.64	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	6.77	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.54	6.54	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	6.64	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.33	6.33	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	6.54	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.54	6.54	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.55	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.82	6.82	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.83	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.77	6.77	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	6.82	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.35	6.35	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.35	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.30	6.30	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.30	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.29	6.29	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.30	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.28	6.28	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	6.29	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.27	6.27	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	6.28	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.53	6.53	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.53	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.65	6.65	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.66	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.66	6.66	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.66	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.65	6.65	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	6.66	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.53	6.53	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	6.65	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.41	6.41	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	6.53	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.60	6.60	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.61	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.60	6.60	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.60	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.60	6.60	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.60	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.41	6.41	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	6.60	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.27	6.27	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	6.41	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.17	6.17	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	6.20	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	6.09	6.09	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	6.17	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.05	11.05	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.07	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.82	10.82	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	11.05	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.05	11.05	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.07	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.03	11.03	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.03	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.02	11.02	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	11.03	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.73	11.73	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	11.94	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.70	11.70	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.73	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.20	11.20	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	11.70	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.02	11.02	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	11.20	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.82	10.82	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	11.02	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.67	10.67	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	10.82	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.84	10.84	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.86	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.83	10.83	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	10.84	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.82	10.82	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	10.83	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.50	10.50	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	10.67	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.08	10.08	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	10.50	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.89	9.89	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	10.08	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.85	9.85	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	9.89	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.83	9.83	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	9.85	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.77	9.77	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	9.83	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.71	9.71	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	9.77	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.59	9.59	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	9.71	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.51	9.51	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	9.59	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.44**	**9.44**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**9.51**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.67	10.67	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.67	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.50	10.50	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	10.51	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.67	10.67	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	10.73	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.50	10.50	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	10.56	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.89	9.89	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.92	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.83	9.83	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.84	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.71	9.71	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.75	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.71	9.71	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.73	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.99	9.99	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.99	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.97	9.97	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.99	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.95	9.95	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.97	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.89	9.89	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	9.95	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.95	9.95	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.96	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.49	10.49	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.51	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.38	10.38	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	10.49	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.27	10.27	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	10.38	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.14	10.14	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	10.27	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.04	10.04	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	10.14	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.83	9.83	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	10.04	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.04	10.04	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.05	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.32	10.32	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.33	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.27	10.27	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	10.32	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.85	9.85	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.85	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.80	9.80	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.80	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.79	9.79	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.80	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.78	9.78	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	9.79	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.77	9.77	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.78	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.03	10.03	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.03	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.15	10.15	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.16	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.16	10.16	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.16	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.15	10.15	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	10.16	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.03	10.03	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	10.15	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.91	9.91	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	10.03	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.10	10.10	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.11	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.10	10.10	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.10	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.10	10.10	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.10	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.91	9.91	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	10.10	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.77	9.77	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	9.91	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.67	9.67	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.70	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.59	9.59	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	9.67	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.55	11.55	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.57	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.32	11.32	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	11.55	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.55	11.55	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.57	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.53	11.53	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.53	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.52	11.52	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	11.53	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.23	12.23	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	12.44	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.20	12.20	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.23	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.70	11.70	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	12.20	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.52	11.52	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	11.70	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.32	11.32	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	11.52	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.17	11.17	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	11.32	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.34	11.34	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.36	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.33	11.33	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	11.34	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.32	11.32	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	11.33	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.00	11.00	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	11.17	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.58	10.58	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	11.00	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.39	10.39	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	10.58	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.35	10.35	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	10.39	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.33	10.33	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	10.35	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.27	10.27	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	10.33	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.21	10.21	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	10.27	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.09	10.09	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	10.21	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.01	10.01	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	10.09	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.94**	**9.94**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**10.01**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.17	11.17	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.17	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.00	11.00	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.01	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.17	11.17	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	11.23	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.00	11.00	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	11.06	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.39	10.39	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.42	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.33	10.33	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.34	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.21	10.21	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	10.25	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.21	10.21	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.23	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.49	10.49	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.49	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.47	10.47	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.49	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.45	10.45	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.47	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.39	10.39	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	10.45	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.45	10.45	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.46	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.99	10.99	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.01	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.88	10.88	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	10.99	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.77	10.77	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	10.88	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.64	10.64	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	10.77	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.54	10.54	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	10.64	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.33	10.33	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	10.54	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.54	10.54	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.55	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.82	10.82	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.83	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.77	10.77	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	10.82	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.35	10.35	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.35	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.30	10.30	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.30	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.29	10.29	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.30	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.28	10.28	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	10.29	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.27	10.27	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	10.28	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.53	10.53	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.53	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.65	10.65	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.66	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.66	10.66	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.66	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	10.65	10.65	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	10.66	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.53	10.53	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	10.65	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.41	10.41	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	10.53	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.60	10.60	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.61	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.60	10.60	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.60	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	10.60	10.60	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.60	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.41	10.41	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	10.60	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.27	10.27	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	10.41	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.17	10.17	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.20	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.09	10.09	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	10.17	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.95	11.95	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.97	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.72	11.72	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	11.95	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.95	11.95	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.97	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.93	11.93	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.93	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.92	11.92	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	11.93	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.63	12.63	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	12.84	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.60	12.60	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.63	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.10	12.10	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	12.60	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.92	11.92	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	12.10	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.72	11.72	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	11.92	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.57	11.57	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	11.72	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.74	11.74	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.76	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.73	11.73	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	11.74	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.72	11.72	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	11.73	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.40	11.40	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	11.57	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.98	10.98	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	11.40	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.79	10.79	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	10.98	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.75	10.75	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	10.79	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.73	10.73	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	10.75	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.67	10.67	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	10.73	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.61	10.61	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	10.67	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.49	10.49	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	10.61	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.41	10.41	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	10.49	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.34**	**10.34**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**10.41**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.57	11.57	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.57	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.40	11.40	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.41	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.57	11.57	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	11.63	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.40	11.40	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	11.46	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.79	10.79	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.82	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.73	10.73	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.74	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.61	10.61	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	10.65	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.61	10.61	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.63	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.89	10.89	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.89	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.87	10.87	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.89	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.85	10.85	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.87	7.12	HGL Too High!

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Hydraulic Grade Line Computations

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County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.79	10.79	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	10.85	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.85	10.85	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.86	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.39	11.39	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.41	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.28	11.28	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	11.39	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.17	11.17	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	11.28	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.04	11.04	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	11.17	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.94	10.94	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	11.04	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.73	10.73	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	10.94	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.94	10.94	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.95	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.22	11.22	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.23	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.17	11.17	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	11.22	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.75	10.75	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.70	10.70	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.70	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.69	10.69	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.70	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	10.68	10.68	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	10.69	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	10.67	10.67	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	10.68	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.93	10.93	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.93	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	11.05	11.05	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.06	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.06	11.06	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.06	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.05	11.05	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	11.06	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	10.93	10.93	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	11.05	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.81	10.81	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	10.93	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.00	11.00	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.01	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.00	11.00	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.00	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.00	11.00	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.00	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	10.81	10.81	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	11.00	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.67	10.67	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	10.81	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.57	10.57	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.60	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.49	10.49	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	10.57	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.45	12.45	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.47	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.22	12.22	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	12.45	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.45	12.45	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.47	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.43	12.43	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.43	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.42	12.42	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	12.43	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.13	13.13	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	13.34	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.10	13.10	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.13	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.60	12.60	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	13.10	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.42	12.42	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	12.60	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.22	12.22	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	12.42	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.07	12.07	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	12.22	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.24	12.24	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.26	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.23	12.23	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	12.24	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.22	12.22	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	12.23	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.90	11.90	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	12.07	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.48	11.48	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	11.90	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.29	11.29	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	11.48	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.25	11.25	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	11.29	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.23	11.23	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	11.25	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.17	11.17	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	11.23	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.11	11.11	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	11.17	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.99	10.99	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	11.11	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.91	10.91	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	10.99	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.84**	**10.84**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**10.91**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.07	12.07	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.07	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.90	11.90	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	11.91	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.07	12.07	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	12.13	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.90	11.90	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	11.96	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.29	11.29	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.32	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.23	11.23	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.24	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.11	11.11	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.15	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.11	11.11	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.13	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.39	11.39	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.39	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.37	11.37	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.39	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.35	11.35	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.37	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.29	11.29	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	11.35	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.35	11.35	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.36	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.89	11.89	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.91	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.78	11.78	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	11.89	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.67	11.67	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	11.78	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.54	11.54	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	11.67	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.44	11.44	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	11.54	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.23	11.23	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	11.44	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.44	11.44	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.45	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.72	11.72	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.73	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.67	11.67	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	11.72	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.25	11.25	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.25	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.20	11.20	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.20	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.19	11.19	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.20	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.18	11.18	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	11.19	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.17	11.17	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.18	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.43	11.43	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.43	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.55	11.55	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.56	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.56	11.56	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.56	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.55	11.55	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	11.56	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.43	11.43	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	11.55	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.31	11.31	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	11.43	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.50	11.50	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.51	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.50	11.50	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.50	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.50	11.50	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.50	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.31	11.31	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	11.50	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.17	11.17	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	11.31	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	11.07	11.07	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.10	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.99	10.99	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	11.07	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.15	13.15	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	13.17	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.92	12.92	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	13.15	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.15	13.15	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.17	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.13	13.13	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.13	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.12	13.12	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	13.13	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.83	13.83	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	14.04	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.80	13.80	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.83	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.30	13.30	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	13.80	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.12	13.12	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	13.30	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.92	12.92	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	13.12	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.77	12.77	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	12.92	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.94	12.94	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.96	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.93	12.93	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	12.94	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.92	12.92	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	12.93	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.60	12.60	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	12.77	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.18	12.18	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	12.60	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.99	11.99	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	12.18	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.95	11.95	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	11.99	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.93	11.93	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	11.95	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.87	11.87	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	11.93	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.81	11.81	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	11.87	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.69	11.69	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	11.81	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	11.61	11.61	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	11.69	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**11.54**	**11.54**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**11.61**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.77	12.77	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.77	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.60	12.60	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	12.61	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.77	12.77	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	12.83	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.60	12.60	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	12.66	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.99	11.99	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.02	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.93	11.93	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.94	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.81	11.81	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.85	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.81	11.81	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.83	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.09	12.09	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.09	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.07	12.07	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.09	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.05	12.05	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.07	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling Inflow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.99	11.99	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	12.05	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.05	12.05	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.06	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.59	12.59	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.61	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.48	12.48	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	12.59	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.37	12.37	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	12.48	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.24	12.24	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	12.37	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.14	12.14	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	12.24	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.93	11.93	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	12.14	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.14	12.14	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.15	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.42	12.42	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.43	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.37	12.37	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	12.42	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.95	11.95	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.95	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.90	11.90	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.90	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.89	11.89	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.90	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.88	11.88	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	11.89	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.87	11.87	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.88	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.13	12.13	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.13	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.25	12.25	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.26	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.26	12.26	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.26	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.25	12.25	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	12.26	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.13	12.13	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	12.25	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.01	12.01	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	12.13	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.20	12.20	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.21	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.20	12.20	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.20	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.20	12.20	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.20	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.01	12.01	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	12.20	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.87	11.87	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	12.01	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.77	11.77	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.80	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.69	11.69	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	11.77	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.65	13.65	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	13.67	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	13.42	13.42	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	13.65	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.65	13.65	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.67	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.63	13.63	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.63	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.62	13.62	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	13.63	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	14.33	14.33	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	14.54	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	14.30	14.30	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	14.33	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.80	13.80	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	14.30	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.62	13.62	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	13.80	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	13.42	13.42	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	13.62	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	13.27	13.27	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	13.42	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	13.44	13.44	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.46	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	13.43	13.43	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	13.44	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	13.42	13.42	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	13.43	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	13.10	13.10	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	13.27	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.68	12.68	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	13.10	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.49	12.49	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	12.68	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	12.45	12.45	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	12.49	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	12.43	12.43	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	12.45	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	12.37	12.37	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	12.43	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	12.31	12.31	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	12.37	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	12.19	12.19	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	12.31	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	12.11	12.11	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	12.19	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**12.04**	**12.04**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**12.11**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	13.27	13.27	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.27	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	13.10	13.10	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	13.11	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	13.27	13.27	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	13.33	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	13.10	13.10	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	13.16	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.49	12.49	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.52	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	12.43	12.43	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.44	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	12.31	12.31	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	12.35	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	12.31	12.31	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.33	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.59	12.59	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.59	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.57	12.57	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.59	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.55	12.55	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.57	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.49	12.49	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	12.55	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.55	12.55	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.56	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	13.09	13.09	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.11	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.98	12.98	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	13.09	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.87	12.87	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	12.98	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.74	12.74	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	12.87	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.64	12.64	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	12.74	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	12.43	12.43	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	12.64	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.64	12.64	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.65	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.92	12.92	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.93	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.87	12.87	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	12.92	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	12.45	12.45	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.45	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	12.40	12.40	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.40	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	12.39	12.39	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	12.40	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	12.38	12.38	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	12.39	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	12.37	12.37	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	12.38	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.63	12.63	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.63	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.75	12.75	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.76	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.76	12.76	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.76	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.75	12.75	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	12.76	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.63	12.63	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	12.75	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.51	12.51	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	12.63	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.70	12.70	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.71	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.70	12.70	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.70	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.70	12.70	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.70	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.51	12.51	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	12.70	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	12.37	12.37	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	12.51	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	12.27	12.27	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.30	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	12.19	12.19	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	12.27	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	14.95	14.95	15	1.4	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	14.97	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	14.72	14.72	15	2.6	2.2	91	154	0.0014	0.22	0	0.00	0.02	1.3	1.6	0.0	1.2	0.0	95	0.01	0.04	1.0	0.5	0.02	0.24	14.95	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	14.95	14.95	15	1.2	1.0	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.97	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	14.93	14.93	15	0.7	0.5	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.93	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	14.92	14.92	15	0.7	0.5	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.5	0.0	109	0.00	0.01	1.0	0.5	0.00	0.00	14.93	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	15.63	15.63	12	2.4	3.0	0	47	0.0038	0.18	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.21	15.84	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	15.60	15.60	12	0.6	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	15.63	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	15.10	15.10	12	3.5	4.4	72	41	0.0082	0.33	0	0.00	0.08	0.5	7.2	0.0	3.0	0.1	0	0.00	0.13	1.3	1.0	0.16	0.50	15.60	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	14.92	14.92	18	3.5	2.0	77	26	0.0009	0.02	0	0.00	0.01	15.5	0.0	0.0	4.4	0.1	72	0.19	0.31	1.0	0.5	0.15	0.18	15.10	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	14.72	14.72	18	4.1	2.3	90	129	0.0013	0.17	0	0.00	0.02	6.8	0.4	0.0	2.0	0.0	77	0.04	0.08	1.0	0.5	0.04	0.21	14.92	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	14.57	14.57	18	7.8	4.4	3	14	0.0047	0.07	0	0.00	0.08	9.5	1.0	5.7	2.3	0.0	90	0.06	0.16	1.0	0.5	0.08	0.15	14.72	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	14.74	14.74	15	0.9	0.7	70	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.76	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	14.73	14.73	15	1.4	1.1	22	5	0.0004	0.00	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	70	0.00	0.01	1.3	1.0	0.02	0.02	14.74	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	14.72	14.72	18	1.4	0.8	2	25	0.0001	0.00	0	0.00	0.00	1.5	0.0	0.0	1.1	0.0	22	0.00	0.01	1.0	0.5	0.01	0.01	14.73	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	14.40	14.40	24	9.2	2.9	4	60	0.0014	0.08	0	0.00	0.03	34.6	1.0	0.4	4.4	0.1	3	0.03	0.17	1.0	0.5	0.09	0.17	14.57	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	13.98	13.98	24	14.3	4.6	4	82	0.0034	0.28	0	0.00	0.08	27.0	13.8	0.0	2.9	0.0	4	0.01	0.14	1.0	1.0	0.14	0.42	14.40	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	13.79	13.79	36	14.5	2.1	7	59	0.0004	0.02	0	0.00	0.02	65.2	0.0	0.0	4.6	0.1	4	0.03	0.16	1.0	1.0	0.16	0.19	13.98	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	13.75	13.75	48	18.3	1.5	3	54	0.0001	0.01	0	0.00	0.01	29.8	8.3	9.0	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	13.79	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	13.73	13.73	48	18.6	1.5	3	68	0.0001	0.01	0	0.00	0.01	26.6	0.1	0.0	1.5	0.0	3	0.00	0.02	1.0	0.5	0.01	0.02	13.75	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	13.67	13.67	48	21.2	1.7	4	180	0.0002	0.03	0	0.00	0.01	27.6	27.1	3.6	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.06	13.73	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	13.61	13.61	48	25.9	2.1	2	58	0.0003	0.02	0	0.00	0.02	35.9	1.3	9.2	1.7	0.0	4	0.00	0.04	1.0	1.0	0.04	0.05	13.67	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	13.49	13.49	48	32.8	2.6	0	158	0.0004	0.07	0	0.00	0.03	53.4	4.2	4.2	2.1	0.0	2	0.00	0.05	1.0	1.0	0.05	0.12	13.61	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	13.41	13.41	48	34.7	2.8	16	35	0.0005	0.02	0	0.00	0.03	85.4	4.4	0.0	2.6	0.0	0	0.00	0.07	1.0	1.0	0.07	0.08	13.49	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**13.34**	**13.34**	**48**	**34.5**	**2.7**	**0**	**48**	**0.0005**	**0.02**	**0**	**0.00**	**0.03**	**95.8**	**0.0**	**0.0**	**2.8**	**0.0**	**16**	**0.02**	**0.09**	**1.0**	**0.5**	**0.05**	**0.07**	**13.41**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	14.57	14.57	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.57	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	14.40	14.40	15	1.1	0.9	88	25	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.00	1.3	1.0	0.01	0.01	14.41	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	14.57	14.57	8	0.4	1.0	93	96	0.0006	0.06	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.06	14.63	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	14.40	14.40	18	4.9	2.8	90	23	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	14.46	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	13.79	13.79	18	3.8	2.2	90	19	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.82	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	13.73	13.73	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.74	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	13.61	13.61	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	13.65	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	13.61	13.61	18	2.7	1.5	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.63	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	13.89	13.89	18	1.3	0.7	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.89	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	13.87	13.87	18	1.7	0.9	0	54	0.0002	0.01	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	13.89	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	13.85	13.85	24	2.3	0.7	90	91	0.0001	0.01	0	0.00	0.00	1.6	0.0	0.0	0.9	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	13.87	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	13.79	13.79	24	5.3	1.7	94	33	0.0005	0.02	0	0.00	0.01	1.7	2.4	0.0	1.2	0.0	90	0.01	0.03	1.3	1.0	0.04	0.06	13.85	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	13.85	13.85	18	2.0	1.2	90	19	0.0003	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.86	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	14.39	14.39	18	2.6	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	14.41	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	14.28	14.28	18	3.0	1.7	90	68	0.0007	0.05	0	0.00	0.01	3.7	0.0	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.11	14.39	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	14.17	14.17	18	3.5	2.0	79	29	0.0009	0.03	0	0.00	0.02	5.2	0.0	0.0	1.7	0.0	90	0.03	0.06	1.3	1.0	0.08	0.11	14.28	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	14.04	14.04	24	6.1	1.9	69	46	0.0006	0.03	0	0.00	0.01	6.9	0.0	0.0	2.0	0.0	79	0.04	0.08	1.3	1.0	0.10	0.13	14.17	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	13.94	13.94	24	6.4	2.0	80	44	0.0007	0.03	0	0.00	0.02	11.9	0.0	0.0	1.9	0.0	69	0.04	0.07	1.0	1.0	0.07	0.10	14.04	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	13.73	13.73	24	9.2	2.9	88	29	0.0014	0.04	0	0.00	0.03	13.1	27.1	0.0	2.9	0.0	88	0.09	0.17	1.0	1.0	0.17	0.22	13.94	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	13.94	13.94	18	2.3	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.95	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	14.22	14.22	18	1.7	1.0	90	22	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.23	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	14.17	14.17	18	2.2	1.2	12	68	0.0004	0.02	0	0.00	0.01	1.6	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.05	14.22	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	13.75	13.75	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.75	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	13.70	13.70	18	0.6	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.70	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	13.69	13.69	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	13.70	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	13.68	13.68	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.01	13.69	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	13.67	13.67	18	1.5	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.8	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	13.68	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	13.93	13.93	18	0.3	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.93	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	14.05	14.05	18	1.8	1.0	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.06	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	14.06	14.06	18	0.4	0.2	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.06	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	14.05	14.05	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	14.06	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	13.93	13.93	18	3.2	1.8	70	108	0.0008	0.09	0	0.00	0.01	0.4	1.9	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.04	0.13	14.05	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	13.81	13.81	18	3.8	2.1	57	27	0.0011	0.03	0	0.00	0.02	5.9	0.0	0.0	1.8	0.0	70	0.03	0.07	1.3	1.0	0.09	0.12	13.93	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	14.00	14.00	18	2.3	1.3	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	14.01	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	14.00	14.00	18	0.4	0.2	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.00	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	14.00	14.00	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	14.00	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	13.81	13.81	18	3.7	2.1	14	119	0.0011	0.13	0	0.00	0.02	0.4	3.0	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.06	0.19	14.00	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	13.67	13.67	18	4.0	2.3	67	50	0.0013	0.06	0	0.00	0.02	7.8	8.1	0.0	2.1	0.0	57	0.04	0.08	1.0	1.0	0.08	0.15	13.81	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	13.57	13.57	18	2.5	1.4	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	13.60	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	13.49	13.49	18	2.8	1.6	90	43	0.0006	0.03	0	0.00	0.01	3.5	0.0	0.0	1.4	0.0	105	0.02	0.04	1.3	1.0	0.05	0.08	13.57	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 200 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
CRB Network STA 109+25 to 111+75																										
CRB-P72	CRB-DI72	CRB-MH-74	7961	0	7961	0.18	1.00	0.18	0.18	6.0	0.00	8.09	1.5	15	16	0.012	0.0004	0.019	7.8	9.6	5.5	0.05	6.05	2.60	2.30	Q ok
CRB-P74	CRB-MH-74	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.34	6.0	6.17	8.02	2.8	15	154	0.012	0.0016	0.005	4.1	5.1	4.2	0.61	6.78	1.65	0.84	Q ok
CRB-P73	CRB-DI73	CRB-MH-74	7042	0	7042	0.16	1.00	0.16	0.16	6.0	0.00	8.09	1.3	15	34	0.012	0.0003	0.005	4.0	4.9	3.3	0.17	6.17	1.92	1.75	Q ok
MSS Network Sta 111+75 to 114+00																										
P-162	DI-162	EXMH-201	3794	0	3794	0.09	1.00	0.09	0.09	6.0	0.00	8.09	**0.70**	15	16	0.011	0.000085	0.0200	8.8	**10.8**	4.3	0.06	6.06	2.50	2.18	Q ok
P-201	EXMH-201	A1-MH-203	1	0	1	0.00	1.00	0.00	0.09	6.0	6.06	8.06	**0.70**	15	18	0.012	0.000101	0.0200	8.1	**9.9**	3.9	0.08	6.14	1.98	1.62	Q ok
Ploener Property																										
EX-P LOT	EXDI LOT	DI-MSS-41	13430	0	13430	0.31	1.00	0.31	0.31	6.0	0.00	8.09	**2.49**	12	47	0.012	0.004176	0.0074	4.2	**3.3**	4.7	0.17	6.17	2.50	2.15	Q ok
P-MSS-48	DI-MSS-40	DI-MSS-41	3590	0	3590	0.08	1.00	0.08	0.08	6.0	0.00	8.09	**0.67**	12	82	0.012	0.000298	0.0050	3.5	**2.7**	2.8	0.48	6.48	2.56	2.15	Q ok
P-MSS-48A	DI-MSS-41	EX-MH	3072	0	3072	0.07	1.00	0.07	0.46	6.0	6.48	7.92	**3.65**	12	41	0.012	0.008947	0.0051	3.5	**2.8**	2.9	0.24	6.72	2.05	1.84	Undersized!
A1-P-202	EX-MH	A1-MH-203	1	0	1	0.00	1.00	0.00	0.46	6.0	6.72	7.85	**3.62**	18	26	0.012	0.001011	0.0046	4.4	**7.7**	4.2	0.10	6.82	1.74	1.62	Q ok
A1-P-204	A1-MH-204	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.55	6.0	6.82	7.81	**4.28**	18	129	0.012	0.001417	0.0052	4.6	**8.2**	4.6	0.47	7.29	1.52	0.85	Q ok
A1-P-205	CRB-MH-67	CMH-1	1	0	1	0.00	1.00	0.00	1.07	6.0	7.29	7.64	**8.18**	18	14	0.012	0.005173	0.0057	4.9	**8.6**	5.6	0.04	7.33	0.75	0.67	Q ok
MSS Network Sta 111+75 to 114+00																										
MSS-P2	MSS-DI2	MSS-DI1	3846	1139	4985	0.11	0.97	0.11	0.11	6.0	0.00	8.09	0.9	15	70	0.012	0.0002	0.005	4.0	4.9	3.0	0.39	6.39	4.03	3.68	Q ok
MSS-P1	MSS-DI1	EXMH	2301	1082	3383	0.08	0.88	0.07	0.18	6.0	6.39	7.95	1.4	15	5	0.012	0.0004	0.003	3.3	4.0	3.0	0.03	6.42	3.39	3.37	Q ok
A1-P-203	EX MH	MH-CRB-67	1	0	1	0.00	1.00	0.00	0.18	6.0	6.42	7.95	**1.42**	18	25	0.012	0.000157	0.0050	4.6	**8.0**	3.4	0.12	6.54	0.92	0.84	Q ok
Jones Street Constructed Under Area 1																										
A1-P-206	CMH-1	A1-DI-207	1	0	1	0.00	1.00	0.00	1.26	6.0	7.33	7.64	**9.63**	24	60	0.012	0.001544	0.0035	4.6	**14.5**	4.9	0.20	7.53	0.57	0.36	Q ok
A1-P-207	A1-DI-207	A1-DI-208	3414	0	3414	0.08	1.00	0.08	1.98	6.0	7.53	7.57	**14.97**	24	82	0.012	0.003733	0.0040	4.9	**15.5**	5.7	0.24	7.77	0.36	0.03	Q ok
A1-P-208	A1-DI-208	A1-DI-209	2490	0	2490	0.06	1.00	0.06	2.04	6.0	7.77	7.46	**15.19**	36	59	0.012	0.000442	0.0041	6.5	**46.1**	5.9	0.17	7.94	0.03	-0.21	Q ok
A1-P-209	A1-DI-209	A1-MH-210	2433	0	2433	0.06	1.00	0.06	2.59	6.0	7.94	7.43	**19.21**	48	54	0.012	0.000152	0.0041	7.9	**99.3**	5.9	0.15	8.09	-0.21	-0.43	Q ok
A1-P-210	A1-MH-210	A1-DI-211	1	0	1	0.00	1.00	0.00	2.65	6.0	8.09	7.36	**19.47**	48	68	0.012	0.000157	0.0040	7.8	**98.1**	5.9	0.19	8.28	-0.43	-0.70	Q ok
A1-P-211	A1-DI-211	A1-DI-212	3353	0	3353	0.08	1.00	0.08	3.05	6.0	8.28	7.29	**22.21**	48	180	0.012	0.000204	0.0040	7.8	**98.4**	6.4	0.47	8.75	-0.70	-1.42	Q ok
A1-P-212	A1-DI-212	A1-DI-213	1885	0	1885	0.04	1.00	0.04	3.81	6.0	8.75	7.15	**27.24**	48	58	0.012	0.000306	0.0040	7.8	**98.0**	6.6	0.15	8.90	-1.42	-1.65	Q ok
A1-P-213	A1-DI-213	A1-DI-214	15288	0	15288	0.35	1.00	0.35	4.87	6.0	8.90	7.08	**34.43**	48	158	0.012	0.000490	0.0040	7.8	**98.3**	7.0	0.37	9.27	-1.65	-2.28	Q ok
A1-P-214	A1-DI-214	A1-DI-215	**1**	0	1	0.00	1.00	0.00	5.23	6.0	9.27	6.94	**36.28**	48	35	0.012	0.000543	0.0040	7.8	**98.4**	7.0	0.08	9.35	-2.28	-2.42	Q ok
A1-P-215	A1-DI-215	A1-MH-216	**1**	0	1	0.00	1.00	0.00	5.23	6.0	9.35	6.90	**36.09**	48	48	0.012	0.000538	0.0040	7.8	**97.9**	7.0	0.11	9.47	-2.42	-2.61	Q ok
MSS-P3 A	MSS-DI14	DI-161	3612	330	3942	0.09	1.00	0.09	0.09	6.0	0.00	8.09	0.7	15	44	0.012	0.0001	0.005	4.0	4.9	2.8	0.26	6.26	4.03	3.81	Q ok
MSS-P3 B	DI-161	MSS-DI13	2062	222	2284	0.05	1.00	0.05	0.14	6.0	6.26	7.99	1.1	15	25	0.012	0.0003	0.005	4.1	5.0	3.3	0.13	6.39	3.81	3.68	Q ok
	DOGHOUSE																									
P-160	DI-160	CMH-1	1768	257	2025	0.05	1.00	0.05	0.05	6.0	0.00	8.09	**0.38**	8	96	0.011	0.000693	0.0200	5.8	**2.0**	4.3	0.37	6.37	2.99	1.07	Q ok
A1 P-200	PARCEL J	A1-DI-207	27861	0	27861	0.64	1.00	0.64	0.64	6.0	0.00	8.09	**5.17**	18	23	0.012	0.002068	0.0100	6.4	11.4	6.2	0.06	6.06	1.59	1.36	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
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Segment: Jones Street Outfall Storm Frequency: 200 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to	Pervious Area, C = 0.18 to	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-336	PARCEL J	A1-DI-209	21549	0	21549	0.49	1.00	0.49	0.49	6.0	0.00	8.09	**4.00**	18	19	0.012	0.001237	0.0100	6.4	11.4	5.8	0.05	6.05	1.48	1.29	Q ok
P-337	PARCEL J	A1-DI-211	14148	0	14148	0.32	1.00	0.32	0.32	6.0	0.00	8.09	**2.63**	18	23	0.012	0.000533	0.0100	6.4	11.4	5.3	0.07	6.07	1.53	1.30	Q ok
P-335	PARCEL N	A1-DI-213	15379	0	15379	0.35	1.00	0.35	0.35	6.0	0.00	8.09	**2.86**	18	56	0.012	0.000630	0.0100	6.4	11.4	5.3	0.18	6.18	1.91	1.35	Q ok
P-340	PARCEL K	A1-DI-213	15267	0	15267	0.35	1.00	0.35	0.35	6.0	0.00	8.09	**2.84**	18	18	0.012	0.000621	0.0100	6.4	11.4	5.3	0.06	6.06	1.53	1.35	Q ok
P-165	DI-165	DI-166	7237	0	7237	0.17	1.00	0.17	0.17	6.0	0.00	8.09	**1.34**	18	28	0.012	0.000140	0.0100	6.4	**11.4**	3.9	0.12	6.12	2.95	2.67	Q ok
P-166	DI-166	DI-167	2265	0	2265	0.05	1.00	0.05	0.22	6.0	6.12	8.06	**1.76**	18	54	0.012	0.000238	0.0100	6.4	**11.4**	4.5	0.20	6.32	2.47	1.93	Q ok
P-167	DI-167	DI-168	3648	0	3648	0.08	1.00	0.08	0.30	6.0	6.32	7.99	**2.41**	24	91	0.012	0.000097	0.0100	7.8	**24.5**	4.7	0.32	6.64	1.73	0.82	Q ok
P-168	DI-168	DI-209	6136	0	6136	0.14	1.00	0.14	0.71	6.0	6.64	7.88	**5.57**	24	33	0.012	0.000517	0.0100	7.8	**24.5**	6.4	0.09	6.73	0.62	0.29	Q ok
P-327	PARCEL L	DI-168	11517	0	11517	0.26	1.00	0.26	0.26	6.0	0.00	8.09	**2.14**	18	19	0.012	0.000353	0.0100	6.4	11.4	4.8	0.07	6.07	1.31	1.12	Q ok
P-326	PARCEL L	DI-170	14378	0	14378	0.33	1.00	0.33	0.33	6.0	0.00	8.09	**2.67**	18	23	0.012	0.000551	0.0100	6.4	11.4	5.3	0.07	6.07	3.99	3.76	Q ok
P-170	DI-170	DI-171	2801	0	2801	0.06	1.00	0.06	0.39	6.0	6.07	8.06	**3.18**	18	68	0.012	0.000779	0.0100	6.4	**11.4**	5.5	0.21	6.28	3.26	2.58	Q ok
P-171	DI-171	DI-173	2811	0	2811	0.06	1.00	0.06	0.46	6.0	6.28	7.99	**3.66**	18	29	0.012	0.001037	0.0100	6.4	**11.4**	5.5	0.09	6.37	2.38	2.09	Q ok
P-173	DI-173	DI-174	2818	0	2818	0.06	1.00	0.06	0.81	6.0	6.37	7.95	**6.40**	24	46	0.012	0.000682	0.0100	7.8	**24.5**	6.4	0.12	6.49	1.89	1.43	Q ok
P-174	DI-174	DI-175	1817	0	1817	0.04	1.00	0.04	0.85	6.0	6.49	7.92	**6.70**	24	44	0.012	0.000748	0.0100	7.8	**24.5**	6.4	0.11	6.60	1.23	0.79	Q ok
P-175	DI-175	DI-211	3620	0	3620	0.08	1.00	0.08	1.23	6.0	6.60	7.88	**9.67**	24	29	0.012	0.001555	0.0100	7.8	**24.5**	7.2	0.07	6.67	0.59	0.30	Q ok
P-331	PARCEL M	DI-175	12913	0	12913	0.30	1.00	0.30	0.30	6.0	0.00	8.09	**2.40**	18	19	0.012	0.000444	0.0100	6.4	11.4	4.8	0.07	6.07	1.28	1.09	Q ok
P-328	PARCEL M	DI-172	9475	0	9475	0.22	1.00	0.22	0.22	6.0	0.00	8.09	**1.76**	18	22	0.012	0.000239	0.0100	6.4	11.4	4.5	0.08	6.08	3.49	3.27	Q ok
P-172	DI-172	DI-173	2798	0	2798	0.06	1.00	0.06	0.28	6.0	6.08	8.06	**2.27**	18	68	0.012	0.000398	0.0100	6.4	**11.4**	4.8	0.23	6.32	2.77	2.09	Q ok
P-169	DI-169	MH-210	2626	0	2626	0.06	1.00	0.06	0.06	6.0	0.00	8.09	**0.49**	18	7	0.012	0.000018	0.0100	6.4	**11.4**	3.2	0.04	6.04	1.64	1.57	Q ok
P-178	DI-178	DI-179	3573	0	3573	0.08	1.00	0.08	0.08	6.0	0.00	8.09	**0.66**	18	39	0.012	0.000034	0.0100	6.4	**11.4**	3.2	0.21	6.21	2.63	2.24	Q ok
P-179	DI-179	DI-180	1913	0	1913	0.04	1.00	0.04	0.13	6.0	0.00	8.09	**1.02**	18	34	0.012	0.000080	0.0100	6.4	**11.4**	3.9	0.15	6.15	2.04	1.70	Q ok
P-180	DI-180	DI-181	1165	0	1165	0.03	1.00	0.03	0.15	6.0	0.00	8.09	**1.24**	18	49	0.012	0.000118	0.0100	6.4	**11.4**	3.9	0.21	6.21	1.50	1.01	Q ok
P-181	DI-181	DI-212	1967	0	1967	0.05	1.00	0.05	0.20	6.0	0.00	8.09	**1.60**	18	23	0.012	0.000198	0.0100	6.4	**11.4**	4.5	0.09	6.09	0.81	0.58	Q ok
P-182	DI-182	DI-186	1887	0	1887	0.04	1.00	0.04	0.04	6.0	0.00	8.09	**0.35**	18	43	0.012	0.000009	0.0100	6.4	**11.4**	3.2	0.23	6.23	4.28	3.85	Q ok
P-338	PARCEL J	DI-185	10195	0	10195	0.23	1.00	0.23	0.23	6.0	0.00	8.09	**1.89**	18	23	0.012	0.000277	0.0100	6.4	11.4	4.5	0.09	6.09	3.86	3.63	Q ok

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Segment: Jones Street Outfall Storm Frequency: 200 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-183	DI-183	DI-184	2436	0	2436	0.06	1.00	0.06	0.06	6.0	0.00	8.09	**0.45**	18	59	0.012	0.000016	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.74	4.15	Q ok
P-184	DI-184	DI-185	2508	0	2508	0.06	1.00	0.06	0.11	6.0	0.00	8.09	**0.92**	18	62	0.012	0.000065	0.0100	6.4	**11.4**	3.9	0.27	6.27	3.95	3.33	Q ok
P-185	DI-185	DI-186	3002	0	3002	0.07	1.00	0.07	0.42	6.0	0.00	8.09	**3.37**	18	108	0.012	0.000877	0.0100	6.4	**11.4**	5.5	0.33	6.33	3.13	2.05	Q ok
P-186	DI-186	DI-190	1354	0	1354	0.03	1.00	0.03	0.49	6.0	0.00	8.09	**3.97**	18	27	0.012	0.001218	0.0100	6.4	**11.4**	5.8	0.08	6.08	1.85	1.58	Q ok
check San x-ing																										
P-339	PARCEL K	DI-189	12930	0	12930	0.30	1.00	0.30	0.30	6.0	0.00	8.09	**2.40**	18	23	0.012	0.000445	0.0100	6.4	11.4	4.8	0.08	6.08	3.20	2.97	Q ok
P-187	DI-187	DI-188	2448	0	2448	0.06	1.00	0.06	0.06	6.0	0.00	8.09	**0.45**	18	59	0.012	0.000016	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.08	3.49	Q ok
P-188	DI-188	DI-189	2550	0	2550	0.06	1.00	0.06	0.11	6.0	0.00	8.09	**0.93**	18	62	0.012	0.000067	0.0100	6.4	**11.4**	3.9	0.27	6.27	3.29	2.67	Q ok
P-189	DI-189	DI-190	3025	0	3025	0.07	1.00	0.07	0.48	6.0	0.00	8.09	**3.89**	18	119	0.012	0.001169	0.0100	6.4	**11.4**	5.8	0.34	6.34	2.47	1.28	Q ok
P-190	DI-190	DI-191	1765	0	1765	0.04	1.00	0.04	0.52	6.0	0.00	8.09	**4.22**	18	50	0.012	0.001375	0.0100	6.4	**11.4**	5.8	0.14	6.14	1.08	0.58	Q ok
P-341	PARCEL K	DI-195	13999	0	13999	0.32	1.00	0.32	0.32	6.0	0.00	8.09	**2.60**	18	53	0.012	0.000522	0.0100	6.4	11.4	5.3	0.17	6.17	3.96	3.43	Q ok
P-195	DI-195	A1-DI-214	**1887**	0	1887	0.04	1.00	0.04	0.36	6.0	6.17	8.02	**2.92**	18	43	0.012	0.000661	0.0100	6.4	**11.4**	5.3	0.14	6.30	2.43	2.00	Q ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	4.97	4.97	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	4.98	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.71	4.71	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	4.97	6.13	HGL ok
CRB-P73	CRB-DI73	CRB-MH-74	1.00	4.97	4.97	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	4.99	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	4.94	4.94	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.94	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	4.93	4.93	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	4.94	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	5.70	5.70	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	5.94	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	5.68	5.68	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	5.70	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	5.13	5.13	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	5.68	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	4.93	4.93	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	5.13	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.71	4.71	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	4.93	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.55	4.55	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	4.71	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.74	4.74	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.75	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.72	4.72	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	4.74	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.71	4.71	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	4.72	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.36	4.36	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	4.55	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.90	3.90	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	4.36	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.70	3.70	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	3.90	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.65	3.65	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	3.70	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.62	3.62	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	3.65	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.56	3.56	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	3.62	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.50	3.50	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	3.56	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.37	3.37	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	3.50	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.28	3.28	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	3.37	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.20**	**3.20**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**3.28**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.55	4.81	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.82	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.36	4.68	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	4.70	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.55	4.55	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	4.62	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.36	4.36	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	4.42	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.70	3.70	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	3.73	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.62	3.62	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.64	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.50	3.50	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	3.54	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.50	3.50	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.52	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.80	3.87	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.88	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.78	3.78	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.80	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.76	3.76	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.78	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.70	3.70	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	3.76	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.76	3.76	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.77	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.35	4.96	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.98	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.23	4.23	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	4.35	10.79	HGL ok
P-171	DI-171	DI-173	1.20	4.11	4.11	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	4.23	10.30	HGL ok
P-173	DI-173	DI-174	1.60	3.97	3.97	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	4.11	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.86	3.86	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	3.97	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.62	3.62	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	3.86	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.86	3.86	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.87	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	4.17	4.47	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	4.11	4.11	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	4.17	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.65	3.65	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.65	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.59	3.59	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.60	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.59	3.59	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.59	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.57	3.57	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	3.59	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.56	3.56	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	3.57	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.85	5.05	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	3.98	4.83	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.54	5.35	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	3.98	4.53	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	4.54	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.85	3.85	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	3.98	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.72	3.72	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	3.85	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	3.92	4.17	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	3.93	4.69	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	3.92	3.92	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	3.93	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.72	3.72	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	3.92	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.56	3.56	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	3.72	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.46	4.63	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	4.66	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.37	3.37	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	3.46	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	5.17	5.17	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	5.18	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.91	4.91	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	5.17	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	5.17	5.17	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.19	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	5.14	5.14	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.14	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	5.13	5.13	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	5.14	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	5.90	5.90	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	6.14	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	5.88	5.88	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	5.90	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	5.33	5.33	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	5.88	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	5.13	5.13	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	5.33	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.91	4.91	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	5.13	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.75	4.75	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	4.91	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.94	4.94	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.95	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.92	4.92	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	4.94	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.91	4.91	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	4.92	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.56	4.56	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	4.75	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	4.10	4.10	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	4.56	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.90	3.90	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	4.10	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.85	3.85	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	3.90	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.82	3.82	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	3.85	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.76	3.76	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	3.82	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.70	3.70	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	3.76	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.57	3.57	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	3.70	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.48	3.48	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	3.57	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.40**	**3.40**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**3.48**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.75	4.81	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.82	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.56	4.68	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	4.70	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.75	4.75	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	4.82	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.56	4.56	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	4.62	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.90	3.90	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	3.93	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.82	3.82	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.84	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.70	3.70	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	3.74	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.70	3.70	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.72	10.00	HGL ok
P-165	DI-165	DI-166	1.20	4.00	4.00	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.01	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.98	3.98	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	4.00	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.96	3.96	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.98	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.90	3.90	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	3.96	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.96	3.96	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.97	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.55	4.96	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.98	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.43	4.43	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	4.55	10.79	HGL ok
P-171	DI-171	DI-173	1.20	4.31	4.31	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	4.43	10.30	HGL ok
P-173	DI-173	DI-174	1.60	4.17	4.17	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	4.31	10.30	HGL ok
P-174	DI-174	DI-175	1.60	4.06	4.06	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	4.17	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.82	3.82	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	4.06	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	4.06	4.06	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.07	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	4.37	4.47	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	4.31	4.31	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	4.37	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.85	3.85	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.85	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.79	3.79	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.80	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.79	3.79	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.79	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.77	3.77	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	3.79	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.76	3.76	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	3.77	11.82	HGL ok
P-182	DI-182	DI-186	1.20	4.05	5.05	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	4.18	4.83	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.54	5.35	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	4.18	4.53	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	4.54	11.91	HGL ok
P-185	DI-185	DI-186	1.20	4.05	4.05	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	4.18	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.92	3.92	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	4.05	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	4.12	4.17	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-187	DI-187	DI-188	1.20	4.13	4.69	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	4.12	4.12	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	4.13	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.92	3.92	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	4.12	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.76	3.76	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	3.92	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.66	4.63	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	4.66	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.57	3.57	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	3.66	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	of
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077.001
Segment:	Jones Street Outfall	Design Freq.:	200	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.67	8.67	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	8.68	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.41	8.41	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	8.67	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.67	8.67	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.69	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.64	8.64	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.64	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.63	8.63	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	8.64	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.40	9.40	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	9.64	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.38	9.38	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.40	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.83	8.83	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	9.38	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.63	8.63	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	8.83	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.41	8.41	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	8.63	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.25	8.25	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	8.41	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.44	8.44	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.45	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.42	8.42	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	8.44	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.41	8.41	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	8.42	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.06	8.06	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	8.25	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.60	7.60	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	8.06	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.40	7.40	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	7.60	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.35	7.35	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	7.40	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.32	7.32	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	7.35	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.26	7.26	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	7.32	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.20	7.20	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	7.26	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.07	7.07	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	7.20	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.98	6.98	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	7.07	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**6.90**	**6.90**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**6.98**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.25	8.25	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.25	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.06	8.06	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	8.07	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.25	8.25	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	8.32	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.06	8.06	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	8.12	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.40	7.40	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	7.43	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.32	7.32	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.34	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.20	7.20	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	7.24	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.20	7.20	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.22	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.50	7.50	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.51	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.48	7.48	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.50	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.46	7.46	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.48	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.40	7.40	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	7.46	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.46	7.46	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.47	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.05	8.05	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.07	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.93	7.93	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	8.05	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.81	7.81	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	7.93	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.67	7.67	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	7.81	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.56	7.56	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	7.67	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.32	7.32	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	7.56	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.56	7.56	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.57	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.87	7.87	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.88	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.81	7.81	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	7.87	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.35	7.35	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.35	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.29	7.29	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.30	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.29	7.29	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.29	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.27	7.27	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	7.29	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.26	7.26	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	7.27	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.55	7.55	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.55	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.68	7.68	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.69	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.69	7.69	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.69	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.68	7.68	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	7.69	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.55	7.55	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	7.68	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.42	7.42	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	7.55	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.62	7.62	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.64	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.63	7.63	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.63	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.62	7.62	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	7.63	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.42	7.42	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	7.62	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.26	7.26	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	7.42	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.16	7.16	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.19	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.07	7.07	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	7.16	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	of
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077.001
Segment:	Jones Street Outfall	Design Freq.:	200	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.17	9.17	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	9.18	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.91	8.91	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	9.17	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.17	9.17	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.19	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.14	9.14	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.14	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.13	9.13	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	9.14	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.90	9.90	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	10.14	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.88	9.88	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.90	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.33	9.33	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	9.88	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.13	9.13	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	9.33	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.91	8.91	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	9.13	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.75	8.75	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	8.91	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.94	8.94	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.95	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.92	8.92	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	8.94	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.91	8.91	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	8.92	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.56	8.56	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	8.75	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.10	8.10	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	8.56	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.90	7.90	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	8.10	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.85	7.85	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	7.90	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.82	7.82	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	7.85	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.76	7.76	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	7.82	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.70	7.70	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	7.76	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.57	7.57	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	7.70	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.48	7.48	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	7.57	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.40**	**7.40**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**7.48**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.75	8.75	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.75	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.56	8.56	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	8.57	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.75	8.75	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	8.82	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.56	8.56	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	8.62	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.90	7.90	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	7.93	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.82	7.82	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.84	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.70	7.70	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	7.74	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.70	7.70	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.72	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.00	8.00	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.01	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.98	7.98	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.00	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.96	7.96	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.98	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.90	7.90	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	7.96	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.96	7.96	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.97	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.55	8.55	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.57	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.43	8.43	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	8.55	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.31	8.31	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	8.43	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.17	8.17	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	8.31	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.06	8.06	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	8.17	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.82	7.82	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	8.06	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.06	8.06	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.07	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.37	8.37	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.38	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.31	8.31	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	8.37	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.85	7.85	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.85	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.79	7.79	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.80	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.79	7.79	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.79	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.77	7.77	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	7.79	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.76	7.76	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	7.77	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.05	8.05	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.18	8.18	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.19	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.19	8.19	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.19	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.18	8.18	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	8.19	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.05	8.05	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	8.18	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.92	7.92	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	8.05	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.12	8.12	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.14	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.13	8.13	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.13	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.12	8.12	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.13	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.92	7.92	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	8.12	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.76	7.76	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	7.92	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.66	7.66	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.69	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.57	7.57	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	7.66	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.57	9.57	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	9.58	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.31	9.31	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	9.57	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.57	9.57	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.59	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.54	9.54	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.54	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.53	9.53	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	9.54	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.30	10.30	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	10.54	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.28	10.28	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.30	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.73	9.73	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	10.28	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.53	9.53	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	9.73	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.31	9.31	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	9.53	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.15	9.15	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	9.31	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.34	9.34	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.35	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.32	9.32	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	9.34	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.31	9.31	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	9.32	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.96	8.96	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	9.15	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.50	8.50	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	8.96	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.30	8.30	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	8.50	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.25	8.25	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	8.30	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.22	8.22	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	8.25	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.16	8.16	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	8.22	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.10	8.10	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	8.16	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.97	7.97	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	8.10	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.88	7.88	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	7.97	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.80**	**7.80**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**7.88**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.15	9.15	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.15	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.96	8.96	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	8.97	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.15	9.15	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	9.22	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.96	8.96	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	9.02	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	8.30	8.30	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.33	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.22	8.22	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.24	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.10	8.10	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	8.14	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.10	8.10	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.12	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.40	8.40	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.41	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.38	8.38	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.40	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.36	8.36	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.38	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.30	8.30	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	8.36	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.36	8.36	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.37	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.95	8.95	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.97	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.83	8.83	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	8.95	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.71	8.71	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	8.83	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.57	8.57	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	8.71	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.46	8.46	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	8.57	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.22	8.22	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	8.46	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.46	8.46	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.47	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.77	8.77	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.78	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.71	8.71	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	8.77	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.25	8.25	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.25	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.19	8.19	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.20	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.19	8.19	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.19	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.17	8.17	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	8.19	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.16	8.16	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	8.17	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.45	8.45	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.45	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.58	8.58	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.59	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.59	8.59	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.59	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.58	8.58	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	8.59	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.45	8.45	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	8.58	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.32	8.32	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	8.45	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.52	8.52	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.54	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.53	8.53	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.53	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.52	8.52	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.53	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.32	8.32	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	8.52	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.16	8.16	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	8.32	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.06	8.06	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.09	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.97	7.97	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	8.06	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.07	10.07	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	10.08	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.81	9.81	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	10.07	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.07	10.07	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.09	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.04	10.04	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.04	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.03	10.03	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	10.04	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.80	10.80	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	11.04	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.78	10.78	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.80	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.23	10.23	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	10.78	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.03	10.03	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	10.23	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.81	9.81	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	10.03	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.65	9.65	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	9.81	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.84	9.84	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.85	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.82	9.82	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	9.84	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.81	9.81	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	9.82	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.46	9.46	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	9.65	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.00	9.00	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	9.46	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.80	8.80	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	9.00	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.75	8.75	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	8.80	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.72	8.72	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	8.75	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.66	8.66	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	8.72	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.60	8.60	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	8.66	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	8.47	8.47	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	8.60	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	8.38	8.38	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	8.47	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**8.30**	**8.30**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**8.38**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.65	9.65	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.65	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.46	9.46	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	9.47	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.65	9.65	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	9.72	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.46	9.46	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	9.52	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	8.80	8.80	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.83	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.72	8.72	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.74	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.60	8.60	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	8.64	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.60	8.60	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.62	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.90	8.90	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.91	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.88	8.88	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.90	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.86	8.86	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.88	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.80	8.80	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	8.86	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.86	8.86	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.87	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	9.45	9.45	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.47	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.33	9.33	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	9.45	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.21	9.21	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	9.33	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.07	9.07	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	9.21	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.96	8.96	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	9.07	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.72	8.72	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	8.96	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.96	8.96	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.97	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	9.27	9.27	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.28	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.21	9.21	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	9.27	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.75	8.75	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.75	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.69	8.69	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.70	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.69	8.69	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.69	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.67	8.67	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	8.69	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.66	8.66	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	8.67	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.95	8.95	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.95	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.08	9.08	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.09	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.09	9.09	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.09	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.08	9.08	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	9.09	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.95	8.95	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	9.08	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.82	8.82	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	8.95	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.02	9.02	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.04	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.03	9.03	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.03	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.02	9.02	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.03	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.82	8.82	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	9.02	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.66	8.66	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	8.82	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.56	8.56	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.59	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	8.47	8.47	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	8.56	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.77	10.77	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	10.78	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.51	10.51	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	10.77	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.77	10.77	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.79	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.74	10.74	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.74	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.73	10.73	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	10.74	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.50	11.50	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	11.74	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.48	11.48	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.50	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.93	10.93	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	11.48	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.73	10.73	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	10.93	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.51	10.51	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	10.73	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.35	10.35	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	10.51	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.54	10.54	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.55	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.52	10.52	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	10.54	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.51	10.51	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	10.52	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.16	10.16	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	10.35	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.70	9.70	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	10.16	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.50	9.50	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	9.70	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.45	9.45	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	9.50	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.42	9.42	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	9.45	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.36	9.36	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	9.42	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.30	9.30	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	9.36	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.17	9.17	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	9.30	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.08	9.08	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	9.17	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.00**	**9.00**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**9.08**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.35	10.35	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.35	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.16	10.16	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	10.17	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.35	10.35	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	10.42	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.16	10.16	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	10.22	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.50	9.50	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.53	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.42	9.42	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.44	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.30	9.30	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	9.34	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.30	9.30	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.32	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.60	9.60	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.61	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.58	9.58	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.60	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.56	9.56	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.58	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.50	9.50	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	9.56	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.56	9.56	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.57	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.15	10.15	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.17	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.03	10.03	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	10.15	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	9.91	9.91	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	10.03	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.77	9.77	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	9.91	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.66	9.66	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	9.77	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.42	9.42	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	9.66	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.66	9.66	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.67	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.97	9.97	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.98	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.91	9.91	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	9.97	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.45	9.45	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.45	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.39	9.39	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.40	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.39	9.39	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.39	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.37	9.37	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	9.39	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.36	9.36	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.37	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.65	9.65	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.65	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.78	9.78	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.79	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.79	9.79	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.79	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.78	9.78	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	9.79	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.65	9.65	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	9.78	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.52	9.52	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	9.65	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.72	9.72	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.74	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.73	9.73	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.73	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.72	9.72	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.73	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.52	9.52	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	9.72	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.36	9.36	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	9.52	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.26	9.26	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.29	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.17	9.17	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	9.26	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.27	11.27	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.28	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.01	11.01	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	11.27	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.27	11.27	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.29	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.24	11.24	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.24	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.23	11.23	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	11.24	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.00	12.00	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	12.24	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.98	11.98	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.00	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.43	11.43	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	11.98	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.23	11.23	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	11.43	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.01	11.01	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	11.23	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.85	10.85	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	11.01	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.04	11.04	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.05	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.02	11.02	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	11.04	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.01	11.01	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	11.02	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.66	10.66	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	10.85	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.20	10.20	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	10.66	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.00	10.00	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	10.20	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.95	9.95	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	10.00	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.92	9.92	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	9.95	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.86	9.86	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	9.92	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.80	9.80	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	9.86	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.67	9.67	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	9.80	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.58	9.58	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	9.67	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.50**	**9.50**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**9.58**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.85	10.85	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.85	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.66	10.66	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	10.67	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.85	10.85	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	10.92	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.66	10.66	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	10.72	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.00	10.00	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.03	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.92	9.92	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.94	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.80	9.80	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	9.84	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.80	9.80	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.82	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.10	10.10	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.11	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.08	10.08	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.10	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.06	10.06	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.08	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.00	10.00	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	10.06	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.06	10.06	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.07	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.65	10.65	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.67	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.53	10.53	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	10.65	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.41	10.41	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	10.53	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.27	10.27	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	10.41	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.16	10.16	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	10.27	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	9.92	9.92	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	10.16	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.16	10.16	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.17	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.47	10.47	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.48	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.41	10.41	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	10.47	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.95	9.95	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.95	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.89	9.89	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.90	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.89	9.89	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.89	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.87	9.87	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	9.89	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.86	9.86	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.87	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.15	10.15	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.15	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.28	10.28	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.29	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.29	10.29	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.29	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.28	10.28	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	10.29	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.15	10.15	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	10.28	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.02	10.02	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	10.15	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.22	10.22	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.24	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.23	10.23	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.23	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.22	10.22	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.23	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.02	10.02	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	10.22	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.86	9.86	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	10.02	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.76	9.76	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.79	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.67	9.67	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	9.76	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.57	12.57	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.58	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.31	12.31	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	12.57	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.57	12.57	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.59	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.54	12.54	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.54	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.53	12.53	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	12.54	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.30	13.30	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	13.54	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.28	13.28	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.30	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.73	12.73	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	13.28	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.53	12.53	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	12.73	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.31	12.31	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	12.53	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.15	12.15	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	12.31	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.34	12.34	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.35	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.32	12.32	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	12.34	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.31	12.31	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	12.32	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.96	11.96	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	12.15	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.50	11.50	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	11.96	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.30	11.30	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	11.50	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.25	11.25	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	11.30	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.22	11.22	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	11.25	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.16	11.16	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	11.22	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.10	11.10	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	11.16	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.97	10.97	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	11.10	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.88	10.88	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	10.97	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.80**	**10.80**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**10.88**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.15	12.15	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.15	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.96	11.96	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	11.97	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.15	12.15	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	12.22	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.96	11.96	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	12.02	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.30	11.30	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.33	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.22	11.22	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.24	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.10	11.10	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	11.14	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.10	11.10	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.12	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.40	11.40	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.41	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.38	11.38	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.40	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.36	11.36	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.38	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.30	11.30	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	11.36	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.36	11.36	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.37	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.95	11.95	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.97	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.83	11.83	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	11.95	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.71	11.71	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	11.83	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.57	11.57	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	11.71	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.46	11.46	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	11.57	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.22	11.22	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	11.46	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.46	11.46	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.47	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.77	11.77	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.78	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.71	11.71	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	11.77	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.25	11.25	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.25	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.19	11.19	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.20	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.19	11.19	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.19	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.17	11.17	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	11.19	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.16	11.16	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.17	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.45	11.45	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.45	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.58	11.58	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.59	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.59	11.59	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.59	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.58	11.58	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	11.59	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.45	11.45	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	11.58	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.32	11.32	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	11.45	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.52	11.52	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.54	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.53	11.53	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.53	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.52	11.52	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.53	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.32	11.32	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	11.52	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.16	11.16	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	11.32	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	11.06	11.06	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.09	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.97	10.97	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	11.06	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.51	7.51	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	7.52	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.25	7.25	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	7.51	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.51	7.51	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.53	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.48	7.48	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.48	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.47	7.47	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	7.48	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.24	8.24	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	8.48	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.22	8.22	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.24	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.67	7.67	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	8.22	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.47	7.47	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	7.67	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.25	7.25	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	7.47	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.09	7.09	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	7.25	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.28	7.28	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.29	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.26	7.26	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	7.28	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.25	7.25	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	7.26	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	6.90	6.90	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	7.09	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.44	6.44	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	6.90	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.24	6.24	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	6.44	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.19	6.19	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	6.24	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.16	6.16	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	6.19	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.10	6.10	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	6.16	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.04	6.04	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	6.10	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.91	5.91	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	6.04	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.82	5.82	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	5.91	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.74**	**5.74**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**5.82**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.09	7.09	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.09	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	6.90	6.90	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	6.91	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.09	7.09	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	7.16	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	6.90	6.90	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	6.96	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.24	6.24	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.27	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.16	6.16	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.18	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.04	6.04	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	6.08	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.04	6.04	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.06	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.34	6.34	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.35	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.32	6.32	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.34	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.30	6.30	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.32	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.24	6.24	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	6.30	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.30	6.30	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.31	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	6.89	6.89	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.91	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.77	6.77	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	6.89	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.65	6.65	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	6.77	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.51	6.51	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	6.65	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.40	6.40	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	6.51	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.16	6.16	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	6.40	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.40	6.40	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.41	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.71	6.71	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.72	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.65	6.65	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	6.71	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.19	6.19	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.19	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.13	6.13	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.14	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.13	6.13	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.13	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.11	6.11	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	6.13	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.10	6.10	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	6.11	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.39	6.39	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.39	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.52	6.52	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.53	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.53	6.53	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.53	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.52	6.52	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	6.53	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.39	6.39	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	6.52	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.26	6.26	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	6.39	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.46	6.46	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.48	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.47	6.47	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.47	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.46	6.46	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.47	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.26	6.26	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	6.46	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.10	6.10	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	6.26	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.00	6.00	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	6.03	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.91	5.91	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	6.00	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.71	7.71	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	7.72	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.45	7.45	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	7.71	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.71	7.71	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.73	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.68	7.68	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.68	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.67	7.67	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	7.68	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.44	8.44	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	8.68	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.42	8.42	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.44	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.87	7.87	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	8.42	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.67	7.67	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	7.87	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.45	7.45	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	7.67	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.29	7.29	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	7.45	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.48	7.48	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.49	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.46	7.46	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	7.48	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.45	7.45	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	7.46	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.10	7.10	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	7.29	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.64	6.64	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	7.10	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.44	6.44	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	6.64	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.39	6.39	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	6.44	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.36	6.36	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	6.39	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.30	6.30	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	6.36	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.24	6.24	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	6.30	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	6.11	6.11	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	6.24	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.02	6.02	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	6.11	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.94**	**5.94**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**6.02**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.29	7.29	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.29	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.10	7.10	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	7.11	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.29	7.29	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	7.36	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.10	7.10	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	7.16	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.44	6.44	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.47	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.36	6.36	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.38	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.24	6.24	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	6.28	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.24	6.24	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.26	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.54	6.54	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.55	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.52	6.52	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.54	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.50	6.50	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.52	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.44	6.44	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	6.50	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.50	6.50	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.51	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.09	7.09	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.11	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.97	6.97	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	7.09	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.85	6.85	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	6.97	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.71	6.71	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	6.85	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.60	6.60	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	6.71	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.36	6.36	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	6.60	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.60	6.60	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.61	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.91	6.91	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.92	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.85	6.85	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	6.91	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.39	6.39	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.39	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.33	6.33	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.34	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.33	6.33	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.33	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.31	6.31	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	6.33	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.30	6.30	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	6.31	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.59	6.59	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.59	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.72	6.72	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.73	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.73	6.73	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.73	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.72	6.72	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	6.73	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.59	6.59	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	6.72	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.46	6.46	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	6.59	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.66	6.66	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.68	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.67	6.67	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.67	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.66	6.66	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.67	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.46	6.46	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	6.66	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.30	6.30	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	6.46	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.20	6.20	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	6.23	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	6.11	6.11	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	6.20	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.21	11.21	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.22	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.95	10.95	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	11.21	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.21	11.21	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.23	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.18	11.18	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.18	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.17	11.17	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	11.18	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.94	11.94	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	12.18	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.92	11.92	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.94	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.37	11.37	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	11.92	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.17	11.17	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	11.37	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.95	10.95	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	11.17	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.79	10.79	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	10.95	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.98	10.98	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.99	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.96	10.96	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	10.98	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.95	10.95	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	10.96	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.60	10.60	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	10.79	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.14	10.14	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	10.60	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.94	9.94	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	10.14	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.89	9.89	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	9.94	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.86	9.86	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	9.89	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.80	9.80	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	9.86	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.74	9.74	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	9.80	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.61	9.61	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	9.74	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.52	9.52	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	9.61	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.44**	**9.44**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**9.52**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.79	10.79	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.79	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.60	10.60	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	10.61	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.79	10.79	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	10.86	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.60	10.60	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	10.66	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.94	9.94	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.97	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.86	9.86	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.88	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.74	9.74	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	9.78	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.74	9.74	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.76	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.04	10.04	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.05	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.02	10.02	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.04	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.00	10.00	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.02	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.94	9.94	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	10.00	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.00	10.00	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.01	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.59	10.59	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.61	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.47	10.47	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	10.59	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.35	10.35	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	10.47	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.21	10.21	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	10.35	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.10	10.10	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	10.21	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	9.86	9.86	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	10.10	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.10	10.10	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.11	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.41	10.41	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.42	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.35	10.35	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	10.41	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.89	9.89	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.89	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.83	9.83	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.84	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.83	9.83	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.83	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.81	9.81	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	9.83	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.80	9.80	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.81	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.09	10.09	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.09	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.22	10.22	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.23	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.23	10.23	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.23	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.22	10.22	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	10.23	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.09	10.09	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	10.22	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.96	9.96	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	10.09	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.16	10.16	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.18	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.17	10.17	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.17	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.16	10.16	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.17	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.96	9.96	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	10.16	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.80	9.80	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	9.96	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.70	9.70	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.73	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.61	9.61	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	9.70	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment; add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.71	11.71	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.72	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.45	11.45	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	11.71	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.71	11.71	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.73	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.68	11.68	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.68	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.67	11.67	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	11.68	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.44	12.44	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	12.68	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.42	12.42	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.44	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.87	11.87	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	12.42	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.67	11.67	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	11.87	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.45	11.45	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	11.67	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.29	11.29	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	11.45	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.48	11.48	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.49	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.46	11.46	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	11.48	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.45	11.45	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	11.46	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.10	11.10	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	11.29	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.64	10.64	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	11.10	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.44	10.44	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	10.64	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.39	10.39	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	10.44	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.36	10.36	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	10.39	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.30	10.30	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	10.36	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.24	10.24	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	10.30	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.11	10.11	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	10.24	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.02	10.02	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	10.11	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.94**	**9.94**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**10.02**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.29	11.29	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.29	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.10	11.10	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	11.11	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.29	11.29	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	11.36	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.10	11.10	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	11.16	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.44	10.44	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.47	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.36	10.36	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.38	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.24	10.24	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	10.28	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.24	10.24	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.26	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.54	10.54	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.55	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.52	10.52	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.54	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.50	10.50	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.52	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.44	10.44	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	10.50	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.50	10.50	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.51	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.09	11.09	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.11	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.97	10.97	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	11.09	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.85	10.85	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	10.97	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.71	10.71	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	10.85	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.60	10.60	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	10.71	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.36	10.36	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	10.60	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.60	10.60	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.61	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.91	10.91	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.92	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.85	10.85	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	10.91	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.39	10.39	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.39	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.33	10.33	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.34	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.33	10.33	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.33	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.31	10.31	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	10.33	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.30	10.30	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	10.31	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.59	10.59	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.59	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.72	10.72	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.73	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.73	10.73	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.73	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	10.72	10.72	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	10.73	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.59	10.59	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	10.72	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.46	10.46	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	10.59	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.66	10.66	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.68	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.67	10.67	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.67	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	10.66	10.66	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.67	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.46	10.46	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	10.66	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.30	10.30	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	10.46	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.20	10.20	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.23	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.11	10.11	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	10.20	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.11	12.11	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.12	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.85	11.85	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	12.11	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.11	12.11	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.13	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.08	12.08	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.08	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.07	12.07	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	12.08	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.84	12.84	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	13.08	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.82	12.82	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.84	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.27	12.27	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	12.82	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.07	12.07	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	12.27	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.85	11.85	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	12.07	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.69	11.69	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	11.85	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.88	11.88	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.89	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.86	11.86	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	11.88	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.85	11.85	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	11.86	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.50	11.50	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	11.69	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.04	11.04	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	11.50	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.84	10.84	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	11.04	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.79	10.79	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	10.84	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.76	10.76	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	10.79	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.70	10.70	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	10.76	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.64	10.64	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	10.70	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.51	10.51	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	10.64	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.42	10.42	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	10.51	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.34**	**10.34**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**10.42**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.69	11.69	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.69	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.50	11.50	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	11.51	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.69	11.69	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	11.76	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.50	11.50	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	11.56	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.84	10.84	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.87	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.76	10.76	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.78	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.64	10.64	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	10.68	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.64	10.64	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.66	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.94	10.94	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.95	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.92	10.92	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.94	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.90	10.90	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.92	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.84	10.84	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	10.90	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.90	10.90	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.91	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.49	11.49	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.51	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.37	11.37	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	11.49	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.25	11.25	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	11.37	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.11	11.11	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	11.25	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.00	11.00	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	11.11	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.76	10.76	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	11.00	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.00	11.00	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.01	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.31	11.31	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.32	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.25	11.25	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	11.31	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.79	10.79	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.79	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.73	10.73	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.74	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.73	10.73	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.73	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	10.71	10.71	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	10.73	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	10.70	10.70	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	10.71	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.99	10.99	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.99	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	11.12	11.12	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.13	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.13	11.13	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.13	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.12	11.12	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	11.13	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	10.99	10.99	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	11.12	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.86	10.86	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	10.99	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.06	11.06	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.08	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.07	11.07	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.07	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.06	11.06	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.07	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	10.86	10.86	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	11.06	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.70	10.70	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	10.86	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.60	10.60	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.63	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.51	10.51	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	10.60	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.61	12.61	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.62	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.35	12.35	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	12.61	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.61	12.61	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.63	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.58	12.58	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.58	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.57	12.57	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	12.58	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.34	13.34	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	13.58	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.32	13.32	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.34	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.77	12.77	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	13.32	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.57	12.57	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	12.77	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.35	12.35	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	12.57	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.19	12.19	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	12.35	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.38	12.38	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.39	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.36	12.36	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	12.38	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.35	12.35	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	12.36	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.00	12.00	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	12.19	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.54	11.54	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	12.00	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.34	11.34	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	11.54	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.29	11.29	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	11.34	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.26	11.26	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	11.29	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.20	11.20	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	11.26	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.14	11.14	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	11.20	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.01	11.01	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	11.14	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.92	10.92	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	11.01	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.84**	**10.84**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**10.92**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.19	12.19	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.19	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.00	12.00	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	12.01	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.19	12.19	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	12.26	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.00	12.00	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	12.06	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.34	11.34	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.37	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.26	11.26	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.28	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.14	11.14	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	11.18	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.14	11.14	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.16	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.44	11.44	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.45	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.42	11.42	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.44	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.40	11.40	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.42	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.34	11.34	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	11.40	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.40	11.40	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.41	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.99	11.99	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.01	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.87	11.87	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	11.99	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.75	11.75	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	11.87	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.61	11.61	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	11.75	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.50	11.50	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	11.61	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.26	11.26	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	11.50	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.50	11.50	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.51	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.81	11.81	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.82	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.75	11.75	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	11.81	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.29	11.29	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.29	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.23	11.23	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.24	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.23	11.23	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.23	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.21	11.21	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	11.23	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.20	11.20	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.21	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.49	11.49	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.49	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.62	11.62	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.63	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.63	11.63	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.63	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.62	11.62	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	11.63	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.49	11.49	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	11.62	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.36	11.36	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	11.49	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.56	11.56	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.58	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.57	11.57	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.57	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.56	11.56	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.57	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.36	11.36	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	11.56	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.20	11.20	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	11.36	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.10	11.10	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.13	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.01	11.01	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	11.10	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.31	13.31	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	13.32	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	13.05	13.05	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	13.31	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.31	13.31	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.33	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.28	13.28	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.28	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.27	13.27	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	13.28	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	14.04	14.04	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	14.28	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	14.02	14.02	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	14.04	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.47	13.47	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	14.02	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.27	13.27	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	13.47	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	13.05	13.05	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	13.27	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.89	12.89	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	13.05	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	13.08	13.08	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.09	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	13.06	13.06	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	13.08	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	13.05	13.05	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	13.06	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.70	12.70	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	12.89	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.24	12.24	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	12.70	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.04	12.04	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	12.24	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.99	11.99	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	12.04	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.96	11.96	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	11.99	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.90	11.90	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	11.96	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.84	11.84	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	11.90	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.71	11.71	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	11.84	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	11.62	11.62	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	11.71	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**11.54**	**11.54**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**11.62**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.89	12.89	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.89	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.70	12.70	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	12.71	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.89	12.89	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	12.96	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.70	12.70	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	12.76	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.04	12.04	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.07	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.96	11.96	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.98	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.84	11.84	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	11.88	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.84	11.84	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.86	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.14	12.14	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.15	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.12	12.12	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.14	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.10	12.10	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.12	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.04	12.04	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	12.10	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.10	12.10	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.11	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.69	12.69	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.71	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.57	12.57	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	12.69	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.45	12.45	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	12.57	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.31	12.31	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	12.45	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.20	12.20	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	12.31	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.96	11.96	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	12.20	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.20	12.20	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.21	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.51	12.51	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.52	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.45	12.45	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	12.51	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.99	11.99	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.99	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.93	11.93	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.94	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.93	11.93	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.93	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.91	11.91	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	11.93	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.90	11.90	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.91	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.19	12.19	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.19	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.32	12.32	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.33	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.33	12.33	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.33	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.32	12.32	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	12.33	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.19	12.19	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	12.32	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.06	12.06	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	12.19	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.26	12.26	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.28	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.27	12.27	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.27	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.26	12.26	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.27	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.06	12.06	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	12.26	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.90	11.90	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	12.06	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.80	11.80	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.83	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.71	11.71	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	11.80	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.81	13.81	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	13.82	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	13.55	13.55	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	0.5	0.02	0.26	13.81	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.81	13.81	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.83	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.78	13.78	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.78	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.77	13.77	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	13.78	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	14.54	14.54	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	14.78	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	14.52	14.52	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	14.54	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.97	13.97	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	1.3	1.0	0.18	0.55	14.52	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.77	13.77	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	0.5	0.17	0.20	13.97	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	13.55	13.55	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	0.5	0.04	0.23	13.77	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	13.39	13.39	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	0.5	0.09	0.16	13.55	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	13.58	13.58	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.59	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	13.56	13.56	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	13.58	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	13.55	13.55	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	0.5	0.01	0.01	13.56	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	13.20	13.20	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	0.5	0.09	0.19	13.39	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.74	12.74	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	13.20	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.54	12.54	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	12.74	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	12.49	12.49	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	12.54	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	12.46	12.46	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	0.5	0.01	0.02	12.49	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	12.40	12.40	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	12.46	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	12.34	12.34	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	12.40	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	12.21	12.21	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	12.34	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	12.12	12.12	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	12.21	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**12.04**	**12.04**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	**0.5**	**0.05**	**0.08**	**12.12**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	13.39	13.39	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.39	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	13.20	13.20	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	13.21	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	13.39	13.39	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	13.46	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	13.20	13.20	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.06	13.26	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.54	12.54	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.57	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	12.46	12.46	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.48	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	12.34	12.34	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	12.38	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	12.34	12.34	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.36	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.64	12.64	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.65	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.62	12.62	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.64	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.60	12.60	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.62	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.54	12.54	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	12.60	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.60	12.60	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.61	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	13.19	13.19	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.21	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	13.07	13.07	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	13.19	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.95	12.95	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	13.07	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.81	12.81	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	12.95	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.70	12.70	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	12.81	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	12.46	12.46	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	12.70	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.70	12.70	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.71	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	13.01	13.01	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.02	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.95	12.95	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	13.01	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	12.49	12.49	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.49	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	12.43	12.43	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.44	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	12.43	12.43	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	12.43	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	12.41	12.41	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	12.43	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	12.40	12.40	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	12.41	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.69	12.69	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.69	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.82	12.82	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.83	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.83	12.83	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.83	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.82	12.82	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	12.83	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.69	12.69	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	12.82	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.56	12.56	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	12.69	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.76	12.76	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.78	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.77	12.77	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.77	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.76	12.76	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.77	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.56	12.56	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	12.76	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	12.40	12.40	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	12.56	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	12.30	12.30	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.33	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	12.21	12.21	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	12.30	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	15.11	15.11	15	1.5	1.2	95	16	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	15.12	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	14.85	14.85	15	2.8	2.3	91	154	0.0016	0.24	0	0.00	0.02	1.4	1.8	0.0	1.2	0.0	95	0.02	0.04	1.0	*0.5*	0.02	0.26	15.11	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	15.11	15.11	15	1.3	1.1	91	34	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	15.13	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	15.08	15.08	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.08	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	15.07	15.07	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	*0.5*	0.00	0.01	15.08	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	15.84	15.84	12	2.5	3.2	0	47	0.0042	0.20	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.24	16.08	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	15.82	15.82	12	0.7	0.8	90	82.1	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	15.84	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	15.27	15.27	12	3.7	4.6	72	41	0.0089	0.37	0	0.00	0.08	0.6	7.9	0.0	3.2	0.1	0	0.00	0.14	*1.3*	1.0	0.18	0.55	15.82	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	15.07	15.07	18	3.6	2.0	77	26	0.0010	0.03	0	0.00	0.02	17.0	0.0	0.0	4.6	0.1	72	0.20	0.34	1.0	*0.5*	0.17	0.20	15.27	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	14.85	14.85	18	4.3	2.4	90	129	0.0014	0.18	0	0.00	0.02	7.4	0.4	0.0	2.0	0.0	77	0.04	0.09	1.0	*0.5*	0.04	0.23	15.07	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	14.69	14.69	18	8.2	4.6	3	14	0.0052	0.07	0	0.00	0.08	10.4	1.1	6.2	2.4	0.0	90	0.06	0.18	1.0	*0.5*	0.09	0.16	14.85	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	14.88	14.88	15	0.9	0.7	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.89	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	14.86	14.86	15	1.4	1.2	22	5	0.0004	0.00	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	70	0.01	0.01	*1.3*	1.0	0.02	0.02	14.88	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	14.85	14.85	18	1.4	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.7	0.0	0.0	1.2	0.0	22	0.01	0.01	1.0	*0.5*	0.01	0.01	14.86	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	14.50	14.50	24	9.6	3.1	4	60	0.0015	0.09	0	0.00	0.04	37.9	1.1	0.4	4.6	0.1	3	0.03	0.19	1.0	*0.5*	0.09	0.19	14.69	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	14.04	14.04	24	15.0	4.8	4	82	0.0037	0.31	0	0.00	0.09	29.5	15.2	0.0	3.1	0.1	4	0.01	0.15	1.0	1.0	0.15	0.46	14.50	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	13.84	13.84	36	15.2	2.1	7	59	0.0004	0.03	0	0.00	0.02	71.4	0.0	0.0	4.8	0.1	4	0.04	0.18	1.0	1.0	0.18	0.20	14.04	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	13.79	13.79	48	19.2	1.5	3	54	0.0002	0.01	0	0.00	0.01	32.7	9.1	9.9	2.1	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	13.84	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	13.76	13.76	48	19.5	1.5	3	68	0.0002	0.01	0	0.00	0.01	29.4	0.1	0.0	1.5	0.0	3	0.00	0.03	1.0	*0.5*	0.01	0.02	13.79	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	13.70	13.70	48	22.2	1.8	4	180	0.0002	0.04	0	0.00	0.01	30.2	29.7	3.9	1.5	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	13.76	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	13.64	13.64	48	27.2	2.2	2	58	0.0003	0.02	0	0.00	0.02	39.3	1.4	10.1	1.8	0.0	4	0.00	0.04	1.0	1.0	0.04	0.06	13.70	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	13.51	13.51	48	34.4	2.7	0	158	0.0005	0.08	0	0.00	0.03	59.0	4.6	4.5	2.2	0.0	2	0.00	0.05	1.0	1.0	0.05	0.13	13.64	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	13.42	13.42	48	36.3	2.9	16	35	0.0005	0.02	0	0.00	0.03	94.3	4.8	0.0	2.7	0.0	0	0.00	0.07	1.0	1.0	0.07	0.09	13.51	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**13.34**	**13.34**	**48**	**36.1**	**2.9**	**0**	**48**	**0.0005**	**0.03**	**0**	**0.00**	**0.03**	**104.7**	**0.0**	**0.0**	**2.9**	**0.0**	**16**	**0.02**	**0.10**	**1.0**	***0.5***	**0.05**	**0.08**	**13.42**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	14.69	14.69	15	0.7	0.6	0	44	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.69	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	14.50	14.50	15	1.1	0.9	88	25	0.0003	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	0	0.00	0.01	*1.3*	1.0	0.01	0.01	14.51	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	14.69	14.69	8	0.4	1.1	93	96	0.0007	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.07	14.76	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	14.50	14.50	18	5.2	2.9	90	23	0.0021	0.05	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	*0.5*	0.02	0.06	14.56	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	13.84	13.84	18	4.0	2.3	90	19	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.03	13.87	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	13.76	13.76	18	2.6	1.5	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.02	13.78	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	13.64	13.64	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.01	0.04	13.68	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	13.64	13.64	18	2.8	1.6	90	18	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.02	13.66	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	13.94	13.94	18	1.3	0.8	0	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.95	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	13.92	13.92	18	1.8	1.0	0	54	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.8	0.0	0	0.00	0.01	*1.3*	1.0	0.01	0.02	13.94	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	13.90	13.90	24	2.4	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.7	0.0	0.0	1.0	0.0	0	0.00	0.01	*1.3*	1.0	0.01	0.02	13.92	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	13.84	13.84	24	5.6	1.8	94	33	0.0005	0.02	0	0.00	0.01	1.8	2.6	0.0	1.2	0.0	90	0.02	0.04	1.3	1.0	0.05	0.06	13.90	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	13.90	13.90	18	2.1	1.2	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.91	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	14.49	14.49	18	2.7	1.5	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	14.51	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	14.37	14.37	18	3.2	1.8	90	68	0.0008	0.05	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	90	0.02	0.05	1.3	1.0	0.06	0.12	14.49	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	14.25	14.25	18	3.7	2.1	79	29	0.0010	0.03	0	0.00	0.02	5.7	0.0	0.0	1.8	0.0	90	0.04	0.07	1.3	1.0	0.09	0.12	14.37	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	14.11	14.11	24	6.4	2.0	69	46	0.0007	0.03	0	0.00	0.02	7.6	0.0	0.0	2.1	0.0	79	0.04	0.08	1.3	1.0	0.11	0.14	14.25	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	14.00	14.00	24	6.7	2.1	80	44	0.0007	0.03	0	0.00	0.02	13.0	0.0	0.0	2.0	0.0	69	0.04	0.08	1.0	1.0	0.08	0.11	14.11	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	13.76	13.76	24	9.7	3.1	88	29	0.0016	0.05	0	0.00	0.04	14.3	29.7	0.0	3.1	0.1	88	0.10	0.19	1.0	1.0	0.19	0.24	14.00	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	14.00	14.00	18	2.4	1.4	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	14.01	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	14.31	14.31	18	1.8	1.0	90	22	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.32	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	14.25	14.25	18	2.3	1.3	12	68	0.0004	0.03	0	0.00	0.01	1.8	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	14.31	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	13.79	13.79	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.79	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	13.73	13.73	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.74	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	13.73	13.73	18	1.0	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	13.73	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	13.71	13.71	18	1.2	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	13.73	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	13.70	13.70	18	1.6	0.9	98	23	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	13.71	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	13.99	13.99	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.99	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	14.12	14.12	18	1.9	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.13	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	14.13	14.13	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.13	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	14.12	14.12	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	14.13	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	13.99	13.99	18	3.4	1.9	70	108	0.0009	0.09	0	0.00	0.01	0.5	2.0	0.0	1.1	0.0	90	0.01	0.03	1.3	1.0	0.04	0.14	14.12	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	13.86	13.86	18	4.0	2.2	57	27	0.0012	0.03	0	0.00	0.02	6.4	0.0	0.0	1.9	0.0	70	0.03	0.07	1.3	1.0	0.10	0.13	13.99	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	14.06	14.06	18	2.4	1.4	90	23	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	14.08	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	14.07	14.07	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.07	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	14.06	14.06	18	0.9	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	14.07	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	13.86	13.86	18	3.9	2.2	14	119	0.0012	0.14	0	0.00	0.02	0.5	3.3	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.06	0.20	14.06	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	13.70	13.70	18	4.2	2.4	67	50	0.0014	0.07	0	0.00	0.02	8.6	8.9	0.0	2.2	0.0	57	0.04	0.09	1.0	1.0	0.09	0.16	13.86	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	13.60	13.60	18	2.6	1.5	105	53	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	13.63	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	13.51	13.51	18	2.9	1.7	90	43	0.0007	0.03	0	0.00	0.01	3.8	0.0	0.0	1.5	0.0	105	0.02	0.05	1.3	1.0	0.06	0.09	13.60	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 500 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
CRB Network STA 109+25 to 111+75																										
CRB-P72	CRB-DI72	CRB-MH-74	7961	0	7961	0.18	1.00	0.18	0.18	6.0	0.00	8.51	1.6	15	16	0.012	0.0005	0.019	7.8	9.6	5.5	0.05	6.05	2.60	2.30	Q ok
CRB-P74	CRB-MH-74	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.34	6.0	6.17	8.43	2.9	15	154	0.012	0.0017	0.005	4.1	5.1	4.2	0.61	6.77	1.65	0.84	Q ok
CRB-P73	CRB-DI73	CRB-MH-74	7042	0	7042	0.16	1.00	0.16	0.16	6.0	0.00	8.51	1.4	15	34	0.012	0.0004	0.005	4.0	4.9	3.4	0.17	6.17	1.92	1.75	Q ok
MSS Network Sta 111+75 to 114+00																										
P-162	DI-162	EXMH-201	3794	0	3794	0.09	1.00	0.09	0.09	6.0	0.00	8.51	**0.74**	15	16	0.011	0.000094	0.0200	8.8	**10.8**	4.3	0.06	6.06	2.50	2.18	Q ok
P-201	EXMH-201	A1-MH-203	1	0	1	0.00	1.00	0.00	0.09	6.0	6.06	8.47	**0.74**	15	18	0.012	0.000111	0.0200	8.1	**9.9**	3.9	0.08	6.14	1.98	1.62	Q ok
Ploener Property																										
EX-P LOT	EXDI LOT	DI-MSS-41	13430	0	13430	0.31	1.00	0.31	0.31	6.0	0.00	8.51	**2.62**	12	47	0.012	0.004619	0.0074	4.2	**3.3**	4.7	0.16	6.16	2.50	2.15	Q ok
P-MSS-48	DI-MSS-40	DI-MSS-41	3590	0	3590	0.08	1.00	0.08	0.08	6.0	0.00	8.51	**0.70**	12	82	0.012	0.000330	0.0050	3.5	**2.7**	2.8	0.48	6.48	2.56	2.15	Q ok
P-MSS-48A	DI-MSS-41	EX-MH	3072	0	3072	0.07	1.00	0.07	0.46	6.0	6.48	8.32	**3.84**	12	41	0.012	0.009890	0.0051	3.5	**2.8**	2.9	0.24	6.72	2.05	1.84	Undersized!
A1-P-202	EX-MH	A1-MH-203	1	0	1	0.00	1.00	0.00	0.46	6.0	6.72	8.25	**3.80**	18	26	0.012	0.001118	0.0046	4.4	**7.7**	4.3	0.10	6.82	1.74	1.62	Q ok
A1-P-204	A1-MH-204	CRB-MH-67	1	0	1	0.00	1.00	0.00	0.55	6.0	6.82	8.21	**4.50**	18	129	0.012	0.001566	0.0052	4.6	**8.2**	4.7	0.45	7.27	1.52	0.85	Q ok
A1-P-205	CRB-MH-67	CMH-1	1	0	1	0.00	1.00	0.00	1.07	6.0	7.27	8.02	**8.60**	18	14	0.012	0.005714	0.0057	4.9	**8.6**	5.7	0.04	7.31	0.75	0.67	Q ok
MSS Network Sta 111+75 to 114+00																										
MSS-P2	MSS-DI2	MSS-DI1	3846	1139	4985	0.11	0.97	0.11	0.11	6.0	0.00	8.51	0.9	15	70	0.012	0.0002	0.005	4.0	4.9	3.0	0.39	6.39	4.03	3.68	Q ok
MSS-P1	MSS-DI1	EXMH	2301	1082	3383	0.08	0.88	0.07	0.18	6.0	6.39	8.36	1.5	15	5	0.012	0.0005	0.003	3.3	4.0	3.0	0.03	6.42	3.39	3.37	Q ok
A1-P-203	EX MH	MH-CRB-67	1	0	1	0.00	1.00	0.00	0.18	6.0	6.42	8.36	**1.50**	18	25	0.012	0.000173	0.0050	4.6	**8.0**	3.4	0.12	6.54	0.92	0.84	Q ok
Jones Street Constructed Under Area 1																										
A1-P-206	CMH-1	A1-DI-207	1	0	1	0.00	1.00	0.00	1.26	6.0	7.31	8.02	**10.12**	24	60	0.012	0.001706	0.0035	4.6	**14.5**	5.0	0.20	7.51	0.57	0.36	Q ok
A1-P-207	A1-DI-207	A1-DI-208	3414	0	3414	0.08	1.00	0.08	1.98	6.0	7.51	7.95	**15.74**	24	82	0.012	0.004123	0.0040	4.9	**15.5**	5.8	0.24	7.75	0.36	0.03	Undersized!
A1-P-208	A1-DI-208	A1-DI-209	2490	0	2490	0.06	1.00	0.06	2.04	6.0	7.75	7.88	**16.04**	36	59	0.012	0.000493	0.0041	6.5	**46.1**	5.9	0.17	7.92	0.03	-0.21	Q ok
A1-P-209	A1-DI-209	A1-MH-210	2433	0	2433	0.06	1.00	0.06	2.59	6.0	7.92	7.80	**20.18**	48	54	0.012	0.000168	0.0041	7.9	**99.3**	5.9	0.15	8.07	-0.21	-0.43	Q ok
A1-P-210	A1-MH-210	A1-DI-211	1	0	1	0.00	1.00	0.00	2.65	6.0	8.07	7.73	**20.46**	48	68	0.012	0.000173	0.0040	7.8	**98.1**	5.9	0.19	8.26	-0.43	-0.70	Q ok
A1-P-211	A1-DI-211	A1-DI-212	3353	0	3353	0.08	1.00	0.08	3.05	6.0	8.26	7.65	**23.33**	48	180	0.012	0.000225	0.0040	7.8	**98.4**	6.4	0.47	8.73	-0.70	-1.42	Q ok
A1-P-212	A1-DI-212	A1-DI-213	1885	0	1885	0.04	1.00	0.04	3.81	6.0	8.73	7.50	**28.60**	48	58	0.012	0.000338	0.0040	7.8	**98.0**	6.6	0.15	8.87	-1.42	-1.65	Q ok
A1-P-213	A1-DI-213	A1-DI-214	15288	0	15288	0.35	1.00	0.35	4.87	6.0	8.87	7.43	**36.15**	48	158	0.012	0.000540	0.0040	7.8	**98.3**	7.0	0.37	9.25	-1.65	-2.28	Q ok
A1-P-214	A1-DI-214	A1-DI-215	**1**	0	1	0.00	1.00	0.00	5.23	6.0	9.25	7.32	**38.28**	48	35	0.012	0.000605	0.0040	7.8	**98.4**	7.2	0.08	9.33	-2.28	-2.42	Q ok
A1-P-215	A1-DI-215	A1-MH-216	**1**	0	1	0.00	1.00	0.00	5.23	6.0	9.33	7.28	**38.08**	48	48	0.012	0.000599	0.0040	7.8	**97.9**	7.2	0.11	9.44	-2.42	-2.61	Q ok
MSS-P3 A	MSS-DI14	DI-161	3612	330	3942	0.09	1.00	0.09	0.09	6.0	0.00	8.51	0.8	15	44	0.012	0.0001	0.005	4.0	4.9	2.8	0.26	6.26	4.03	3.81	Q ok
MSS-P3 B	DI-161	MSS-DI13	2062	222	2284	0.05	1.00	0.05	0.14	6.0	6.26	8.40	1.2	15	25	0.012	0.0003	0.005	4.1	5.0	3.3	0.13	6.39	3.81	3.68	Q ok
	DOGHOUSE																									
P-160	DI-160	CMH-1	1768	257	2025	0.05	1.00	0.05	0.05	6.0	0.00	8.51	**0.40**	8	96	0.011	0.000767	0.0200	5.8	**2.0**	4.3	0.37	6.37	2.99	1.07	Q ok
A1 P-200	PARCEL J	A1-DI-207	27861	0	27861	0.64	1.00	0.64	0.64	6.0	0.00	8.51	**5.44**	18	23	0.012	0.002287	0.0100	6.4	11.4	6.4	0.06	6.06	1.59	1.36	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 500 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-336	PARCEL J	A1-DI-209	21549	0	21549	0.49	1.00	0.49	0.49	6.0	0.00	8.51	**4.21**	18	19	0.012	0.001368	0.0100	6.4	11.4	5.8	0.05	6.05	1.48	1.29	Q ok
P-337	PARCEL J	A1-DI-211	14148	0	14148	0.32	1.00	0.32	0.32	6.0	0.00	8.51	**2.76**	18	23	0.012	0.000590	0.0100	6.4	11.4	5.3	0.07	6.07	1.53	1.30	Q ok
P-335	PARCEL N	A1-DI-213	15379	0	15379	0.35	1.00	0.35	0.35	6.0	0.00	8.51	**3.00**	18	56	0.012	0.000697	0.0100	6.4	11.4	5.3	0.18	6.18	1.91	1.35	Q ok
P-340	PARCEL K	A1-DI-213	15267	0	15267	0.35	1.00	0.35	0.35	6.0	0.00	8.51	**2.98**	18	18	0.012	0.000687	0.0100	6.4	11.4	5.3	0.06	6.06	1.53	1.35	Q ok
P-165	DI-165	DI-166	7237	0	7237	0.17	1.00	0.17	0.17	6.0	0.00	8.51	**1.41**	18	28	0.012	0.000154	0.0100	6.4	**11.4**	3.9	0.12	6.12	2.95	2.67	Q ok
P-166	DI-166	DI-167	2265	0	2265	0.05	1.00	0.05	0.22	6.0	6.12	8.47	**1.85**	18	54	0.012	0.000264	0.0100	6.4	**11.4**	4.5	0.20	6.32	2.47	1.93	Q ok
P-167	DI-167	DI-168	3648	0	3648	0.08	1.00	0.08	0.30	6.0	6.32	8.40	**2.53**	24	91	0.012	0.000107	0.0100	7.8	**24.5**	4.7	0.32	6.64	1.73	0.82	Q ok
P-168	DI-168	DI-209	6136	0	6136	0.14	1.00	0.14	0.71	6.0	6.64	8.28	**5.86**	24	33	0.012	0.000571	0.0100	7.8	**24.5**	6.4	0.09	6.73	0.62	0.29	Q ok
P-327	PARCEL L	DI-168	11517	0	11517	0.26	1.00	0.26	0.26	6.0	0.00	8.51	**2.25**	18	19	0.012	0.000391	0.0100	6.4	11.4	4.8	0.07	6.07	1.31	1.12	Q ok
P-326	PARCEL L	DI-170	14378	0	14378	0.33	1.00	0.33	0.33	6.0	0.00	8.51	**2.81**	18	23	0.012	0.000609	0.0100	6.4	11.4	5.3	0.07	6.07	3.99	3.76	Q ok
P-170	DI-170	DI-171	2801	0	2801	0.06	1.00	0.06	0.39	6.0	6.07	8.47	**3.34**	18	68	0.012	0.000862	0.0100	6.4	**11.4**	5.5	0.21	6.28	3.26	2.58	Q ok
P-171	DI-171	DI-173	2811	0	2811	0.06	1.00	0.06	0.46	6.0	6.28	8.40	**3.85**	18	29	0.012	0.001147	0.0100	6.4	**11.4**	5.8	0.08	6.36	2.38	2.09	Q ok
P-173	DI-173	DI-174	2818	0	2818	0.06	1.00	0.06	0.81	6.0	6.36	8.36	**6.73**	24	46	0.012	0.000755	0.0100	7.8	**24.5**	6.4	0.12	6.48	1.89	1.43	Q ok
P-174	DI-174	DI-175	1817	0	1817	0.04	1.00	0.04	0.85	6.0	6.48	8.32	**7.05**	24	44	0.012	0.000827	0.0100	7.8	**24.5**	6.6	0.11	6.59	1.23	0.79	Q ok
P-175	DI-175	DI-211	3620	0	3620	0.08	1.00	0.08	1.23	6.0	6.59	8.28	**10.16**	24	29	0.012	0.001719	0.0100	7.8	**24.5**	7.2	0.07	6.66	0.59	0.30	Q ok
P-331	PARCEL M	DI-175	12913	0	12913	0.30	1.00	0.30	0.30	6.0	0.00	8.51	**2.52**	18	19	0.012	0.000491	0.0100	6.4	11.4	4.8	0.07	6.07	1.28	1.09	Q ok
P-328	PARCEL M	DI-172	9475	0	9475	0.22	1.00	0.22	0.22	6.0	0.00	8.51	**1.85**	18	22	0.012	0.000264	0.0100	6.4	11.4	4.5	0.08	6.08	3.49	3.27	Q ok
P-172	DI-172	DI-173	2798	0	2798	0.06	1.00	0.06	0.28	6.0	6.08	8.47	**2.39**	18	68	0.012	0.000440	0.0100	6.4	**11.4**	4.8	0.23	6.32	2.77	2.09	Q ok
P-169	DI-169	MH-210	2626	0	2626	0.06	1.00	0.06	0.06	6.0	0.00	8.51	**0.51**	18	7	0.012	0.000020	0.0100	6.4	**11.4**	3.2	0.04	6.04	1.64	1.57	Q ok
P-178	DI-178	DI-179	3573	0	3573	0.08	1.00	0.08	0.08	6.0	0.00	8.51	**0.70**	18	39	0.012	0.000038	0.0100	6.4	**11.4**	3.2	0.21	6.21	2.63	2.24	Q ok
P-179	DI-179	DI-180	1913	0	1913	0.04	1.00	0.04	0.13	6.0	0.00	8.51	**1.07**	18	34	0.012	0.000089	0.0100	6.4	**11.4**	3.9	0.15	6.15	2.04	1.70	Q ok
P-180	DI-180	DI-181	1165	0	1165	0.03	1.00	0.03	0.15	6.0	0.00	8.51	**1.30**	18	49	0.012	0.000130	0.0100	6.4	**11.4**	3.9	0.21	6.21	1.50	1.01	Q ok
P-181	DI-181	DI-212	1967	0	1967	0.05	1.00	0.05	0.20	6.0	0.00	8.51	**1.68**	18	23	0.012	0.000219	0.0100	6.4	**11.4**	4.5	0.09	6.09	0.81	0.58	Q ok
P-182	DI-182	DI-186	1887	0	1887	0.04	1.00	0.04	0.04	6.0	0.00	8.51	**0.37**	18	43	0.012	0.000010	0.0100	6.4	**11.4**	3.2	0.23	6.23	4.28	3.85	Q ok
P-338	PARCEL J	DI-185	10195	0	10195	0.23	1.00	0.23	0.23	6.0	0.00	8.51	**1.99**	18	23	0.012	0.000306	0.0100	6.4	11.4	4.5	0.09	6.09	3.86	3.63	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 1 of 1
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.001
Segment: Jones Street Outfall Storm Frequency: 500 -year (50-year for sumps)

Location			Impervious Area, C = 0.95	Pervious Area, C = 0.18	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-183	DI-183	DI-184	2436	0	2436	0.06	1.00	0.06	0.06	6.0	0.00	8.51	**0.48**	18	59	0.012	0.000017	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.74	4.15	Q ok
P-184	DI-184	DI-185	2508	0	2508	0.06	1.00	0.06	0.11	6.0	0.00	8.51	**0.97**	18	62	0.012	0.000072	0.0100	6.4	**11.4**	3.9	0.27	6.27	3.95	3.33	Q ok
P-185	DI-185	DI-186	3002	0	3002	0.07	1.00	0.07	0.42	6.0	0.00	8.51	**3.54**	18	108	0.012	0.000969	0.0100	6.4	**11.4**	5.5	0.33	6.33	3.13	2.05	Q ok
P-186	DI-186	DI-190	1354	0	1354	0.03	1.00	0.03	0.49	6.0	0.00	8.51	**4.18**	18	27	0.012	0.001347	0.0100	6.4	**11.4**	5.8	0.08	6.08	1.85	1.58	Q ok
check San x-ing																										
P-339	PARCEL K	DI-189	12930	0	12930	0.30	1.00	0.30	0.30	6.0	0.00	8.51	**2.53**	18	23	0.012	0.000493	0.0100	6.4	11.4	4.8	0.08	6.08	3.20	2.97	Q ok
P-187	DI-187	DI-188	2448	0	2448	0.06	1.00	0.06	0.06	6.0	0.00	8.51	**0.48**	18	59	0.012	0.000018	0.0100	6.4	**11.4**	3.2	0.31	6.31	4.08	3.49	Q ok
P-188	DI-188	DI-189	2550	0	2550	0.06	1.00	0.06	0.11	6.0	0.00	8.51	**0.98**	18	62	0.012	0.000074	0.0100	6.4	**11.4**	3.9	0.27	6.27	3.29	2.67	Q ok
P-189	DI-189	DI-190	3025	0	3025	0.07	1.00	0.07	0.48	6.0	0.00	8.51	**4.09**	18	119	0.012	0.001293	0.0100	6.4	**11.4**	5.8	0.34	6.34	2.47	1.28	Q ok
P-190	DI-190	DI-191	1765	0	1765	0.04	1.00	0.04	0.52	6.0	0.00	8.51	**4.44**	18	50	0.012	0.001520	0.0100	6.4	**11.4**	5.9	0.14	6.14	1.08	0.58	Q ok
P-341	PARCEL K	DI-195	13999	0	13999	0.32	1.00	0.32	0.32	6.0	0.00	8.51	**2.73**	18	53	0.012	0.000577	0.0100	6.4	11.4	5.3	0.17	6.17	3.96	3.43	Q ok
P-195	DI-195	A1-DI-214	**1887**	0	1887	0.04	1.00	0.04	0.36	6.0	6.17	8.43	**3.08**	18	43	0.012	0.000730	0.0100	6.4	**11.4**	5.3	0.14	6.30	2.43	2.00	Q ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	5.16	5.16	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	5.17	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	4.87	4.87	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	5.16	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	5.16	5.16	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.17	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	5.12	5.12	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.13	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	5.12	5.12	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	5.12	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	5.97	5.97	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	6.23	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	5.94	5.94	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	5.97	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	5.33	5.33	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	5.94	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	5.12	5.12	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	5.33	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	4.87	4.87	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	5.12	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.69	4.69	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	4.87	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	4.90	4.90	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.92	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	4.88	4.88	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	4.90	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	4.87	4.87	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	4.88	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.48	4.48	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	4.69	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	3.97	3.97	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	4.48	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.75	3.75	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	3.97	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.70	3.70	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	3.75	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.67	3.67	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	3.70	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.60	3.60	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	3.67	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.53	3.53	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	3.60	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.39	3.39	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	3.53	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.29	3.29	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	3.39	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.20**	**3.20**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**3.29**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.69	4.81	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.82	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.48	4.68	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	4.70	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.69	4.69	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	4.77	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.48	4.48	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	4.55	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.75	3.75	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	3.79	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.67	3.67	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.69	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.53	3.53	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	3.58	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.53	3.53	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.55	10.00	HGL ok
P-165	DI-165	DI-166	1.20	3.87	3.87	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.88	6.14	HGL ok
P-166	DI-166	DI-167	1.20	3.84	3.84	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.87	6.26	HGL ok
P-167	DI-167	DI-168	1.60	3.82	3.82	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	3.84	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.75	3.75	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	3.82	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	3.82	3.82	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.83	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.47	4.96	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.98	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.34	4.34	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	4.47	10.79	HGL ok
P-171	DI-171	DI-173	1.20	4.21	4.21	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	4.34	10.30	HGL ok
P-173	DI-173	DI-174	1.60	4.05	4.05	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	4.21	10.30	HGL ok
P-174	DI-174	DI-175	1.60	3.93	3.93	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	4.05	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.67	3.67	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	3.93	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	3.93	3.93	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	3.94	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	4.27	4.47	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	4.21	4.21	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	4.27	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.70	3.70	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.70	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.64	3.64	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.64	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.63	3.63	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.64	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.61	3.61	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	3.63	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.60	3.60	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	3.61	11.82	HGL ok
P-182	DI-182	DI-186	1.20	3.92	5.05	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	4.07	4.83	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.54	5.35	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	4.07	4.53	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	4.54	11.91	HGL ok
P-185	DI-185	DI-186	1.20	3.92	3.92	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	4.07	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.77	3.77	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	3.92	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	4.00	4.17	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.19	10.00	HGL ok
P-187	DI-187	DI-188	1.20	4.00	4.69	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	4.00	4.00	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	4.00	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.77	3.77	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	4.00	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.60	3.60	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	3.77	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.49	4.63	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	4.67	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.39	3.39	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	3.49	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	5.36	5.36	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	5.37	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	5.07	5.07	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	5.36	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	5.36	5.36	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.37	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	5.32	5.32	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.33	7.51	HGL ok
P-201	EXMH-201	A1-MH-203	1.00	5.32	5.32	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	5.32	8.31	HGL ok
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	6.17	6.17	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	6.43	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	6.14	6.14	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	6.17	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	5.53	5.53	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	6.14	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	5.32	5.32	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	5.53	7.82	HGL ok
A1-P-204	A1-MH-204	CRB-MH-67	1.20	5.07	5.07	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	5.32	8.02	HGL ok
A1-P-205	CRB-MH-67	CMH-1	1.20	4.89	4.89	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	5.07	7.07	HGL ok
MSS-P2	MSS-DI2	MSS-DI1	1.00	5.10	5.10	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.12	7.27	HGL ok
MSS-P1	MSS-DI1	EXMH	1.00	5.08	5.08	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	5.10	6.56	HGL ok
A1-P-203	EX MH	MH-CRB-67	1.20	5.07	5.07	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	5.08	6.62	HGL ok
A1-P-206	CMH-1	A1-DI-207	1.60	4.68	4.68	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	4.89	6.63	HGL ok
A1-P-207	A1-DI-207	A1-DI-208	1.60	4.17	4.17	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	4.68	6.26	HGL ok
A1-P-208	A1-DI-208	A1-DI-209	2.40	3.95	3.95	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	4.17	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	3.90	3.90	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	3.95	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	3.87	3.87	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	3.90	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	3.80	3.80	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	3.87	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	3.73	3.73	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	3.80	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	3.59	3.59	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	3.73	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	3.49	3.49	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	3.59	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**3.40**	**3.40**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**3.49**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	4.89	4.89	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.89	7.17	HGL ok
MSS-P3 B	DI-161	MSS-DI13	1.00	4.68	4.68	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	4.70	6.88	HGL ok
P-160	DI-160	CMH-1	0.53	4.89	4.89	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	4.97	6.26	HGL ok
A1 P-200	PARCEL J	A1-DI-207	1.20	4.68	4.68	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	4.75	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	3.95	3.95	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	3.99	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	3.87	3.87	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.89	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	3.73	3.73	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	3.78	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	3.73	3.73	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.75	10.00	HGL ok
P-165	DI-165	DI-166	1.20	4.07	4.07	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.07	6.14	HGL ok
P-166	DI-166	DI-167	1.20	4.04	4.04	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	4.07	6.26	HGL ok
P-167	DI-167	DI-168	1.60	4.02	4.02	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	4.04	7.12	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 500

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	3.95	3.95	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	4.02	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	4.02	4.02	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.03	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	4.67	4.96	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.98	10.00	HGL ok
P-170	DI-170	DI-171	1.20	4.54	4.54	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	4.67	10.79	HGL ok
P-171	DI-171	DI-173	1.20	4.41	4.41	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	4.54	10.30	HGL ok
P-173	DI-173	DI-174	1.60	4.25	4.25	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	4.41	10.30	HGL ok
P-174	DI-174	DI-175	1.60	4.13	4.13	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	4.25	11.19	HGL ok
P-175	DI-175	DI-211	1.60	3.87	3.87	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	4.13	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	4.13	4.13	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.14	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	4.47	4.47	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	4.41	4.41	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	4.47	10.79	HGL ok
P-169	DI-169	MH-210	1.20	3.90	3.90	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.90	10.25	HGL ok
P-178	DI-178	DI-179	1.20	3.84	3.84	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.84	11.90	HGL ok
P-179	DI-179	DI-180	1.20	3.83	3.83	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	3.84	11.68	HGL ok
P-180	DI-180	DI-181	1.20	3.81	3.81	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	3.83	11.68	HGL ok
P-181	DI-181	DI-212	1.20	3.80	3.80	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	3.81	11.82	HGL ok
P-182	DI-182	DI-186	1.20	4.12	5.05	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	4.27	4.83	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.84	10.00	HGL ok
P-183	DI-183	DI-184	1.20	4.54	5.35	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	11.58	HGL ok
P-184	DI-184	DI-185	1.20	4.27	4.53	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	4.54	11.91	HGL ok
P-185	DI-185	DI-186	1.20	4.12	4.12	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	4.27	12.23	HGL ok
P-186	DI-186	DI-190	1.20	3.97	3.97	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	4.12	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	4.20	4.20	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.21	10.00	HGL ok
P-187	DI-187	DI-188	1.20	4.20	4.69	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.69	11.58	HGL ok
P-188	DI-188	DI-189	1.20	4.20	4.20	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	4.20	11.91	HGL ok
P-189	DI-189	DI-190	1.20	3.97	3.97	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	4.20	12.23	HGL ok
P-190	DI-190	DI-191	1.20	3.80	3.80	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	3.97	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	3.69	4.63	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	4.67	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	3.59	3.59	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	3.69	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = 0.002*O*V_o^2/2g to H	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	8.86	8.86	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	8.87	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	8.57	8.57	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	8.86	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	8.86	8.86	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.87	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	8.82	8.82	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.83	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	8.82	8.82	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	8.82	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	9.67	9.67	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	9.93	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	9.64	9.64	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.67	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.03	9.03	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	9.64	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	8.82	8.82	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	9.03	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	8.57	8.57	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	8.82	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.39	8.39	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	8.57	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	8.60	8.60	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.62	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	8.58	8.58	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	8.60	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	8.57	8.57	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	8.58	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.18	8.18	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	8.39	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	7.67	7.67	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	8.18	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.45	7.45	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	7.67	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.40	7.40	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	7.45	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.37	7.37	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	7.40	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.30	7.30	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	7.37	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.23	7.23	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	7.30	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.09	7.09	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	7.23	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.99	6.99	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	7.09	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**6.90**	**6.90**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**6.99**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.39	8.39	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.39	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.18	8.18	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	8.20	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.39	8.39	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	8.47	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.18	8.18	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.25	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.45	7.45	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	7.49	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.37	7.37	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.39	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.23	7.23	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	7.28	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.23	7.23	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.25	10.00	HGL ok
P-165	DI-165	DI-166	1.20	7.57	7.57	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.57	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	7.54	7.54	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.57	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	7.52	7.52	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	7.54	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.45	7.45	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	7.52	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	7.52	7.52	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.53	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.17	8.17	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.19	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.04	8.04	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	8.17	10.79	HGL ok
P-171	DI-171	DI-173	1.20	7.91	7.91	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	8.04	10.30	HGL ok
P-173	DI-173	DI-174	1.60	7.75	7.75	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	7.91	10.30	HGL ok
P-174	DI-174	DI-175	1.60	7.63	7.63	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	7.75	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.37	7.37	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	7.63	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	7.63	7.63	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.64	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.97	7.97	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.98	10.00	HGL ok
P-172	DI-172	DI-173	1.20	7.91	7.91	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	7.97	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.40	7.40	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.40	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.34	7.34	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.34	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.33	7.33	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.34	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.31	7.31	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	7.33	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.30	7.30	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	7.31	11.82	HGL ok
P-182	DI-182	DI-186	1.20	7.62	7.62	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.62	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	7.77	7.77	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.78	10.00	HGL ok
P-183	DI-183	DI-184	1.20	7.77	7.77	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.78	11.58	HGL ok
P-184	DI-184	DI-185	1.20	7.77	7.77	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	7.77	11.91	HGL ok
P-185	DI-185	DI-186	1.20	7.62	7.62	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	7.77	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.47	7.47	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	7.62	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	7.70	7.70	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.71	10.00	HGL ok
P-187	DI-187	DI-188	1.20	7.70	7.70	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.71	11.58	HGL ok
P-188	DI-188	DI-189	1.20	7.70	7.70	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	7.70	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.47	7.47	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	7.70	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.30	7.30	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	7.47	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.19	7.19	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	7.22	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.09	7.09	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	7.19	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.36	9.36	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	9.37	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.07	9.07	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	9.36	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.36	9.36	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.37	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.32	9.32	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.33	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.32	9.32	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	9.32	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.17	10.17	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	10.43	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.14	10.14	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.17	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.53	9.53	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	10.14	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.32	9.32	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	9.53	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.07	9.07	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	9.32	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	8.89	8.89	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	9.07	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.10	9.10	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.12	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.08	9.08	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	9.10	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.07	9.07	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	9.08	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	8.68	8.68	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	8.89	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.17	8.17	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	8.68	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	7.95	7.95	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	8.17	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	7.90	7.90	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	7.95	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	7.87	7.87	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	7.90	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	7.80	7.80	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	7.87	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	7.73	7.73	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	7.80	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.59	7.59	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	7.73	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.49	7.49	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	7.59	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.40**	**7.40**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**7.49**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	8.89	8.89	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.89	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	8.68	8.68	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	8.70	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	8.89	8.89	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	8.97	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	8.68	8.68	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.75	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	7.95	7.95	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	7.99	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	7.87	7.87	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.89	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	7.73	7.73	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	7.78	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	7.73	7.73	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.75	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.07	8.07	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.07	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.04	8.04	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.07	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.02	8.02	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.04	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 500

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	7.95	7.95	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	8.02	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.02	8.02	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.03	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	8.67	8.67	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.69	10.00	HGL ok
P-170	DI-170	DI-171	1.20	8.54	8.54	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	8.67	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.41	8.41	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	8.54	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.25	8.25	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	8.41	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.13	8.13	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	8.25	11.19	HGL ok
P-175	DI-175	DI-211	1.60	7.87	7.87	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	8.13	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.13	8.13	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.14	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.47	8.47	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.48	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.41	8.41	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	8.47	10.79	HGL ok
P-169	DI-169	MH-210	1.20	7.90	7.90	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.90	10.25	HGL ok
P-178	DI-178	DI-179	1.20	7.84	7.84	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.84	11.90	HGL ok
P-179	DI-179	DI-180	1.20	7.83	7.83	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	7.84	11.68	HGL ok
P-180	DI-180	DI-181	1.20	7.81	7.81	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	7.83	11.68	HGL ok
P-181	DI-181	DI-212	1.20	7.80	7.80	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	7.81	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.12	8.12	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.12	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.27	8.27	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.28	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.27	8.27	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.28	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.27	8.27	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	8.27	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.12	8.12	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	8.27	12.23	HGL ok
P-186	DI-186	DI-190	1.20	7.97	7.97	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	8.12	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.20	8.20	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.21	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.20	8.20	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.21	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.20	8.20	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.20	11.91	HGL ok
P-189	DI-189	DI-190	1.20	7.97	7.97	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	8.20	12.23	HGL ok
P-190	DI-190	DI-191	1.20	7.80	7.80	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	7.97	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	7.69	7.69	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	7.72	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.59	7.59	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	7.69	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	9.76	9.76	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	9.77	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.47	9.47	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	9.76	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	9.76	9.76	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.77	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	9.72	9.72	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.73	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	9.72	9.72	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	9.72	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	10.57	10.57	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	10.83	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	10.54	10.54	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.57	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	9.93	9.93	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	10.54	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	9.72	9.72	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	9.93	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.47	9.47	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	9.72	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.29	9.29	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	9.47	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	9.50	9.50	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.52	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.48	9.48	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	9.50	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.47	9.47	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	9.48	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.08	9.08	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	9.29	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	8.57	8.57	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	9.08	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.35	8.35	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	8.57	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.30	8.30	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	8.35	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.27	8.27	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	8.30	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.20	8.20	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	8.27	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.13	8.13	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	8.20	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	7.99	7.99	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	8.13	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	7.89	7.89	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	7.99	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**7.80**	**7.80**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**7.89**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.29	9.29	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.29	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.08	9.08	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	9.10	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.29	9.29	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	9.37	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.08	9.08	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.15	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	8.35	8.35	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	8.39	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.27	8.27	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.29	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.13	8.13	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	8.18	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.13	8.13	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.15	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.47	8.47	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.47	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.44	8.44	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.47	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.42	8.42	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.44	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.35	8.35	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	8.42	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.42	8.42	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.43	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	9.07	9.07	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.09	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	8.94	8.94	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	9.07	10.79	HGL ok
P-171	DI-171	DI-173	1.20	8.81	8.81	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	8.94	10.30	HGL ok
P-173	DI-173	DI-174	1.60	8.65	8.65	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	8.81	10.30	HGL ok
P-174	DI-174	DI-175	1.60	8.53	8.53	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	8.65	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.27	8.27	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	8.53	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	8.53	8.53	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.54	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	8.87	8.87	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.88	10.00	HGL ok
P-172	DI-172	DI-173	1.20	8.81	8.81	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	8.87	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.30	8.30	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.30	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.24	8.24	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.24	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.23	8.23	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.24	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.21	8.21	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	8.23	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.20	8.20	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	8.21	11.82	HGL ok
P-182	DI-182	DI-186	1.20	8.52	8.52	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.52	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	8.67	8.67	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.68	10.00	HGL ok
P-183	DI-183	DI-184	1.20	8.67	8.67	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.68	11.58	HGL ok
P-184	DI-184	DI-185	1.20	8.67	8.67	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	8.67	11.91	HGL ok
P-185	DI-185	DI-186	1.20	8.52	8.52	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	8.67	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.37	8.37	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	8.52	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	8.60	8.60	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.61	10.00	HGL ok
P-187	DI-187	DI-188	1.20	8.60	8.60	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.61	11.58	HGL ok
P-188	DI-188	DI-189	1.20	8.60	8.60	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.60	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.37	8.37	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	8.60	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.20	8.20	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	8.37	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.09	8.09	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	8.12	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	7.99	7.99	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	8.09	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.26	10.26	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	10.27	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	9.97	9.97	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	10.26	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.26	10.26	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.27	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.22	10.22	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.23	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.22	10.22	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	10.22	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.07	11.07	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	11.33	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.04	11.04	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.07	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	10.43	10.43	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	11.04	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.22	10.22	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	10.43	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	9.97	9.97	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	10.22	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	9.79	9.79	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	9.97	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.00	10.00	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.02	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	9.98	9.98	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	10.00	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	9.97	9.97	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	9.98	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	9.58	9.58	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	9.79	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.07	9.07	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	9.58	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	8.85	8.85	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	9.07	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	8.80	8.80	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	8.85	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	8.77	8.77	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	8.80	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	8.70	8.70	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	8.77	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	8.63	8.63	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	8.70	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	8.49	8.49	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	8.63	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	8.39	8.39	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	8.49	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**8.30**	**8.30**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**8.39**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	9.79	9.79	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.79	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	9.58	9.58	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	9.60	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	9.79	9.79	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	9.87	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	9.58	9.58	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.65	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	8.85	8.85	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	8.89	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	8.77	8.77	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.79	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	8.63	8.63	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	8.68	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	8.63	8.63	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.65	10.00	HGL ok
P-165	DI-165	DI-166	1.20	8.97	8.97	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.97	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	8.94	8.94	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.97	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	8.92	8.92	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	8.94	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 500

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	8.85	8.85	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	8.92	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	8.92	8.92	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.93	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	9.57	9.57	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.59	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	9.44	9.44	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	9.57	10.79	HGL ok
P-171	DI-171	DI-173	1.20	9.31	9.31	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	9.44	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.15	9.15	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	9.31	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.03	9.03	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	9.15	11.19	HGL ok
P-175	DI-175	DI-211	1.60	8.77	8.77	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	9.03	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.03	9.03	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.04	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	9.37	9.37	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.38	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	9.31	9.31	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	9.37	10.79	HGL ok
P-169	DI-169	MH-210	1.20	8.80	8.80	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.80	10.25	HGL ok
P-178	DI-178	DI-179	1.20	8.74	8.74	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.74	11.90	HGL ok
P-179	DI-179	DI-180	1.20	8.73	8.73	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	8.74	11.68	HGL ok
P-180	DI-180	DI-181	1.20	8.71	8.71	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	8.73	11.68	HGL ok
P-181	DI-181	DI-212	1.20	8.70	8.70	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	8.71	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.02	9.02	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.02	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.17	9.17	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.18	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.17	9.17	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.18	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.17	9.17	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	9.17	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.02	9.02	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	9.17	12.23	HGL ok
P-186	DI-186	DI-190	1.20	8.87	8.87	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	9.02	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.10	9.10	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.11	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.10	9.10	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.11	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.10	9.10	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.10	11.91	HGL ok
P-189	DI-189	DI-190	1.20	8.87	8.87	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	9.10	12.23	HGL ok
P-190	DI-190	DI-191	1.20	8.70	8.70	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	8.87	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	8.59	8.59	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	8.62	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	8.49	8.49	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	8.59	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = 0.002*O*V_o^2/2g to H.	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	10.96	10.96	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	10.97	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	10.67	10.67	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	10.96	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	10.96	10.96	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.97	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	10.92	10.92	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.93	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	10.92	10.92	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	10.92	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	11.77	11.77	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	12.03	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	11.74	11.74	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.77	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.13	11.13	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	11.74	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	10.92	10.92	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	11.13	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	10.67	10.67	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	10.92	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.49	10.49	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	10.67	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	10.70	10.70	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.72	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	10.68	10.68	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	10.70	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	10.67	10.67	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	10.68	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.28	10.28	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	10.49	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	9.77	9.77	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	10.28	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.55	9.55	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	9.77	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.50	9.50	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	9.55	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.47	9.47	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	9.50	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.40	9.40	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	9.47	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.33	9.33	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	9.40	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.19	9.19	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	9.33	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.09	9.09	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	9.19	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.00**	**9.00**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**9.09**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.49	10.49	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.49	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.28	10.28	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	10.30	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.49	10.49	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	10.57	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.28	10.28	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.35	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.55	9.55	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	9.59	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.47	9.47	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.49	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.33	9.33	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	9.38	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.33	9.33	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.35	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	9.67	9.67	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.67	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	9.64	9.64	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.67	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	9.62	9.62	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	9.64	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.55	9.55	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	9.62	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	9.62	9.62	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.63	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.27	10.27	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.29	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.14	10.14	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	10.27	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.01	10.01	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	10.14	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	9.85	9.85	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	10.01	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	9.73	9.73	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	9.85	11.19	HGL ok
P-175	DI-175	DI-211	1.60	9.47	9.47	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	9.73	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	9.73	9.73	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.74	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.07	10.07	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.08	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.01	10.01	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	10.07	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.50	9.50	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.50	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.44	9.44	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.44	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.43	9.43	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.44	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.41	9.41	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	9.43	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.40	9.40	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.41	11.82	HGL ok
P-182	DI-182	DI-186	1.20	9.72	9.72	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.72	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	9.87	9.87	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.88	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	9.87	9.87	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.88	11.58	HGL ok
P-184	DI-184	DI-185	1.20	9.87	9.87	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	9.87	11.91	HGL ok
P-185	DI-185	DI-186	1.20	9.72	9.72	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	9.87	12.23	HGL ok
P-186	DI-186	DI-190	1.20	9.57	9.57	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	9.72	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	9.80	9.80	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.81	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	9.80	9.80	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.81	11.58	HGL ok
P-188	DI-188	DI-189	1.20	9.80	9.80	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.80	11.91	HGL ok
P-189	DI-189	DI-190	1.20	9.57	9.57	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	9.80	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.40	9.40	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	9.57	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.29	9.29	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.32	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.19	9.19	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	9.29	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.46	11.46	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.47	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.17	11.17	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	11.46	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.46	11.46	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.47	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.42	11.42	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.43	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.42	11.42	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	11.42	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.27	12.27	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	12.53	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.24	12.24	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.27	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.63	11.63	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	12.24	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.42	11.42	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	11.63	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.17	11.17	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	11.42	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.99	10.99	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	11.17	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.20	11.20	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.22	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.18	11.18	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	11.20	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.17	11.17	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	11.18	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.78	10.78	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	10.99	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.27	10.27	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	10.78	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.05	10.05	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	10.27	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.00	10.00	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	10.05	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.97	9.97	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	10.00	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.90	9.90	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	9.97	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.83	9.83	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	9.90	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.69	9.69	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	9.83	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.59	9.59	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	9.69	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.50**	**9.50**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**9.59**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.99	10.99	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.99	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.78	10.78	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	10.80	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.99	10.99	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	11.07	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.78	10.78	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.85	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.05	10.05	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	10.09	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.97	9.97	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.99	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.83	9.83	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	9.88	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.83	9.83	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.85	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.17	10.17	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.17	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.14	10.14	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.17	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.12	10.12	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.14	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.05	10.05	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	10.12	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.12	10.12	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.13	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.77	10.77	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.79	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.64	10.64	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	10.77	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.51	10.51	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	10.64	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.35	10.35	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	10.51	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.23	10.23	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	10.35	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	9.97	9.97	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	10.23	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.23	10.23	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.24	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.57	10.57	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.58	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.51	10.51	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	10.57	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.00	10.00	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.00	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.94	9.94	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.94	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.93	9.93	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.94	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.91	9.91	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	9.93	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.90	9.90	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.91	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.22	10.22	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.22	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.37	10.37	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.38	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.37	10.37	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.38	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.37	10.37	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	10.37	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.22	10.22	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	10.37	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.07	10.07	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	10.22	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.30	10.30	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.31	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.30	10.30	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.31	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.30	10.30	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.30	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.07	10.07	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	10.30	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.90	9.90	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	10.07	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.79	9.79	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.82	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.69	9.69	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	9.79	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.76	12.76	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.77	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.47	12.47	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	12.76	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.76	12.76	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.77	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.72	12.72	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.73	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.72	12.72	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	12.72	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.57	13.57	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	13.83	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.54	13.54	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.57	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.93	12.93	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	13.54	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.72	12.72	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	12.93	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.47	12.47	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	12.72	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.29	12.29	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	12.47	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.50	12.50	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.52	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.48	12.48	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	12.50	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.47	12.47	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	12.48	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.08	12.08	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	12.29	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.57	11.57	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	12.08	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.35	11.35	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	11.57	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.30	11.30	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	11.35	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.27	11.27	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	11.30	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.20	11.20	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	11.27	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.13	11.13	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	11.20	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.99	10.99	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	11.13	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.89	10.89	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	10.99	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.80**	**10.80**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**10.89**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.29	12.29	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.29	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.08	12.08	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	12.10	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.29	12.29	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	12.37	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.08	12.08	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.15	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.35	11.35	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	11.39	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.27	11.27	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.29	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.13	11.13	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	11.18	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.13	11.13	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.15	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.47	11.47	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.47	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.44	11.44	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.47	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.42	11.42	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.44	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 500 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.35	11.35	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	11.42	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.42	11.42	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.43	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.07	12.07	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.09	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.94	11.94	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	12.07	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.81	11.81	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	11.94	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.65	11.65	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	11.81	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.53	11.53	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	11.65	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.27	11.27	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	11.53	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.53	11.53	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.54	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.87	11.87	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.88	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.81	11.81	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	11.87	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.30	11.30	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.30	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.24	11.24	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.24	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.23	11.23	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.24	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.21	11.21	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	11.23	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.20	11.20	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.21	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.52	11.52	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.52	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.67	11.67	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.68	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.67	11.67	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.68	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.67	11.67	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	11.67	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.52	11.52	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	11.67	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.37	11.37	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	11.52	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.60	11.60	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.61	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.60	11.60	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.61	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.60	11.60	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.60	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.37	11.37	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	11.60	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.20	11.20	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	11.37	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.09	11.09	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.12	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.99	10.99	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	11.09	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.70	7.70	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	7.71	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.41	7.41	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	7.70	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.70	7.70	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.71	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.66	7.66	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.67	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.66	7.66	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	7.66	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.51	8.51	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	8.77	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.48	8.48	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.51	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	7.87	7.87	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	8.48	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.66	7.66	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	7.87	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.41	7.41	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	7.66	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.23	7.23	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	7.41	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.44	7.44	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.46	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.42	7.42	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	7.44	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.41	7.41	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	7.42	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.02	7.02	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	7.23	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.51	6.51	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	7.02	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.29	6.29	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	6.51	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.24	6.24	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	6.29	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.21	6.21	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	6.24	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.14	6.14	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	6.21	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.07	6.07	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	6.14	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	5.93	5.93	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	6.07	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	5.83	5.83	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	5.93	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.74**	**5.74**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**5.83**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.23	7.23	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.23	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.02	7.02	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	7.04	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.23	7.23	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	7.31	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.02	7.02	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	7.09	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.29	6.29	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	6.33	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.21	6.21	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.23	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.07	6.07	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	6.12	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.07	6.07	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.09	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.41	6.41	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.41	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.38	6.38	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.41	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.36	6.36	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.38	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.29	6.29	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	6.36	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.36	6.36	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.37	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.01	7.01	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.03	10.00	HGL ok
P-170	DI-170	DI-171	1.20	6.88	6.88	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	7.01	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.75	6.75	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	6.88	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.59	6.59	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	6.75	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.47	6.47	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	6.59	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.21	6.21	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	6.47	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.47	6.47	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.48	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	6.81	6.81	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.82	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.75	6.75	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	6.81	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.24	6.24	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.24	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.18	6.18	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.18	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.17	6.17	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.18	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.15	6.15	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	6.17	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.14	6.14	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	6.15	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.46	6.46	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.46	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.61	6.61	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.62	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.61	6.61	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.62	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.61	6.61	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	6.61	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.46	6.46	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	6.61	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.31	6.31	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	6.46	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.54	6.54	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.55	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.54	6.54	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.55	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.54	6.54	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.54	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.31	6.31	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	6.54	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.14	6.14	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	6.31	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.03	6.03	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	6.06	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	5.93	5.93	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	6.03	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	7.90	7.90	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	7.91	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	7.61	7.61	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	7.90	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	7.90	7.90	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.91	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	7.86	7.86	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.87	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	7.86	7.86	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	7.86	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	8.71	8.71	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	8.97	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	8.68	8.68	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.71	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	8.07	8.07	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	8.68	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	7.86	7.86	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	8.07	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	7.61	7.61	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	7.86	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	7.43	7.43	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	7.61	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	7.64	7.64	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.66	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	7.62	7.62	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	7.64	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	7.61	7.61	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	7.62	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	7.22	7.22	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	7.43	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	6.71	6.71	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	7.22	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	6.49	6.49	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	6.71	7.73	HGL ok
A1-P-209	A1-DI-209	A1-MH-210	3.20	6.44	6.44	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	6.49	9.00	HGL ok
A1-P-210	A1-MH-210	A1-DI-211	3.20	6.41	6.41	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	6.44	10.00	HGL ok
A1-P-211	A1-DI-211	A1-DI-212	3.20	6.34	6.34	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	6.41	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	6.27	6.27	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	6.34	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	6.13	6.13	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	6.27	10.50	HGL ok
A1-P-214	A1-DI-214	A1-DI-215	3.20	6.03	6.03	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	6.13	10.50	HGL ok
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**5.94**	**5.94**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**6.03**	**10.50**	**HGL ok**
MSS-P3 A	MSS-DI14	DI-161	1.00	7.43	7.43	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.43	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	7.22	7.22	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	7.24	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	7.43	7.43	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	7.51	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	7.22	7.22	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	7.29	10.00	HGL ok
P-336	PARCEL J	A1-DI-209	1.20	6.49	6.49	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	6.53	10.00	HGL ok
P-337	PARCEL J	A1-DI-211	1.20	6.41	6.41	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.43	10.00	HGL ok
P-335	PARCEL N	A1-DI-213	1.20	6.27	6.27	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	6.32	10.00	HGL ok
P-340	PARCEL K	A1-DI-213	1.20	6.27	6.27	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.29	10.00	HGL ok
P-165	DI-165	DI-166	1.20	6.61	6.61	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.61	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	6.58	6.58	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.61	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	6.56	6.56	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	6.58	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	6.49	6.49	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	6.56	9.01	HGL ok
P-327	PARCEL L	DI-168	1.20	6.56	6.56	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.57	10.00	HGL ok
P-326	PARCEL L	DI-170	1.20	7.21	7.21	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.23	10.00	HGL ok
P-170	DI-170	DI-171	1.20	7.08	7.08	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	7.21	10.79	HGL ok
P-171	DI-171	DI-173	1.20	6.95	6.95	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	7.08	10.30	HGL ok
P-173	DI-173	DI-174	1.60	6.79	6.79	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	6.95	10.30	HGL ok
P-174	DI-174	DI-175	1.60	6.67	6.67	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	6.79	11.19	HGL ok
P-175	DI-175	DI-211	1.60	6.41	6.41	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	6.67	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	6.67	6.67	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.68	10.00	HGL ok
P-328	PARCEL M	DI-172	1.20	7.01	7.01	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.02	10.00	HGL ok
P-172	DI-172	DI-173	1.20	6.95	6.95	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	7.01	10.79	HGL ok
P-169	DI-169	MH-210	1.20	6.44	6.44	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.44	10.25	HGL ok
P-178	DI-178	DI-179	1.20	6.38	6.38	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.38	11.90	HGL ok
P-179	DI-179	DI-180	1.20	6.37	6.37	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	6.38	11.68	HGL ok
P-180	DI-180	DI-181	1.20	6.35	6.35	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	6.37	11.68	HGL ok
P-181	DI-181	DI-212	1.20	6.34	6.34	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	6.35	11.82	HGL ok
P-182	DI-182	DI-186	1.20	6.66	6.66	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.66	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	6.81	6.81	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.82	10.00	HGL ok
P-183	DI-183	DI-184	1.20	6.81	6.81	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.82	11.58	HGL ok
P-184	DI-184	DI-185	1.20	6.81	6.81	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	6.81	11.91	HGL ok
P-185	DI-185	DI-186	1.20	6.66	6.66	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	6.81	12.23	HGL ok
P-186	DI-186	DI-190	1.20	6.51	6.51	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	6.66	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	6.74	6.74	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.75	10.00	HGL ok
P-187	DI-187	DI-188	1.20	6.74	6.74	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.75	11.58	HGL ok
P-188	DI-188	DI-189	1.20	6.74	6.74	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.74	11.91	HGL ok
P-189	DI-189	DI-190	1.20	6.51	6.51	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	6.74	12.23	HGL ok
P-190	DI-190	DI-191	1.20	6.34	6.34	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	6.51	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	6.23	6.23	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	6.26	10.00	HGL ok
P-195	DI-195	A1-DI-214	1.20	6.13	6.13	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	6.23	10.50	HGL ok

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.40	11.40	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.41	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.11	11.11	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	11.40	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.40	11.40	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.41	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.36	11.36	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.37	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.36	11.36	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	11.36	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.21	12.21	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	12.47	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.18	12.18	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.21	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	11.57	11.57	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	12.18	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.36	11.36	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	11.57	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.11	11.11	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	11.36	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	10.93	10.93	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	11.11	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.14	11.14	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.16	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.12	11.12	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	11.14	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.11	11.11	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	11.12	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	10.72	10.72	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	10.93	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.21	10.21	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	10.72	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	9.99	9.99	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	10.21	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	9.94	9.94	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	9.99	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	9.91	9.91	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	9.94	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	9.84	9.84	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	9.91	11.32	HGL ok
A1-P-212	A1-DI-212	A1-DI-213	3.20	9.77	9.77	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	9.84	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	9.63	9.63	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	9.77	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	9.53	9.53	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	9.63	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.44**	**9.44**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**9.53**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	10.93	10.93	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.93	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	10.72	10.72	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	10.74	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	10.93	10.93	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	11.01	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	10.72	10.72	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.79	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	9.99	9.99	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	10.03	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	9.91	9.91	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.93	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	9.77	9.77	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	9.82	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	9.77	9.77	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.79	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.11	10.11	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.11	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.08	10.08	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.11	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.06	10.06	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.08	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ____ of ____
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077.001
Segment: Jones Street Outfall — Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	9.99	9.99	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	10.06	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.06	10.06	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.07	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	10.71	10.71	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.73	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	10.58	10.58	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	10.71	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.45	10.45	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	10.58	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.29	10.29	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	10.45	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.17	10.17	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	10.29	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	9.91	9.91	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	10.17	11.31	HGL ok
P-331	PARCEL M	DI-175	1.20	10.17	10.17	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.18	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	10.51	10.51	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.52	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.45	10.45	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	10.51	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	9.94	9.94	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.94	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	9.88	9.88	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.88	11.90	HGL ok
P-179	DI-179	DI-180	1.20	9.87	9.87	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	9.88	11.68	HGL ok
P-180	DI-180	DI-181	1.20	9.85	9.85	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	9.87	11.68	HGL ok
P-181	DI-181	DI-212	1.20	9.84	9.84	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	9.85	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.16	10.16	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.16	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.31	10.31	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.32	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.31	10.31	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	11.58	HGL ok
P-184	DI-184	DI-185	1.20	10.31	10.31	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	10.31	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.16	10.16	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	10.31	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.01	10.01	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	10.16	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.24	10.24	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.25	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.24	10.24	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.25	11.58	HGL ok
P-188	DI-188	DI-189	1.20	10.24	10.24	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.24	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.01	10.01	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	10.24	12.23	HGL ok
P-190	DI-190	DI-191	1.20	9.84	9.84	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	10.01	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	9.73	9.73	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.76	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	9.63	9.63	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	9.73	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	11.90	11.90	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.91	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	11.61	11.61	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	11.90	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	11.90	11.90	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.91	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	11.86	11.86	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.87	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	11.86	11.86	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	11.86	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	12.71	12.71	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	12.97	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	12.68	12.68	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.71	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.07	12.07	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	12.68	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	11.86	11.86	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	12.07	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	11.61	11.61	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	11.86	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.43	11.43	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	11.61	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	11.64	11.64	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.66	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	11.62	11.62	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	11.64	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	11.61	11.61	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	11.62	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.22	11.22	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	11.43	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	10.71	10.71	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	11.22	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.49	10.49	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	10.71	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.44	10.44	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	10.49	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.41	10.41	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	10.44	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.34	10.34	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	10.41	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.27	10.27	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	10.34	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.13	10.13	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	10.27	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.03	10.03	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	10.13	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**9.94**	**9.94**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**10.03**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.43	11.43	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.43	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.22	11.22	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	11.24	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.43	11.43	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	11.51	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.22	11.22	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	11.29	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.49	10.49	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	10.53	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.41	10.41	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.43	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.27	10.27	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	10.32	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.27	10.27	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.29	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	10.61	10.61	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.61	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.58	10.58	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.61	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.56	10.56	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.58	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.49	10.49	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	10.56	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.56	10.56	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.57	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.21	11.21	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.23	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.08	11.08	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	11.21	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	10.95	10.95	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	11.08	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	10.79	10.79	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	10.95	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	10.67	10.67	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	10.79	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.41	10.41	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	10.67	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	10.67	10.67	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.68	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.01	11.01	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.02	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	10.95	10.95	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	11.01	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.44	10.44	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.44	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.38	10.38	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.38	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.37	10.37	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.38	11.68	HGL ok
P-180	DI-180	DI-181	1.20	10.35	10.35	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	10.37	11.68	HGL ok
P-181	DI-181	DI-212	1.20	10.34	10.34	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	10.35	11.82	HGL ok
P-182	DI-182	DI-186	1.20	10.66	10.66	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.66	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	10.81	10.81	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.82	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	10.81	10.81	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.82	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	10.81	10.81	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	10.81	11.91	HGL ok
P-185	DI-185	DI-186	1.20	10.66	10.66	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	10.81	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.51	10.51	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	10.66	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	10.74	10.74	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.75	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	10.74	10.74	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	10.74	10.74	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.74	11.91	HGL ok
P-189	DI-189	DI-190	1.20	10.51	10.51	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	10.74	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.34	10.34	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	10.51	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.23	10.23	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	10.26	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.13	10.13	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	10.23	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ____ of ____
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077.001
Segment: Jones Street Outfall — Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.30	12.30	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.31	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.01	12.01	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	12.30	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.30	12.30	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.31	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.26	12.26	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.27	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.26	12.26	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	12.26	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.11	13.11	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	13.37	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.08	13.08	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.11	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.47	12.47	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	13.08	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.26	12.26	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	12.47	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.01	12.01	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	12.26	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	11.83	11.83	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	12.01	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.04	12.04	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.06	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.02	12.02	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	12.04	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.01	12.01	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	12.02	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	11.62	11.62	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	11.83	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.11	11.11	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	11.62	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	10.89	10.89	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	11.11	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	10.84	10.84	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	10.89	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	10.81	10.81	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	10.84	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	10.74	10.74	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	10.81	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	10.67	10.67	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	10.74	12.00	HGL ok
A1-P-213	A1-DI-213	A1-DI-214	3.20	10.53	10.53	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	10.67	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.43	10.43	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	10.53	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.34**	**10.34**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**10.43**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	11.83	11.83	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.83	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	11.62	11.62	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	11.64	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	11.83	11.83	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	11.91	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	11.62	11.62	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	11.69	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	10.89	10.89	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	10.93	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	10.81	10.81	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.83	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	10.67	10.67	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	10.72	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	10.67	10.67	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.69	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.01	11.01	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.01	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	10.98	10.98	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.01	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	10.96	10.96	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	10.98	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	10.89	10.89	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	10.96	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	10.96	10.96	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.97	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	11.61	11.61	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.63	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.48	11.48	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	11.61	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.35	11.35	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	11.48	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.19	11.19	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	11.35	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.07	11.07	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	11.19	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	10.81	10.81	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	11.07	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.07	11.07	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.08	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.41	11.41	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.42	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.35	11.35	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	11.41	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	10.84	10.84	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.84	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	10.78	10.78	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.78	11.90	HGL ok
P-179	DI-179	DI-180	1.20	10.77	10.77	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	10.78	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	10.75	10.75	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	10.77	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	10.74	10.74	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	10.75	11.82	HGL ok
P-182	DI-182	DI-186	1.20	11.06	11.06	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.06	12.11	HGL ok
P-338	PARCEL J	DI-185	1.20	11.21	11.21	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.22	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.21	11.21	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.22	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.21	11.21	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	11.21	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.06	11.06	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	11.21	12.23	HGL ok
P-186	DI-186	DI-190	1.20	10.91	10.91	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	11.06	12.36	HGL ok
P-339	PARCEL K	DI-189	1.20	11.14	11.14	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.15	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.14	11.14	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.15	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.14	11.14	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.14	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	10.91	10.91	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	11.14	12.23	HGL ok
P-190	DI-190	DI-191	1.20	10.74	10.74	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	10.91	12.33	HGL ok
P-341	PARCEL K	DI-195	1.20	10.63	10.63	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	10.66	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	10.53	10.53	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	10.63	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	12.80	12.80	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.81	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	12.51	12.51	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	12.80	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	12.80	12.80	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.81	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	12.76	12.76	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.77	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	12.76	12.76	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	12.76	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	13.61	13.61	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	13.87	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	13.58	13.58	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.61	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	12.97	12.97	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	13.58	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	12.76	12.76	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	12.97	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	12.51	12.51	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	12.76	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	12.33	12.33	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	12.51	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	12.54	12.54	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.56	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	12.52	12.52	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	12.54	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	12.51	12.51	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	12.52	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.12	12.12	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	12.33	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	11.61	11.61	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	12.12	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	11.39	11.39	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	11.61	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	11.34	11.34	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	11.39	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	11.31	11.31	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	11.34	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.24	11.24	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	11.31	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.17	11.17	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	11.24	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.03	11.03	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	11.17	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	10.93	10.93	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	11.03	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**10.84**	**10.84**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**10.93**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	12.33	12.33	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.33	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.12	12.12	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	12.14	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	12.33	12.33	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	12.41	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.12	12.12	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.19	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	11.39	11.39	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	11.43	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	11.31	11.31	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.33	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.17	11.17	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	11.22	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.17	11.17	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.19	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	11.51	11.51	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.51	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	11.48	11.48	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.51	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	11.46	11.46	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	11.48	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_o	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	11.39	11.39	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	11.46	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	11.46	11.46	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.47	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.11	12.11	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.13	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	11.98	11.98	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	12.11	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	11.85	11.85	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	11.98	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	11.69	11.69	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	11.85	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	11.57	11.57	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	11.69	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	11.31	11.31	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	11.57	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	11.57	11.57	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.58	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	11.91	11.91	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.92	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	11.85	11.85	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	11.91	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	11.34	11.34	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.34	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.28	11.28	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.28	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.27	11.27	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.28	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.25	11.25	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	11.27	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.24	11.24	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.25	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	11.56	11.56	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.56	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	11.71	11.71	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.72	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	11.71	11.71	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.72	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	11.71	11.71	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	11.71	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	11.56	11.56	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	11.71	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	11.41	11.41	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	11.56	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	11.64	11.64	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.65	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	11.64	11.64	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.65	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	11.64	11.64	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.64	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	11.41	11.41	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	11.64	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.24	11.24	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	11.41	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.13	11.13	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.16	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.03	11.03	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	11.13	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	13.50	13.50	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	13.51	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	13.21	13.21	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	13.50	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	13.50	13.50	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.51	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.46	13.46	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.47	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.46	13.46	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	13.46	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	14.31	14.31	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	14.57	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	14.28	14.28	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	14.31	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	13.67	13.67	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	14.28	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.46	13.46	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	13.67	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	13.21	13.21	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	13.46	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	13.03	13.03	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	13.21	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	13.24	13.24	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.26	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	13.22	13.22	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	13.24	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	13.21	13.21	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	13.22	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	12.82	12.82	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	13.03	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.31	12.31	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	12.82	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.09	12.09	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	12.31	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	12.04	12.04	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	12.09	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	12.01	12.01	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	12.04	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	11.94	11.94	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	12.01	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	11.87	11.87	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	11.94	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	11.73	11.73	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	11.87	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	11.63	11.63	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	11.73	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**11.54**	**11.54**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**11.63**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	13.03	13.03	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.03	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	12.82	12.82	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	12.84	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	13.03	13.03	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	13.11	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	12.82	12.82	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.89	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.09	12.09	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	12.13	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	12.01	12.01	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.03	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	11.87	11.87	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	11.92	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	11.87	11.87	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.89	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.21	12.21	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.21	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.18	12.18	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.21	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.16	12.16	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.18	7.12	HGL Too High!

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County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.09	12.09	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	12.16	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.16	12.16	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.17	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	12.81	12.81	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.83	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	12.68	12.68	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	12.81	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	12.55	12.55	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	12.68	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.39	12.39	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	12.55	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.27	12.27	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	12.39	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	12.01	12.01	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	12.27	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.27	12.27	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.28	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	12.61	12.61	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.62	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	12.55	12.55	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	12.61	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	12.04	12.04	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.04	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	11.98	11.98	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.98	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	11.97	11.97	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	11.98	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	11.95	11.95	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	11.97	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	11.94	11.94	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	11.95	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.26	12.26	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.26	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.41	12.41	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.42	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.41	12.41	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.42	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.41	12.41	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	12.41	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.26	12.26	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	12.41	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.11	12.11	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	12.26	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.34	12.34	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.35	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.34	12.34	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.35	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.34	12.34	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.34	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.11	12.11	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	12.34	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	11.94	11.94	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	12.11	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	11.83	11.83	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.86	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	11.73	11.73	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	11.83	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	14.00	14.00	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	14.01	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	13.71	13.71	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	14.00	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	14.00	14.00	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	14.01	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	13.96	13.96	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.97	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	13.96	13.96	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	13.96	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	14.81	14.81	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	15.07	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	14.78	14.78	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	14.81	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	14.17	14.17	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	14.78	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	13.96	13.96	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	14.17	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	13.71	13.71	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	13.96	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	13.53	13.53	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	13.71	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	13.74	13.74	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.76	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	13.72	13.72	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	13.74	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	13.71	13.71	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	13.72	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	13.32	13.32	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	13.53	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	12.81	12.81	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	13.32	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	12.59	12.59	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	12.81	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	12.54	12.54	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	12.59	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	12.51	12.51	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	12.54	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	12.44	12.44	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	12.51	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	12.37	12.37	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	12.44	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	12.23	12.23	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	12.37	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	12.13	12.13	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	12.23	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**12.04**	**12.04**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**12.13**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	13.53	13.53	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.53	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	13.32	13.32	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	13.34	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	13.53	13.53	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	13.61	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	13.32	13.32	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	13.39	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	12.59	12.59	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	12.63	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	12.51	12.51	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.53	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	12.37	12.37	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	12.42	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	12.37	12.37	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.39	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	12.71	12.71	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.71	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	12.68	12.68	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.71	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	12.66	12.66	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	12.68	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Jones Street Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 500

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: ____ of ____
Cm. No.: 20077.001

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_f	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	12.59	12.59	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	12.66	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	12.66	12.66	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.67	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	13.31	13.31	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.33	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	13.18	13.18	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	13.31	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	13.05	13.05	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	13.18	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	12.89	12.89	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	13.05	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	12.77	12.77	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	12.89	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	12.51	12.51	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	12.77	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	12.77	12.77	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.78	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	13.11	13.11	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.12	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	13.05	13.05	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	13.11	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	12.54	12.54	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.54	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	12.48	12.48	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.48	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	12.47	12.47	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	12.48	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	12.45	12.45	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	12.47	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	12.44	12.44	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	12.45	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	12.76	12.76	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.76	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	12.91	12.91	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.92	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	12.91	12.91	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.92	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	12.91	12.91	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	12.91	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	12.76	12.76	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	12.91	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	12.61	12.61	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	12.76	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	12.84	12.84	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.85	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	12.84	12.84	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.85	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	12.84	12.84	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.84	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	12.61	12.61	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	12.84	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	12.44	12.44	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	12.61	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	12.33	12.33	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	12.36	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	12.23	12.23	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	12.33	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
CRB-P72	CRB-DI72	CRB-MH-74	1.00	15.30	15.30	15	1.6	1.3	95	16	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	15.31	5.76	HGL Too High!
CRB-P74	CRB-MH-74	CRB-MH-67	1.00	15.01	15.01	15	2.9	2.4	91	154	0.0017	0.27	0	0.00	0.02	1.5	2.0	0.0	1.3	0.0	95	0.02	0.05	1.0	0.5	0.02	0.29	15.30	6.13	HGL Too High!
CRB-P73	CRB-DI73	CRB-MH-74	1.00	15.30	15.30	15	1.4	1.1	91	34	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	15.31	5.87	HGL Too High!
P-162	DI-162	EXMH-201	1.00	15.26	15.26	15	0.7	0.6	109	16	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.27	7.51	HGL Too High!
P-201	EXMH-201	A1-MH-203	1.00	15.26	15.26	15	0.7	0.6	104	18	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	109	0.00	0.01	1.0	0.5	0.00	0.01	15.26	8.31	HGL Too High!
EX-P LOT	EXDI LOT	DI-MSS-41	0.80	16.11	16.11	12	2.6	3.3	0	47	0.0046	0.22	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.26	16.37	3.50	HGL Too High!
P-MSS-48	DI-MSS-40	DI-MSS-41	0.80	16.08	16.08	12	0.7	0.9	90	82.1	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	16.11	4.75	HGL Too High!
P-MSS-48A	DI-MSS-41	EX-MH	0.80	15.47	15.47	12	3.8	4.9	72	41	0.0099	0.41	0	0.00	0.09	0.6	8.8	0.0	3.3	0.1	0	0.00	0.15	1.3	1.0	0.20	0.60	16.08	4.50	HGL Too High!
A1-P-202	EX-MH	A1-MH-203	1.20	15.26	15.26	18	3.8	2.2	77	26	0.0011	0.03	0	0.00	0.02	18.8	0.0	0.0	4.9	0.1	72	0.23	0.37	1.0	0.5	0.19	0.22	15.47	7.82	HGL Too High!
A1-P-204	A1-MH-204	CRB-MH-67	1.20	15.01	15.01	18	4.5	2.5	90	129	0.0016	0.20	0	0.00	0.03	8.2	0.4	0.0	2.2	0.0	77	0.05	0.10	1.0	0.5	0.05	0.25	15.26	8.02	HGL Too High!
A1-P-205	CRB-MH-67	CMH-1	1.20	14.83	14.83	18	8.6	4.9	3	14	0.0057	0.08	0	0.00	0.09	11.5	1.3	6.9	2.5	0.0	90	0.07	0.20	1.0	0.5	0.10	0.18	15.01	7.07	HGL Too High!
MSS-P2	MSS-DI2	MSS-DI1	1.00	15.04	15.04	15	0.9	0.8	70	70	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.06	7.27	HGL Too High!
MSS-P1	MSS-DI1	EXMH	1.00	15.02	15.02	15	1.5	1.2	22	5	0.0005	0.00	0	0.00	0.01	0.7	0.0	0.0	0.8	0.0	70	0.01	0.01	1.3	1.0	0.02	0.02	15.04	6.56	HGL Too High!
A1-P-203	EX MH	MH-CRB-67	1.20	15.01	15.01	18	1.5	0.8	2	25	0.0002	0.00	0	0.00	0.00	1.8	0.0	0.0	1.2	0.0	22	0.01	0.02	1.0	0.5	0.01	0.01	15.02	6.62	HGL Too High!
A1-P-206	CMH-1	A1-DI-207	1.60	14.62	14.62	24	10.1	3.2	4	60	0.0017	0.10	0	0.00	0.04	41.9	1.2	0.4	4.9	0.1	3	0.04	0.21	1.0	0.5	0.10	0.21	14.83	6.63	HGL Too High!
A1-P-207	A1-DI-207	A1-DI-208	1.60	14.11	14.11	24	15.7	5.0	4	82	0.0041	0.34	0	0.00	0.10	32.6	16.8	0.0	3.2	0.1	4	0.02	0.17	1.0	1.0	0.17	0.51	14.62	6.26	HGL Too High!
A1-P-208	A1-DI-208	A1-DI-209	2.40	13.89	13.89	36	16.0	2.3	7	59	0.0005	0.03	0	0.00	0.02	78.8	0.0	0.0	5.0	0.1	4	0.04	0.20	1.0	1.0	0.20	0.22	14.11	7.73	HGL Too High!
A1-P-209	A1-DI-209	A1-MH-210	3.20	13.84	13.84	48	20.2	1.6	3	54	0.0002	0.01	0	0.00	0.01	36.4	10.0	10.9	2.3	0.0	7	0.01	0.05	1.0	1.0	0.05	0.06	13.89	9.00	HGL Too High!
A1-P-210	A1-MH-210	A1-DI-211	3.20	13.81	13.81	48	20.5	1.6	3	68	0.0002	0.01	0	0.00	0.01	32.4	0.1	0.0	1.6	0.0	3	0.00	0.03	1.0	0.5	0.01	0.03	13.84	10.00	HGL Too High!
A1-P-211	A1-DI-211	A1-DI-212	3.20	13.74	13.74	48	23.3	1.9	4	180	0.0002	0.04	0	0.00	0.01	33.3	32.9	4.3	1.6	0.0	3	0.00	0.03	1.0	1.0	0.03	0.07	13.81	11.32	HGL Too High!
A1-P-212	A1-DI-212	A1-DI-213	3.20	13.67	13.67	48	28.6	2.3	2	58	0.0003	0.02	0	0.00	0.02	43.3	1.6	11.1	1.9	0.0	4	0.01	0.04	1.0	1.0	0.04	0.06	13.74	12.00	HGL Too High!
A1-P-213	A1-DI-213	A1-DI-214	3.20	13.53	13.53	48	36.2	2.9	0	158	0.0005	0.09	0	0.00	0.03	65.1	5.1	5.0	2.3	0.0	2	0.00	0.06	1.0	1.0	0.06	0.15	13.67	10.50	HGL Too High!
A1-P-214	A1-DI-214	A1-DI-215	3.20	13.43	13.43	48	38.3	3.0	16	35	0.0006	0.02	0	0.00	0.04	104.0	5.4	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.10	13.53	10.50	HGL Too High!
A1-P-215	**A1-DI-215**	**A1-MH-216**	**3.20**	**13.34**	**13.34**	**48**	**38.1**	**3.0**	**0**	**48**	**0.0006**	**0.03**	**0**	**0.00**	**0.04**	**116.6**	**0.0**	**0.0**	**3.0**	**0.1**	**16**	**0.03**	**0.11**	**1.0**	**0.5**	**0.06**	**0.09**	**13.43**	**10.50**	**HGL Too High!**
MSS-P3 A	MSS-DI14	DI-161	1.00	14.83	14.83	15	0.8	0.6	0	44	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.83	7.17	HGL Too High!
MSS-P3 B	DI-161	MSS-DI13	1.00	14.62	14.62	15	1.2	1.0	88	25	0.0003	0.01	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	0	0.00	0.01	1.3	1.0	0.01	0.01	14.64	6.88	HGL Too High!
P-160	DI-160	CMH-1	0.53	14.83	14.83	8	0.4	1.1	93	96	0.0008	0.07	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.08	14.91	6.26	HGL Too High!
A1 P-200	PARCEL J	A1-DI-207	1.20	14.62	14.62	18	5.4	3.1	90	23	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	14.69	10.00	HGL Too High!
P-336	PARCEL J	A1-DI-209	1.20	13.89	13.89	18	4.2	2.4	90	19	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	13.93	10.00	HGL Too High!
P-337	PARCEL J	A1-DI-211	1.20	13.81	13.81	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.83	10.00	HGL Too High!
P-335	PARCEL N	A1-DI-213	1.20	13.67	13.67	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	13.72	10.00	HGL Too High!
P-340	PARCEL K	A1-DI-213	1.20	13.67	13.67	18	3.0	1.7	90	18	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.69	10.00	HGL Too High!
P-165	DI-165	DI-166	1.20	14.01	14.01	18	1.4	0.8	0	28	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.01	6.14	HGL Too High!
P-166	DI-166	DI-167	1.20	13.98	13.98	18	1.8	1.0	0	54	0.0003	0.01	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	14.01	6.26	HGL Too High!
P-167	DI-167	DI-168	1.60	13.96	13.96	24	2.5	0.8	90	91	0.0001	0.01	0	0.00	0.00	1.9	0.0	0.0	1.0	0.0	0	0.00	0.01	1.3	1.0	0.01	0.02	13.98	7.12	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ____ of ____
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077.001
Segment: Jones Street Outfall | Design Freq.: 500 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved alignment, add Hc = $0.002*O*V_o^2/2g$ to H_t	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-168	DI-168	DI-209	1.60	13.89	13.89	24	5.9	1.9	94	33	0.0006	0.02	0	0.00	0.01	2.0	2.9	0.0	1.3	0.0	90	0.02	0.04	1.3	1.0	0.05	0.07	13.96	9.01	HGL Too High!
P-327	PARCEL L	DI-168	1.20	13.96	13.96	18	2.2	1.3	90	19	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.97	10.00	HGL Too High!
P-326	PARCEL L	DI-170	1.20	14.61	14.61	18	2.8	1.6	90	23	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	14.63	10.00	HGL Too High!
P-170	DI-170	DI-171	1.20	14.48	14.48	18	3.3	1.9	90	68	0.0009	0.06	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	90	0.03	0.06	1.3	1.0	0.07	0.13	14.61	10.79	HGL Too High!
P-171	DI-171	DI-173	1.20	14.35	14.35	18	3.9	2.2	79	29	0.0011	0.03	0	0.00	0.02	6.3	0.0	0.0	1.9	0.0	90	0.04	0.08	1.3	1.0	0.10	0.13	14.48	10.30	HGL Too High!
P-173	DI-173	DI-174	1.60	14.19	14.19	24	6.7	2.1	69	46	0.0008	0.03	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	79	0.05	0.09	1.3	1.0	0.12	0.15	14.35	10.30	HGL Too High!
P-174	DI-174	DI-175	1.60	14.07	14.07	24	7.0	2.2	80	44	0.0008	0.04	0	0.00	0.02	14.4	0.0	0.0	2.1	0.0	69	0.04	0.09	1.0	1.0	0.09	0.12	14.19	11.19	HGL Too High!
P-175	DI-175	DI-211	1.60	13.81	13.81	24	10.2	3.2	88	29	0.0017	0.05	0	0.00	0.04	15.8	32.9	0.0	3.2	0.1	88	0.11	0.21	1.0	1.0	0.21	0.26	14.07	11.31	HGL Too High!
P-331	PARCEL M	DI-175	1.20	14.07	14.07	18	2.5	1.4	90	19	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	14.08	10.00	HGL Too High!
P-328	PARCEL M	DI-172	1.20	14.41	14.41	18	1.9	1.0	90	22	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.42	10.00	HGL Too High!
P-172	DI-172	DI-173	1.20	14.35	14.35	18	2.4	1.4	12	68	0.0004	0.03	0	0.00	0.01	1.9	0.0	0.0	1.0	0.0	90	0.01	0.02	1.3	1.0	0.03	0.06	14.41	10.79	HGL Too High!
P-169	DI-169	MH-210	1.20	13.84	13.84	18	0.5	0.3	90	7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.84	10.25	HGL Too High!
P-178	DI-178	DI-179	1.20	13.78	13.78	18	0.7	0.4	68	39	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.78	11.90	HGL Too High!
P-179	DI-179	DI-180	1.20	13.77	13.77	18	1.1	0.6	80	34	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.4	0.0	68	0.00	0.00	1.3	1.0	0.00	0.01	13.78	11.68	HGL Too High!
P-180	DI-180	DI-181	1.20	13.75	13.75	18	1.3	0.7	12	49	0.0001	0.01	0	0.00	0.00	0.6	0.0	0.0	0.6	0.0	80	0.00	0.01	1.3	1.0	0.01	0.02	13.77	11.68	HGL Too High!
P-181	DI-181	DI-212	1.20	13.74	13.74	18	1.7	1.0	98	23	0.0002	0.01	0	0.00	0.00	1.0	0.0	0.0	0.7	0.0	12	0.00	0.01	1.3	1.0	0.01	0.01	13.75	11.82	HGL Too High!
P-182	DI-182	DI-186	1.20	14.06	14.06	18	0.4	0.2	90	43	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.06	12.11	HGL Too High!
P-338	PARCEL J	DI-185	1.20	14.21	14.21	18	2.0	1.1	90	23	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.22	10.00	HGL Too High!
P-183	DI-183	DI-184	1.20	14.21	14.21	18	0.5	0.3	4	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.22	11.58	HGL Too High!
P-184	DI-184	DI-185	1.20	14.21	14.21	18	1.0	0.5	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	4	0.00	0.00	1.3	1.0	0.00	0.01	14.21	11.91	HGL Too High!
P-185	DI-185	DI-186	1.20	14.06	14.06	18	3.5	2.0	70	108	0.0010	0.10	0	0.00	0.02	0.5	2.2	0.0	1.1	0.0	90	0.01	0.04	1.3	1.0	0.05	0.15	14.21	12.23	HGL Too High!
P-186	DI-186	DI-190	1.20	13.91	13.91	18	4.2	2.4	57	27	0.0013	0.04	0	0.00	0.02	7.1	0.0	0.0	2.0	0.0	70	0.04	0.08	1.3	1.0	0.11	0.14	14.06	12.36	HGL Too High!
P-339	PARCEL K	DI-189	1.20	14.14	14.14	18	2.5	1.4	90	23	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	14.15	10.00	HGL Too High!
P-187	DI-187	DI-188	1.20	14.14	14.14	18	0.5	0.3	2	59	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.15	11.58	HGL Too High!
P-188	DI-188	DI-189	1.20	14.14	14.14	18	1.0	0.6	2	62	0.0001	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	14.14	11.91	HGL Too High!
P-189	DI-189	DI-190	1.20	13.91	13.91	18	4.1	2.3	14	119	0.0013	0.15	0	0.00	0.02	0.5	3.6	0.0	1.4	0.0	90	0.02	0.05	1.3	1.0	0.07	0.22	14.14	12.23	HGL Too High!
P-190	DI-190	DI-191	1.20	13.74	13.74	18	4.4	2.5	67	50	0.0015	0.08	0	0.00	0.02	9.5	9.9	0.0	2.4	0.0	57	0.05	0.10	1.0	1.0	0.10	0.18	13.91	12.33	HGL Too High!
P-341	PARCEL K	DI-195	1.20	13.63	13.63	18	2.7	1.5	105	53	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	13.66	10.00	HGL Too High!
P-195	DI-195	A1-DI-214	1.20	13.53	13.53	18	3.1	1.7	90	43	0.0007	0.03	0	0.00	0.01	4.2	0.0	0.0	1.5	0.0	105	0.03	0.05	1.3	1.0	0.07	0.10	13.63	10.50	HGL Too High!

KEY	
	Constructed under Area 1
	Constructed under Area 2
	Existing to remain

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 1 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-41	MH-41	MH-42	1	0	1	0.00	0.95	0.00	0.89	6.0	8.13	3.66	3.26	24	92	0.012	0.000177	0.0033	4.5	14.0	3.7	0.42	8.55	1.50	1.20	Q ok
P-42	MH-42	DI-43	1	0	1	0.00	0.95	0.00	1.79	6.0	8.55	3.59	6.43	30	30	0.012	0.000209	0.0030	5.0	24.3	4.1	0.12	8.67	1.10	1.01	Q ok
P-43	DI-43	DI-44	4208	31	4239	0.10	0.94	0.09	1.88	6.0	8.67	3.56	6.69	30	25	0.012	0.000227	0.0032	5.1	25.1	4.2	0.10	8.77	0.91	0.83	Q ok
P-44	DI-44	DI-45	4675	523	5198	0.12	0.87	0.10	1.99	6.0	8.77	3.54	7.03	30	69	0.012	0.000250	0.0030	5.0	24.5	4.2	0.27	9.04	0.73	0.52	Q ok
P-45	DI-45	MH-46	4490	535	5025	0.12	0.87	0.10	2.09	6.0	9.04	3.51	7.32	30	52	0.012	0.000271	0.0031	5.0	24.6	4.3	0.20	9.24	0.42	0.26	Q ok
P-46	MH-46	DI-47	1	0	1	0.00	0.95	0.00	2.78	6.0	9.24	3.47	9.67	30	42	0.012	0.000474	0.0031	5.0	24.7	4.6	0.15	9.40	0.16	0.03	Q ok
P-47	DI-47	MH-60	4551	287	4838	0.11	0.90	0.10	2.88	6.0	9.40	3.44	9.93	36	23	0.012	0.000189	0.0030	5.6	39.9	4.6	0.08	9.48	-0.07	-0.14	Q ok
P-60	MH-60	MH-61	1	0	1	0.00	0.95	0.00	4.01	6.0	9.48	3.42	13.73	36	75	0.012	0.000361	0.0039	6.4	44.9	5.4	0.23	9.71	-0.24	-0.53	Q ok
P-61	MH-61	DI-62	1	0	1	0.00	0.95	0.00	4.01	6.0	9.71	3.39	13.60	36	76	0.012	0.000354	0.0039	6.4	45.4	5.5	0.23	9.94	-0.63	-0.93	Q ok
P-62	DI-62	DI-63	1435	40	1475	0.03	0.93	0.03	4.04	6.0	9.94	3.36	13.57	36	50	0.012	0.000353	0.0040	6.5	45.7	5.5	0.15	10.09	-1.03	-1.23	Q ok
P-63	DI-63	DI-77	1999	107	2106	0.05	0.91	0.04	4.79	6.0	10.09	3.33	15.94	36	25	0.012	0.000487	0.0036	6.1	43.4	5.5	0.08	10.17	-1.33	-1.42	Q ok
P-77	DI-77	DI-85	2311	122	2433	0.06	0.91	0.05	5.88	6.0	10.17	3.32	19.50	48	50	0.012	0.000157	0.0030	6.8	85.2	5.6	0.15	10.32	-1.52	-1.67	Q ok
P-85	DI-85	MH-86	5006	304	5310	0.12	0.91	0.11	10.47	6.0	10.32	3.31	34.62	60	186	0.012	0.000151	0.0030	7.9	154.8	5.9	0.52	10.84	-1.77	-2.33	Q ok
P-86	MH-86	MH-87	1	0	1	0.00	0.95	0.00	11.07	6.0	10.84	3.25	35.98	60	45	0.012	0.000163	0.0031	8.0	157.4	6.6	0.11	10.96	-2.43	-2.57	Q ok
P-87	**MH-87**	**OUTFALL**	**1**	**0**	**1**	**0.00**	**0.95**	**0.00**	**11.79**	**6.0**	**10.96**	**3.23**	**38.05**	**60**	**9**	**0.012**	**0.000182**	**0.0033**	**8.3**	**162.9**	**6.8**	**0.02**	**10.98**	**-2.67**	**-2.70**	**Q ok**
P-48	MSS MH-08	MH-49	1	0	1	0.00	0.95	0.00	0.90	6.0	7.63	3.74	3.36	24	64	0.012	0.000188	0.0070	6.5	20.6	4.6	0.23	7.87	1.65	1.20	Q ok
P-50	B7 North	1.00	32048	0	32048	0.74	0.95	0.70	0.70	6.0	0.00	4.01	2.80	18	16	0.012	0.000607	0.0050	4.6	8.0	4.1	0.07	6.07	0.35	0.27	Q ok
P-65	B7 West	MH-64	32234	0	32234	0.74	0.95	0.70	0.70	6.0	0.00	4.01	2.82	18	17	0.012	0.000614	0.0047	4.4	7.8	4.0	0.07	6.07	-0.95	-1.03	Q ok
P-64	MH-64	DI-63	1	0	1	0.00	0.95	0.00	0.70	6.0	6.07	4.00	2.81	18	20	0.012	0.000609	0.0050	4.6	8.0	4.1	0.08	6.15	-1.13	-1.23	Q ok
P-51	DI-51	DI-52	3030	31	3061	0.07	0.94	0.07	0.07	6.0	0.00	4.01	0.27	15	26	0.012	0.000014	0.0050	4.0	4.9	2.0	0.22	6.22	3.70	3.57	Q ok
P-52	DI-52	DI-53	4699	521	5220	0.12	0.87	0.10	0.17	6.0	6.22	3.98	0.68	15	69	0.012	0.000094	0.0049	4.0	4.9	2.8	0.41	6.63	3.37	3.03	Q ok
P-53	DI-53	MH-54	4484	537	5021	0.12	0.87	0.10	0.27	6.0	6.63	3.91	1.06	15	51	0.012	0.000229	0.0051	4.1	5.0	3.1	0.28	6.91	2.83	2.57	Q ok
P-54	MH-54	DI-55	1	0	1	0.00	0.95	0.00	1.00	6.0	6.91	3.86	3.86	24	41	0.012	0.000249	0.0049	5.4	17.1	4.5	0.15	7.06	2.37	2.17	Q ok
P-55	DI-55	MH-60	5685	291	5976	0.14	0.91	0.13	1.13	6.0	7.06	3.83	4.31	24	23	0.012	0.000309	0.0052	5.6	17.7	4.6	0.08	7.14	1.97	1.85	Q ok
P-56	B5 South	MH-54	33482	0	33482	0.77	0.95	0.73	0.73	6.0	0.00	4.01	2.93	18	17	0.012	0.000663	0.0053	4.7	8.3	4.2	0.07	6.07	2.56	2.47	Q ok
P-78	DI-78	DI-79	3667	223	3890	0.09	0.91	0.08	0.08	6.0	0.00	4.01	0.32	15	84	0.012	0.000022	0.0200	8.1	9.9	4.0	0.35	6.35	7.12	5.44	Q ok
P-79	DI-79	DI-71	3253	204	3457	0.08	0.90	0.07	0.15	6.0	6.35	3.94	0.60	18	29	0.012	0.000028	0.0200	9.1	16.1	4.5	0.11	6.46	5.24	4.66	Q ok
P-71	DI-71	DI-72	3698	198	3896	0.09	0.91	0.08	0.32	6.0	6.46	3.93	1.25	18	42	0.012	0.000121	0.0200	9.1	16.1	5.5	0.13	6.59	4.46	3.62	Q ok
P-72	DI-72	DI-73	2021	16	2037	0.05	0.94	0.04	0.36	6.0	6.59	3.91	1.42	18	29	0.012	0.000155	0.0200	9.1	16.1	5.5	0.09	6.68	3.42	2.84	Q ok
P-73	DI-73	MH-74	1071	0	1071	0.02	0.95	0.02	0.39	6.0	6.68	3.89	1.50	18	17	0.012	0.000174	0.0200	9.1	16.1	5.5	0.05	6.73	2.64	2.30	Q ok
P-74	MH-74	DI-75	1	0	1	0.00	0.95	0.00	0.95	6.0	6.73	3.89	3.69	18	17	0.012	0.001053	0.0200	9.1	16.1	7.5	0.04	6.77	2.10	1.76	Q ok
P-75	DI-75	DI-76	2135	0	2135	0.05	0.95	0.05	0.99	6.0	6.77	3.88	3.86	18	43	0.012	0.001149	0.0200	9.1	16.1	7.5	0.10	6.86	1.56	0.70	Q ok
P-76	DI-76	DI-77	1993	48	2041	0.05	0.93	0.04	1.04	6.0	6.86	3.86	4.01	18	51	0.012	0.001241	0.0200	9.1	16.1	7.5	0.11	6.98	0.50	-0.52	Q ok
P-70	DI-70	DI-71	3812	274	4086	0.09	0.90	0.08	0.08	6.0	0.00	4.01	0.34	15	86	0.012	0.000023	0.0200	8.1	9.9	4.0	0.36	6.36	6.38	4.66	Q ok
P-80	DI-80	MH-74	22886	15258	38144	0.88	0.64	0.56	0.56	6.0	0.00	4.01	2.26	18	24	0.012	0.000393	0.0050	4.6	8.0	3.9	0.10	6.10	2.42	2.30	Q ok
P-90	DI-90	DI-91	6026	1962	7988	0.18	0.76	0.14	0.14	6.0	0.00	4.01	0.56	15	79	0.012	0.000064	0.0200	8.1	9.9	4.0	0.33	6.33	2.54	0.96	Q ok
P-91	DI-91	MH-87	6475	2667	9142	0.21	0.73	0.15	0.72	6.0	6.33	3.96	2.85	18	81	0.012	0.000626	0.0200	9.1	16.1	6.8	0.20	6.53	-0.04	-1.66	Q ok
P-92	B6 North	DI-91	19569	0	19569	0.45	0.95	0.43	0.43	6.0	0.00	4.01	1.71	18	63	0.012	0.000226	0.0049	4.5	8.0	3.4	0.31	6.31	0.47	0.16	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 1 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-95	TD-04	MH-86	21353	32030	53383	1.23	0.49	0.60	0.60	6.0	0.00	4.01	2.40	12	16	0.011	0.003247	0.0506	12.1	9.5	9.9	0.03	6.03	8.01	7.20	Q ok
P-38	DI-38	DI-39	1483	0	1483	0.03	0.95	0.03	0.03	6.0	0.00	4.01	0.13	15	99	0.012	0.000003	0.0200	8.1	9.9	4.0	0.42	6.42	2.75	0.77	Q ok
P-39	DI-39	DI-40	3833	220	4053	0.09	0.91	0.08	0.12	6.0	6.42	3.94	0.46	15	70	0.012	0.000043	0.0200	8.1	9.9	4.0	0.30	6.71	0.57	-0.83	Q ok
P-40	DI-40	DI-85	4668	293	4961	0.11	0.90	0.10	0.22	6.0	6.71	3.89	0.86	18	26	0.012	0.000057	0.0208	9.3	16.4	4.5	0.10	6.81	-1.03	-1.57	Q ok
P-35	MH-35	DI-36	1	0	1	0.00	0.95	0.00	4.13	6.0	7.81	3.71	15.34	**36**	94	0.012	0.000451	0.0050	7.2	51.1	6.1	0.25	8.07	-0.16	-0.63	Q ok
P-36	DI-36	DI-37	1851	0	1851	0.04	0.95	0.04	4.17	6.0	8.07	3.66	15.28	**36**	98	0.012	0.000447	0.0050	7.2	51.1	6.1	0.27	8.33	-0.73	-1.22	Q ok
P-37	DI-37	DI-85	3893	195	4088	0.09	0.91	0.09	4.26	6.0	8.33	3.63	15.45	36	70	0.012	0.000457	0.0050	7.2	51.1	6.1	0.19	8.52	-1.32	-1.67	Q ok
P-30	DI-30	MH-35	1403	0	1403	0.03	0.95	0.03	0.03	6.0	0.00	4.01	0.12	18	47	0.012	0.000001	0.0200	9.1	16.1	4.5	0.18	6.18	0.98	0.04	Q ok
P-11	DI-11	DI-12	4746	684	5430	0.12	0.85	0.11	0.11	6.0	0.00	4.01	0.43	15	20	0.012	0.000037	0.0065	4.6	5.6	2.8	0.12	6.12	2.91	2.78	Q ok
P-12	DI-12	DI-13	4957	1287	6244	0.14	0.79	0.11	0.22	6.0	6.12	4.00	0.88	15	92	0.012	0.000157	0.0065	4.6	5.7	3.2	0.48	6.60	2.68	2.08	Q ok
P-13	DI-13	MH-14	4947	1296	6243	0.14	0.79	0.11	0.33	6.0	6.60	3.91	1.30	15	54	0.012	0.000346	0.0065	4.6	5.6	3.8	0.24	6.84	1.98	1.63	Q ok
P-14	MH-14	DI-15	1	0	1	0.00	0.95	0.00	1.03	6.0	6.84	3.88	3.99	24	38	0.012	0.000265	0.0066	6.3	19.9	4.7	0.13	6.97	1.53	1.28	Q ok
P-15	DI-15	DI-16	3998	870	4868	0.11	0.81	0.09	1.12	6.0	6.97	3.84	4.31	24	73	0.012	0.000309	0.0064	6.3	19.7	4.7	0.26	7.23	1.18	0.71	Q ok
P-16	DI-16	MH-17	5113	501	5614	0.13	0.88	0.11	1.23	6.0	7.23	3.81	4.70	24	31	0.012	0.000368	0.0071	6.6	20.6	5.4	0.10	7.32	0.61	0.39	Q ok
P-18	B7 South	MH-14	31929	0	31929	0.73	0.95	0.70	0.70	6.0	0.00	4.01	2.79	18	17	0.012	0.000603	0.0053	4.7	8.3	4.2	0.07	6.07	1.72	1.63	Q ok
P-01	DI-01	DI-02	7520	1261	8781	0.20	0.84	0.17	0.17	6.0	0.00	4.01	0.68	15	77	0.012	0.000094	0.0065	4.6	5.6	2.8	0.47	6.47	2.91	2.41	Q ok
P-02	DI-02	DI-03	2113	487	2600	0.06	0.81	0.05	0.22	6.0	6.47	3.93	0.85	15	38	0.012	0.000149	0.0066	4.6	5.7	3.2	0.20	6.66	2.31	2.06	Q ok
P-03	DI-03	MH-04	4989	1312	6301	0.14	0.79	0.11	0.33	6.0	6.66	3.89	1.29	15	46	0.012	0.000340	0.0065	4.6	5.7	3.8	0.20	6.86	1.96	1.66	Q ok
P-04	MH-04	DI-05	1	0	1	0.00	0.95	0.00	0.78	6.0	6.86	3.86	3.01	18	46	0.012	0.000701	0.0065	5.2	9.2	4.7	0.16	7.03	1.56	1.26	Q ok
P-05	DI-05	DI-06	3831	995	4826	0.11	0.79	0.09	0.87	6.0	7.03	3.84	3.34	24	73	0.012	0.000185	0.0064	6.3	19.7	4.4	0.28	7.31	1.16	0.69	Q ok
P-06	DI-06	MH-17	5161	592	5753	0.13	0.87	0.12	1.49	6.0	7.31	3.79	5.66	24	30	0.012	0.000534	0.0067	6.4	20.0	5.4	0.09	7.40	0.59	0.39	Q ok
P-17	MH-17	MH-35	1	0	1	0.00	0.95	0.00	2.73	6.0	7.40	3.78	10.30	*36*	115	0.012	0.000203	0.0030	5.6	39.9	4.6	0.41	7.81	0.29	-0.06	Q ok
Check P-17 for Sanitary Crossing for Conflict																										Check P-1
P-08	DI-08	MH-07	1526	0	1526	0.04	0.95	0.03	0.03	6.0	0.00	4.01	0.13	15	58	0.012	0.000004	0.0066	4.6	5.7	2.3	0.43	6.43	1.36	0.98	Q ok
P-07	MH-07	DI-06	1	0	1	0.00	0.95	0.00	0.51	6.0	0.00	4.01	2.04	18	14	0.012	0.000323	0.0064	5.2	9.1	3.9	0.06	6.06	0.88	0.79	Q ok
P-09	B9/J	MH-04	20585	0	20585	0.47	0.95	0.45	0.45	6.0	0.00	4.01	1.80	18	17	0.012	0.000251	0.0053	4.7	8.3	3.5	0.08	6.08	1.75	1.66	Q ok
P-10	B9/J	MH-07	21845	0	21845	0.50	0.95	0.48	0.48	6.0	0.00	4.01	1.91	18	17	0.012	0.000282	0.0053	4.7	8.3	3.8	0.07	6.07	1.07	0.98	Q ok
P-20	TD-05	DI-21	5394	0	5394	0.12	0.95	0.12	0.12	6.0	0.00	4.01	0.47	8	39	0.011	0.001092	0.0500	9.1	3.2	6.4	0.10	6.10	8.50	6.55	Q ok
P-21	DI-21	MH-22	6185	3410	9595	0.22	0.68	0.15	0.27	6.0	6.10	4.00	1.07	15	31	0.012	0.000232	0.0200	8.1	9.9	4.8	0.11	6.21	4.54	3.92	Q ok
P-22	MH-22	MH-23	1	0	1	0.00	0.95	0.00	0.42	6.0	6.21	3.98	1.69	18	42	0.012	0.000220	0.0200	9.1	16.1	5.5	0.13	6.34	3.72	2.88	Q ok
P-23	MH-23	MH-24	1	0	1	0.00	0.95	0.00	1.20	6.0	6.34	3.96	4.77	18	66	0.012	0.001759	0.0200	9.1	16.1	7.7	0.14	6.48	2.68	1.36	Q ok
P-24	MH-24	MH-35	1	0	1	0.00	0.95	0.00	1.38	6.0	6.48	3.93	5.41	18	56	0.012	0.002260	0.0200	9.1	16.1	8.2	0.11	6.59	1.16	0.04	Q ok
P-25	DI-25	MH-22	6504	3883	10387	0.24	0.66	0.16	0.16	6.0	0.00	4.01	0.63	15	31	0.012	0.000082	0.0200	8.1	9.9	4.0	0.13	6.13	4.54	3.92	Q ok
P-26	B8/K	MH-23	16317	0	16317	0.37	0.95	0.36	0.36	6.0	0.00	4.01	1.43	18	56	0.012	0.000157	0.0050	4.6	8.0	3.4	0.27	6.27	3.06	2.78	Q ok
P-27	B6 South	MH-23	19451	0	19451	0.45	0.95	0.42	0.42	6.0	0.00	4.01	1.70	18	56	0.012	0.000224	0.0050	4.6	8.0	3.4	0.27	6.27	3.06	2.78	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/2023 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/2023 | Cm. No.: 20077.000
Segment: Central Green Outfall | Storm Frequency: 1 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-28	DI-28	MH-24	3596	533	4129	0.09	0.85	0.08	0.08	6.0	0.00	4.01	0.32	18	34	0.012	0.000008	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok
P-29	DI-29	MH-24	4110	551	4661	0.11	0.86	0.09	0.09	6.0	0.00	4.01	0.37	18	34	0.012	0.000011	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok

KEY

	Upsized from Semi-Final Design to have capacity for 50-yr design storm
	Optional Upsize-50-yr design storm results in >85% Full
	No Change from Semi-Final Design

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe TW (ft)	Outlet W. S. Elevation HGL Dn (ft)	Outflow Pipe Diameter D_o (in)	Outflow Pipe Design Flow Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$ V_o (fps)	Skew angle vs. Δ_o (deg)	Outflow Pipe Length L (ft)	Friction Slope S_{fo} (ft/ft)	Friction Loss H_f (ft)	Angle of Curvature O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c (ft)	Contraction Loss H_o (ft)	Q*V for determining controlling inflow pipe Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q3V3 (ft^4/s^2)	Controlling Inflow Velocity Vi	Expansion Loss Hi (ft)	Controlling In-flow skew Δ_i (deg)	Bend Loss H_Δ (ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ (ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ H (ft)	Inlet W. S. Elevation HGL Up (ft)	Top of Grate T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	3.95	3.95	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	3.98	7.00	HGL ok
P-42	MH-42	DI-43	2.00	3.94	3.94	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	3.95	7.86	HGL ok
P-43	DI-43	DI-44	2.00	3.91	3.91	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	3.94	7.11	HGL ok
P-44	DI-44	DI-45	2.00	3.87	3.87	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	3.91	7.03	HGL ok
P-45	DI-45	MH-46	2.00	3.84	3.84	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	3.87	7.59	HGL ok
P-46	MH-46	DI-47	2.00	3.80	3.80	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	3.84	8.54	HGL ok
P-47	DI-47	MH-60	2.40	3.73	3.73	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	3.80	9.09	HGL ok
P-60	MH-60	MH-61	2.40	3.68	3.68	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	3.73	9.84	HGL ok
P-61	MH-61	DI-62	2.40	3.61	3.61	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	3.68	11.03	HGL ok
P-62	DI-62	DI-63	2.40	3.56	3.56	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	3.61	10.34	HGL ok
P-63	DI-63	DI-77	1.93	3.46	3.46	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	3.56	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.36	3.36	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	3.46	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.24	3.24	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	3.36	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.22	3.22	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	3.24	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.20**	**3.20**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**3.22**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	3.95	3.95	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	3.97	8.07	HGL ok
P-50	B7 North	1.00	1.20	3.84	3.84	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	3.86	10.00	HGL ok
P-65	B7 West	MH-64	1.20	3.59	3.59	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.61	10.00	HGL ok
P-64	MH-64	DI-63	1.20	3.56	3.56	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	3.59	10.14	HGL ok
P-51	DI-51	DI-52	1.00	4.04	4.57	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.57	7.11	HGL ok
P-52	DI-52	DI-53	1.00	3.83	4.03	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	4.04	7.03	HGL ok
P-53	DI-53	MH-54	1.00	3.81	3.81	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	3.83	7.59	HGL ok
P-54	MH-54	DI-55	1.60	3.78	3.78	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	3.81	8.54	HGL ok
P-55	DI-55	MH-60	1.60	3.73	3.73	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	3.78	9.09	HGL ok
P-56	B5 South	MH-54	1.20	3.81	3.81	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.83	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.86	6.44	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.44	11.60	HGL ok
P-79	DI-79	DI-71	1.20	4.83	5.86	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	5.86	11.15	HGL ok
P-71	DI-71	DI-72	1.20	4.05	4.82	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	4.83	11.15	HGL ok
P-72	DI-72	DI-73	1.20	3.73	4.04	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	4.05	10.99	HGL ok
P-73	DI-73	MH-74	1.20	3.72	3.72	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	3.73	10.84	HGL ok
P-74	MH-74	DI-75	1.20	3.68	3.68	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	3.72	11.24	HGL ok
P-75	DI-75	DI-76	1.20	3.58	3.58	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	3.68	10.63	HGL ok
P-76	DI-76	DI-77	1.20	3.46	3.46	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	3.58	10.34	HGL ok
P-70	DI-70	DI-71	1.00	4.83	5.66	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.66	11.60	HGL ok
P-80	DI-80	MH-74	1.20	3.72	3.72	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	3.73	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.30	3.30	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.31	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.22	3.22	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	3.30	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.30	3.30	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	3.32	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.24	8.00	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.07	10.50	HGL ok
P-38	DI-38	DI-39	1.00	3.37	3.37	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.37	10.67	HGL ok
P-39	DI-39	DI-40	1.00	3.37	3.37	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.37	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.36	3.36	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	3.37	9.98	HGL ok
P-35	MH-35	DI-36	2.40	3.53	3.53	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	3.66	11.72	HGL ok
P-36	DI-36	DI-37	2.40	3.45	3.45	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	3.53	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add $H_c = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.36	3.36	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	3.45	10.16	HGL ok
P-30	DI-30	MH-35	1.20	3.66	3.66	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.66	11.24	HGL ok
P-11	DI-11	DI-12	1.00	3.88	3.88	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.89	6.84	HGL ok
P-12	DI-12	DI-13	1.00	3.87	3.87	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	3.88	6.99	HGL ok
P-13	DI-13	MH-14	1.00	3.84	3.84	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	3.87	7.91	HGL ok
P-14	MH-14	DI-15	1.60	3.80	3.80	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	3.84	8.68	HGL ok
P-15	DI-15	DI-16	1.60	3.76	3.76	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	3.80	9.01	HGL ok
P-16	DI-16	MH-17	1.60	3.71	3.71	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	3.76	9.77	HGL ok
P-18	B7 South	MH-14	1.20	3.84	3.84	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.85	10.00	HGL ok
P-01	DI-01	DI-02	1.00	3.88	3.88	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.89	6.84	HGL ok
P-02	DI-02	DI-03	1.00	3.87	3.87	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	3.88	7.35	HGL ok
P-03	DI-03	MH-04	1.00	3.84	3.84	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	3.87	7.91	HGL ok
P-04	MH-04	DI-05	1.20	3.80	3.80	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	3.84	8.60	HGL ok
P-05	DI-05	DI-06	1.60	3.76	3.76	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	3.80	9.01	HGL ok
P-06	DI-06	MH-17	1.60	3.71	3.71	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	3.76	9.87	HGL ok
P-17	MH-17	MH-35	1.60	3.66	3.66	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	3.71	10.61	HGL ok
P-08	DI-08	MH-07	1.00	3.78	3.78	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.78	11.39	HGL ok
P-07	MH-07	DI-06	1.20	3.76	3.76	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	3.78	10.19	HGL ok
P-09	B9/J	MH-04	1.20	3.84	3.84	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.85	10.00	HGL ok
P-10	B9/J	MH-07	1.20	3.78	3.78	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.78	10.00	HGL ok
P-20	TD-05	DI-21	0.53	4.96	7.08	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	7.13	10.50	HGL ok
P-21	DI-21	MH-22	1.00	4.10	4.92	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	4.96	9.46	HGL ok
P-22	MH-22	MH-23	1.20	3.96	4.08	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	4.10	9.72	HGL ok
P-23	MH-23	MH-24	1.20	3.82	3.82	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	3.96	10.97	HGL ok
P-24	MH-24	MH-35	1.20	3.66	3.66	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	3.82	11.20	HGL ok
P-25	DI-25	MH-22	1.00	4.10	4.92	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.92	9.46	HGL ok
P-26	B8/K	MH-23	1.20	3.96	3.98	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.99	10.00	HGL ok
P-27	B6 South	MH-23	1.20	3.96	3.98	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.99	10.00	HGL ok
P-28	DI-28	MH-24	1.20	3.82	3.82	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.82	10.95	HGL ok
P-29	DI-29	MH-24	1.20	3.82	3.82	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.82	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	4.15	4.15	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	4.18	7.00	HGL ok
P-42	MH-42	DI-43	2.00	4.14	4.14	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	4.15	7.86	HGL ok
P-43	DI-43	DI-44	2.00	4.11	4.11	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	4.14	7.11	HGL ok
P-44	DI-44	DI-45	2.00	4.07	4.07	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	4.11	7.03	HGL ok
P-45	DI-45	MH-46	2.00	4.04	4.04	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	4.07	7.59	HGL ok
P-46	MH-46	DI-47	2.00	4.00	4.00	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	4.04	8.54	HGL ok
P-47	DI-47	MH-60	2.40	3.93	3.93	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	4.00	9.09	HGL ok
P-60	MH-60	MH-61	2.40	3.88	3.88	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	3.93	9.84	HGL ok
P-61	MH-61	DI-62	2.40	3.81	3.81	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	3.88	11.03	HGL ok
P-62	DI-62	DI-63	2.40	3.76	3.76	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	3.81	10.34	HGL ok
P-63	DI-63	DI-77	1.93	3.66	3.66	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	3.76	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.56	3.56	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	3.66	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.44	3.44	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	3.56	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.42	3.42	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	3.44	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.40**	**3.40**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**3.42**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	4.15	4.15	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	4.17	8.07	HGL ok
P-50	B7 North	1.00	1.20	4.04	4.04	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	4.06	10.00	HGL ok
P-65	B7 West	MH-64	1.20	3.79	3.79	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.81	10.00	HGL ok
P-64	MH-64	DI-63	1.20	3.76	3.76	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	3.79	10.14	HGL ok
P-51	DI-51	DI-52	1.00	4.04	4.57	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.57	7.11	HGL ok
P-52	DI-52	DI-53	1.00	4.03	4.03	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	4.04	7.03	HGL ok
P-53	DI-53	MH-54	1.00	4.01	4.01	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	4.03	7.59	HGL ok
P-54	MH-54	DI-55	1.60	3.98	3.98	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	4.01	8.54	HGL ok
P-55	DI-55	MH-60	1.60	3.93	3.93	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	3.98	9.09	HGL ok
P-56	B5 South	MH-54	1.20	4.01	4.01	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	4.03	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.86	6.44	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.44	11.60	HGL ok
P-79	DI-79	DI-71	1.20	4.83	5.86	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	5.86	11.15	HGL ok
P-71	DI-71	DI-72	1.20	4.05	4.82	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	4.83	11.15	HGL ok
P-72	DI-72	DI-73	1.20	3.93	4.04	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	4.05	10.99	HGL ok
P-73	DI-73	MH-74	1.20	3.92	3.92	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	3.93	10.84	HGL ok
P-74	MH-74	DI-75	1.20	3.88	3.88	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	3.92	11.24	HGL ok
P-75	DI-75	DI-76	1.20	3.78	3.78	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	3.88	10.63	HGL ok
P-76	DI-76	DI-77	1.20	3.66	3.66	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	3.78	10.34	HGL ok
P-70	DI-70	DI-71	1.00	4.83	5.66	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.66	11.60	HGL ok
P-80	DI-80	MH-74	1.20	3.92	3.92	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	3.93	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.50	3.50	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.51	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.42	3.42	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	3.50	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.50	3.50	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	3.52	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.44	8.00	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.07	10.50	HGL ok
P-38	DI-38	DI-39	1.00	3.57	3.57	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.57	10.67	HGL ok
P-39	DI-39	DI-40	1.00	3.57	3.57	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	3.57	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.56	3.56	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	3.57	9.98	HGL ok
P-35	MH-35	DI-36	2.40	3.73	3.73	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	3.86	11.72	HGL ok
P-36	DI-36	DI-37	2.40	3.65	3.65	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	3.73	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add $H_c = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.56	3.56	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	3.65	10.16	HGL ok
P-30	DI-30	MH-35	1.20	3.86	3.86	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.86	11.24	HGL ok
P-11	DI-11	DI-12	1.00	4.08	4.08	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.09	6.84	HGL ok
P-12	DI-12	DI-13	1.00	4.07	4.07	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	4.08	6.99	HGL ok
P-13	DI-13	MH-14	1.00	4.04	4.04	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	4.07	7.91	HGL ok
P-14	MH-14	DI-15	1.60	4.00	4.00	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	4.04	8.68	HGL ok
P-15	DI-15	DI-16	1.60	3.96	3.96	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	4.00	9.01	HGL ok
P-16	DI-16	MH-17	1.60	3.91	3.91	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	3.96	9.77	HGL ok
P-18	B7 South	MH-14	1.20	4.04	4.04	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.05	10.00	HGL ok
P-01	DI-01	DI-02	1.00	4.08	4.08	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.09	6.84	HGL ok
P-02	DI-02	DI-03	1.00	4.07	4.07	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	4.08	7.35	HGL ok
P-03	DI-03	MH-04	1.00	4.04	4.04	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	4.07	7.91	HGL ok
P-04	MH-04	DI-05	1.20	4.00	4.00	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	4.04	8.60	HGL ok
P-05	DI-05	DI-06	1.60	3.96	3.96	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	4.00	9.01	HGL ok
P-06	DI-06	MH-17	1.60	3.91	3.91	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	3.96	9.87	HGL ok
P-17	MH-17	MH-35	1.60	3.86	3.86	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	3.91	10.61	HGL ok
P-08	DI-08	MH-07	1.00	3.98	3.98	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.98	11.39	HGL ok
P-07	MH-07	DI-06	1.20	3.96	3.96	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	3.98	10.19	HGL ok
P-09	B9/J	MH-04	1.20	4.04	4.04	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.05	10.00	HGL ok
P-10	B9/J	MH-07	1.20	3.98	3.98	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	3.98	10.00	HGL ok
P-20	TD-05	DI-21	0.53	4.96	7.08	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	7.13	10.50	HGL ok
P-21	DI-21	MH-22	1.00	4.18	4.92	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	4.96	9.46	HGL ok
P-22	MH-22	MH-23	1.20	4.16	4.16	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	4.18	9.72	HGL ok
P-23	MH-23	MH-24	1.20	4.02	4.02	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	4.16	10.97	HGL ok
P-24	MH-24	MH-35	1.20	3.86	3.86	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	4.02	11.20	HGL ok
P-25	DI-25	MH-22	1.00	4.18	4.92	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.92	9.46	HGL ok
P-26	B8/K	MH-23	1.20	4.16	4.16	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.17	10.00	HGL ok
P-27	B6 South	MH-23	1.20	4.16	4.16	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.18	10.00	HGL ok
P-28	DI-28	MH-24	1.20	4.02	4.02	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.02	10.95	HGL ok
P-29	DI-29	MH-24	1.20	4.02	4.02	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.02	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q'V'for determining controlling Inflow pipe	Q''V''for determining controlling Inflow pipe	Q'''V'''for determining controlling Inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	7.65	7.65	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	7.68	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	7.64	7.64	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	7.65	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	7.61	7.61	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	7.64	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	7.57	7.57	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	7.61	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	7.54	7.54	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	7.57	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	7.50	7.50	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	7.54	8.54	HGL ok
P-47	DI-47	MH-60	2.40	7.43	7.43	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	7.50	9.09	HGL ok
P-60	MH-60	MH-61	2.40	7.38	7.38	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	7.43	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.31	7.31	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	7.38	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.26	7.26	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	7.31	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.16	7.16	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	7.26	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.06	7.06	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	7.16	10.08	HGL ok
P-85	DI-85	MH-86	4.00	6.94	6.94	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	7.06	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.92	6.92	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	6.94	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**6.90**	**6.90**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**6.92**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	7.65	7.65	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	7.67	8.07	HGL Too H
P-50	B7 North	1.00	1.20	7.54	7.54	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	7.56	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.29	7.29	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.31	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.26	7.26	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	7.29	10.14	HGL ok
P-51	DI-51	DI-52	1.00	7.54	7.54	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.54	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	7.53	7.53	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	7.54	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	7.51	7.51	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	7.53	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	7.48	7.48	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	7.51	8.54	HGL ok
P-55	DI-55	MH-60	1.60	7.43	7.43	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	7.48	9.09	HGL ok
P-56	B5 South	MH-54	1.20	7.51	7.51	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.53	10.00	HGL ok
P-78	DI-78	DI-79	1.00	7.45	7.45	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.45	11.60	HGL ok
P-79	DI-79	DI-71	1.20	7.45	7.45	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	7.45	11.15	HGL ok
P-71	DI-71	DI-72	1.20	7.44	7.44	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	7.45	11.15	HGL ok
P-72	DI-72	DI-73	1.20	7.43	7.43	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	7.44	10.99	HGL ok
P-73	DI-73	MH-74	1.20	7.42	7.42	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	7.43	10.84	HGL ok
P-74	MH-74	DI-75	1.20	7.38	7.38	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	7.42	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.28	7.28	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	7.38	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.16	7.16	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	7.28	10.34	HGL ok
P-70	DI-70	DI-71	1.00	7.45	7.45	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.45	11.60	HGL ok
P-80	DI-80	MH-74	1.20	7.42	7.42	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	7.43	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.00	7.00	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.01	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.92	6.92	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	7.00	8.33	HGL ok
P-92	B6 North	DI-91	1.20	7.00	7.00	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	7.02	10.00	HGL ok
P-95	TD-04	MH-86	0.80	6.94	8.00	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.07	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.07	7.07	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.07	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.07	7.07	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.07	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.06	7.06	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	7.07	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.23	7.23	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	7.36	11.72	HGL ok
P-36	DI-36	DI-37	2.40	7.15	7.15	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	7.23	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add $H_c = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.06	7.06	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	7.15	10.16	HGL ok
P-30	DI-30	MH-35	1.20	7.36	7.36	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.36	11.24	HGL ok
P-11	DI-11	DI-12	1.00	7.58	7.58	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.59	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	7.57	7.57	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	7.58	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	7.54	7.54	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	7.57	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	7.50	7.50	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	7.54	8.68	HGL ok
P-15	DI-15	DI-16	1.60	7.46	7.46	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	7.50	9.01	HGL ok
P-16	DI-16	MH-17	1.60	7.41	7.41	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	7.46	9.77	HGL ok
P-18	B7 South	MH-14	1.20	7.54	7.54	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.55	10.00	HGL ok
P-01	DI-01	DI-02	1.00	7.58	7.58	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.59	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	7.57	7.57	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	7.58	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	7.54	7.54	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	7.57	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	7.50	7.50	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	7.54	8.60	HGL ok
P-05	DI-05	DI-06	1.60	7.46	7.46	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	7.50	9.01	HGL ok
P-06	DI-06	MH-17	1.60	7.41	7.41	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	7.46	9.87	HGL ok
P-17	MH-17	MH-35	1.60	7.36	7.36	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	7.41	10.61	HGL ok
P-08	DI-08	MH-07	1.00	7.48	7.48	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.48	11.39	HGL ok
P-07	MH-07	DI-06	1.20	7.46	7.46	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	7.48	10.19	HGL ok
P-09	B9/J	MH-04	1.20	7.54	7.54	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.55	10.00	HGL ok
P-10	B9/J	MH-07	1.20	7.48	7.48	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.48	10.00	HGL ok
P-20	TD-05	DI-21	0.53	7.72	7.72	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	7.77	10.50	HGL ok
P-21	DI-21	MH-22	1.00	7.68	7.68	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	7.72	9.46	HGL ok
P-22	MH-22	MH-23	1.20	7.66	7.66	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	7.68	9.72	HGL ok
P-23	MH-23	MH-24	1.20	7.52	7.52	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	7.66	10.97	HGL ok
P-24	MH-24	MH-35	1.20	7.36	7.36	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	7.52	11.20	HGL ok
P-25	DI-25	MH-22	1.00	7.68	7.68	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.68	9.46	HGL ok
P-26	B8/K	MH-23	1.20	7.66	7.66	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.67	10.00	HGL ok
P-27	B6 South	MH-23	1.20	7.66	7.66	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.68	10.00	HGL ok
P-28	DI-28	MH-24	1.20	7.52	7.52	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.52	10.95	HGL ok
P-29	DI-29	MH-24	1.20	7.52	7.52	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.52	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q'V'for determining controlling inflow pipe	Q'V'for determining controlling inflow pipe	Q'V'for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	8.15	8.15	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	8.18	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	8.14	8.14	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	8.15	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	8.11	8.11	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	8.14	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	8.07	8.07	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	8.11	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	8.04	8.04	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	8.07	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	8.00	8.00	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	8.04	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	7.93	7.93	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	8.00	9.09	HGL ok
P-60	MH-60	MH-61	2.40	7.88	7.88	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	7.93	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.81	7.81	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	7.88	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.76	7.76	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	7.81	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.66	7.66	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	7.76	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.56	7.56	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	7.66	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.44	7.44	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	7.56	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.42	7.42	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	7.44	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.40**	**7.40**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**7.42**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	8.15	8.15	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	8.17	8.07	HGL Too H
P-50	B7 North	1.00	1.20	8.04	8.04	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	8.06	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.79	7.79	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.81	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.76	7.76	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	7.79	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.04	8.04	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.04	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	8.03	8.03	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	8.04	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	8.01	8.01	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	8.03	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	7.98	7.98	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	8.01	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	7.93	7.93	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	7.98	9.09	HGL ok
P-56	B5 South	MH-54	1.20	8.01	8.01	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.03	10.00	HGL ok
P-78	DI-78	DI-79	1.00	7.95	7.95	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.95	11.60	HGL ok
P-79	DI-79	DI-71	1.20	7.95	7.95	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	7.95	11.15	HGL ok
P-71	DI-71	DI-72	1.20	7.94	7.94	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	7.95	11.15	HGL ok
P-72	DI-72	DI-73	1.20	7.93	7.93	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	7.94	10.99	HGL ok
P-73	DI-73	MH-74	1.20	7.92	7.92	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	7.93	10.84	HGL ok
P-74	MH-74	DI-75	1.20	7.88	7.88	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	7.92	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.78	7.78	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	7.88	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.66	7.66	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	7.78	10.34	HGL ok
P-70	DI-70	DI-71	1.00	7.95	7.95	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.95	11.60	HGL ok
P-80	DI-80	MH-74	1.20	7.92	7.92	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	7.93	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.50	7.50	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.51	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.42	7.42	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	7.50	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	7.50	7.50	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	7.52	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.44	8.00	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.07	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.57	7.57	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.57	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.57	7.57	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.57	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.56	7.56	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	7.57	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.73	7.73	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	7.86	11.72	HGL ok
P-36	DI-36	DI-37	2.40	7.65	7.65	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	7.73	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.56	7.56	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	7.65	10.16	HGL ok
P-30	DI-30	MH-35	1.20	7.86	7.86	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.86	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.08	8.08	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.09	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	8.07	8.07	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	8.08	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	8.04	8.04	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	8.07	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	8.00	8.00	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	8.04	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	7.96	7.96	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	8.00	9.01	HGL ok
P-16	DI-16	MH-17	1.60	7.91	7.91	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	7.96	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.04	8.04	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.05	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.08	8.08	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.09	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	8.07	8.07	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	8.08	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	8.04	8.04	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	8.07	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	8.00	8.00	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	8.04	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	7.96	7.96	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	8.00	9.01	HGL ok
P-06	DI-06	MH-17	1.60	7.91	7.91	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	7.96	9.87	HGL ok
P-17	MH-17	MH-35	1.60	7.86	7.86	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	7.91	10.61	HGL ok
P-08	DI-08	MH-07	1.00	7.98	7.98	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.98	11.39	HGL ok
P-07	MH-07	DI-06	1.20	7.96	7.96	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	7.98	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.04	8.04	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.05	10.00	HGL ok
P-10	B9/J	MH-07	1.20	7.98	7.98	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.98	10.00	HGL ok
P-20	TD-05	DI-21	0.53	8.22	8.22	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	8.27	10.50	HGL ok
P-21	DI-21	MH-22	1.00	8.18	8.18	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	8.22	9.46	HGL ok
P-22	MH-22	MH-23	1.20	8.16	8.16	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	8.18	9.72	HGL ok
P-23	MH-23	MH-24	1.20	8.02	8.02	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	8.16	10.97	HGL ok
P-24	MH-24	MH-35	1.20	7.86	7.86	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	8.02	11.20	HGL ok
P-25	DI-25	MH-22	1.00	8.18	8.18	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.18	9.46	HGL ok
P-26	B8/K	MH-23	1.20	8.16	8.16	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.17	10.00	HGL ok
P-27	B6 South	MH-23	1.20	8.16	8.16	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.18	10.00	HGL ok
P-28	DI-28	MH-24	1.20	8.02	8.02	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.02	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.02	8.02	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.02	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q'V'for determining controlling inflow pipe	Q''V''for determining controlling inflow pipe	Q'''V'''for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	8.55	8.55	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	8.58	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	8.54	8.54	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	8.55	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	8.51	8.51	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	8.54	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	8.47	8.47	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	8.51	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	8.44	8.44	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	8.47	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	8.40	8.40	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	8.44	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	8.33	8.33	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	8.40	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	8.28	8.28	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	8.33	9.84	HGL ok
P-61	MH-61	DI-62	2.40	8.21	8.21	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	8.28	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.16	8.16	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	8.21	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.06	8.06	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	8.16	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.96	7.96	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	8.06	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.84	7.84	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	7.96	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.82	7.82	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	7.84	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.80**	**7.80**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	0.5	**0.02**	**0.02**	**7.82**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	8.55	8.55	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	8.57	8.07	HGL Too H
P-50	B7 North	1.00	1.20	8.44	8.44	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	8.46	10.00	HGL ok
P-65	B7 West	MH-64	1.20	8.19	8.19	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.21	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.16	8.16	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	8.19	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.44	8.44	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.44	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	8.43	8.43	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	8.44	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	8.41	8.41	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	8.43	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	8.38	8.38	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	8.41	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	8.33	8.33	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	8.38	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	8.41	8.41	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.43	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.35	8.35	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.35	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.35	8.35	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	8.35	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.34	8.34	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	8.35	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.33	8.33	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	8.34	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.32	8.32	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	8.33	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.28	8.28	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	8.32	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.18	8.18	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	8.28	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.06	8.06	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	8.18	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.35	8.35	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.35	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.32	8.32	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	8.33	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.90	7.90	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.91	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.82	7.82	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	7.90	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	7.90	7.90	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	7.92	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.84	8.00	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.07	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.97	7.97	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.97	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.97	7.97	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	7.97	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.96	7.96	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	7.97	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.13	8.13	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	8.26	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.05	8.05	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	8.13	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add Hc = 0.002*O*V_o^2/2g	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.96	7.96	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	8.05	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.26	8.26	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.26	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.48	8.48	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.49	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	8.47	8.47	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	8.48	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	8.44	8.44	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	8.47	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	8.40	8.40	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	8.44	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	8.36	8.36	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	8.40	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	8.31	8.31	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	8.36	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.44	8.44	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.45	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.48	8.48	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.49	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	8.47	8.47	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	8.48	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	8.44	8.44	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	8.47	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	8.40	8.40	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	8.44	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	8.36	8.36	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	8.40	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	8.31	8.31	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	8.36	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.26	8.26	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	8.31	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.38	8.38	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.38	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.36	8.36	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	8.38	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.44	8.44	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.45	10.00	HGL ok
P-10	B9/J	MH-07	1.20	8.38	8.38	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.38	10.00	HGL ok
P-20	TD-05	DI-21	0.53	8.62	8.62	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	8.67	10.50	HGL ok
P-21	DI-21	MH-22	1.00	8.58	8.58	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	8.62	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	8.56	8.56	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	8.58	9.72	HGL ok
P-23	MH-23	MH-24	1.20	8.42	8.42	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	8.56	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.26	8.26	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	8.42	11.20	HGL ok
P-25	DI-25	MH-22	1.00	8.58	8.58	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.58	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	8.56	8.56	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.57	10.00	HGL ok
P-27	B6 South	MH-23	1.20	8.56	8.56	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.58	10.00	HGL ok
P-28	DI-28	MH-24	1.20	8.42	8.42	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.42	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.42	8.42	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.42	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	9.05	9.05	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	9.08	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	9.04	9.04	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	9.05	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	9.01	9.01	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	9.04	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	8.97	8.97	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	9.01	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	8.94	8.94	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	8.97	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	8.90	8.90	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	8.94	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	8.83	8.83	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	8.90	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	8.78	8.78	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	8.83	9.84	HGL ok
P-61	MH-61	DI-62	2.40	8.71	8.71	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	8.78	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.66	8.66	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	8.71	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.56	8.56	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	8.66	10.08	HGL ok
P-77	DI-77	DI-85	3.20	8.46	8.46	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	8.56	10.08	HGL ok
P-85	DI-85	MH-86	4.00	8.34	8.34	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	8.46	9.98	HGL ok
P-86	MH-86	MH-87	4.00	8.32	8.32	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	8.34	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**8.30**	**8.30**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**8.32**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.05	9.05	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	9.07	8.07	HGL Too H
P-50	B7 North	1.00	1.20	8.94	8.94	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	8.96	10.00	HGL ok
P-65	B7 West	MH-64	1.20	8.69	8.69	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.71	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.66	8.66	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	8.69	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.94	8.94	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.94	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	8.93	8.93	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	8.94	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	8.91	8.91	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	8.93	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	8.88	8.88	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	8.91	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	8.83	8.83	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	8.88	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	8.91	8.91	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.93	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.85	8.85	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.85	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.85	8.85	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	8.85	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.84	8.84	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	8.85	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.83	8.83	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	8.84	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.82	8.82	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	8.83	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.78	8.78	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	8.82	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.68	8.68	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	8.78	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.56	8.56	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	8.68	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.85	8.85	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.85	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.82	8.82	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	8.83	11.00	HGL ok
P-90	DI-90	DI-91	1.00	8.40	8.40	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.41	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	8.32	8.32	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	8.40	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	8.40	8.40	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	8.42	10.00	HGL ok
P-95	TD-04	MH-86	0.80	8.34	8.34	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.41	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.47	8.47	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.47	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.47	8.47	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	8.47	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.46	8.46	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	8.47	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.63	8.63	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	8.76	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.55	8.55	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	8.63	10.67	HGL ok

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add Hc = 0.002*O*V_o^2/2g	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.46	8.46	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	8.55	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.76	8.76	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.76	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.98	8.98	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.99	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	8.97	8.97	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	8.98	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	8.94	8.94	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	8.97	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	8.90	8.90	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	8.94	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	8.86	8.86	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	8.90	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	8.81	8.81	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	8.86	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	8.94	8.94	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.95	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.98	8.98	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.99	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	8.97	8.97	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	8.98	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	8.94	8.94	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	8.97	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	8.90	8.90	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	8.94	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	8.86	8.86	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	8.90	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	8.81	8.81	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	8.86	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.76	8.76	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	8.81	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.88	8.88	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.88	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.86	8.86	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	8.88	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.94	8.94	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.95	10.00	HGL ok
P-10	B9/J	MH-07	1.20	8.88	8.88	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.88	10.00	HGL ok
P-20	TD-05	DI-21	0.53	9.12	9.12	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	9.17	10.50	HGL ok
P-21	DI-21	MH-22	1.00	9.08	9.08	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	9.12	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	9.06	9.06	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	9.08	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	8.92	8.92	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	9.06	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.76	8.76	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	8.92	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.08	9.08	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.08	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	9.06	9.06	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.07	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	9.06	9.06	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.08	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	8.92	8.92	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.92	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.92	8.92	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.92	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q'V'for determining controlling Inflow pipe	Q'V'for determining controlling Inflow pipe	Q'V'for determining controlling Inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^3/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	9.75	9.75	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	9.78	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	9.74	9.74	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	9.75	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	9.71	9.71	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	9.74	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	9.67	9.67	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	9.71	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	9.64	9.64	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	9.67	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	9.60	9.60	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	9.64	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	9.53	9.53	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	9.60	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	9.48	9.48	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	9.53	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	9.41	9.41	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	9.48	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.36	9.36	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	9.41	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	9.26	9.26	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	9.36	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	9.16	9.16	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	9.26	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	9.04	9.04	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	9.16	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	9.02	9.02	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	9.04	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.00**	**9.00**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**9.02**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.75	9.75	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	9.77	8.07	HGL Too H
P-50	B7 North	1.00	1.20	9.64	9.64	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.66	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	9.39	9.39	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.41	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	9.36	9.36	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	9.39	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	9.64	9.64	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.64	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	9.63	9.63	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	9.64	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	9.61	9.61	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	9.63	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	9.58	9.58	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	9.61	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	9.53	9.53	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	9.58	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	9.61	9.61	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.63	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	9.55	9.55	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.55	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.55	9.55	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	9.55	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.54	9.54	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	9.55	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.53	9.53	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	9.54	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.52	9.52	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	9.53	10.84	HGL ok
P-74	MH-74	DI-75	1.20	9.48	9.48	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	9.52	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.38	9.38	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	9.48	10.63	HGL ok
P-76	DI-76	DI-77	1.20	9.26	9.26	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	9.38	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	9.55	9.55	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.55	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.52	9.52	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.53	11.00	HGL ok
P-90	DI-90	DI-91	1.00	9.10	9.10	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.11	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	9.02	9.02	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	9.10	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	9.10	9.10	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	9.12	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	9.04	9.04	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.11	10.50	HGL ok
P-38	DI-38	DI-39	1.00	9.17	9.17	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.17	10.67	HGL ok
P-39	DI-39	DI-40	1.00	9.17	9.17	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.17	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	9.16	9.16	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	9.17	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	9.33	9.33	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	9.46	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.25	9.25	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	9.33	10.67	HGL ok

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.16	9.16	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	9.25	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	9.46	9.46	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.46	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.68	9.68	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.69	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	9.67	9.67	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	9.68	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	9.64	9.64	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	9.67	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	9.60	9.60	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	9.64	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	9.56	9.56	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	9.60	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	9.51	9.51	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	9.56	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	9.64	9.64	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.65	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	9.68	9.68	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.69	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	9.67	9.67	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	9.68	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	9.64	9.64	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	9.67	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	9.60	9.60	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	9.64	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	9.56	9.56	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	9.60	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	9.51	9.51	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	9.56	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	9.46	9.46	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	9.51	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.58	9.58	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.58	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.56	9.56	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	9.58	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	9.64	9.64	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.65	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	9.58	9.58	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.58	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	9.82	9.82	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	9.87	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	9.78	9.78	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	9.82	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	9.76	9.76	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	9.78	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	9.62	9.62	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	9.76	10.97	HGL ok
P-24	MH-24	MH-35	1.20	9.46	9.46	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	9.62	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.78	9.78	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.78	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	9.76	9.76	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.77	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	9.76	9.76	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.78	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	9.62	9.62	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.62	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.62	9.62	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.62	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)	

No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D) ft	Tailwater, link to Inle WSE of downstream pipe (TW) ft	Outlet W. S. Elevation (HGL Dn) ft	Outflow Pipe Diameter (D_o) in	Outflow Pipe Design Flow (Q_o) cfs	Pressure-flow Vel., $V_o=Q_o/A$ (V_o) fps	Skew angle vs. (Δ_o) deg	Outflow Pipe Length (L) ft	Friction Slope (S_{fo}) ft/ft	Friction Loss (H_f) ft	Angle of Curvatu (O) deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c) ft	Contraction Loss (H_o) ft	Q*V for determining controlling inflow pipe (Q1V1) ft^4/s^2	Q*V for determining controlling inflow pipe (Q2V2) ft^4/s^2	Q*V for determining controlling inflow pipe (Q3V3) ft^4/s^2	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi) ft	Controlling In-flow skew (Δ_i) deg	Bend Loss (H_Δ) ft	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ (H_t) cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\ adj}$) ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ (H) ft	Inlet W. S. Elevation (HGL Up) ft	Top of Grate (T/G) ft	HGL Check
P-41	MH-41	MH-42	1.60	10.25	10.25	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	10.28	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	10.24	10.24	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	10.25	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	10.21	10.21	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	10.24	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	10.17	10.17	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	10.21	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	10.14	10.14	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	10.17	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	10.10	10.10	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	10.14	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	10.03	10.03	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	10.10	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	9.98	9.98	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	10.03	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	9.91	9.91	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	9.98	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.86	9.86	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	9.91	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	9.76	9.76	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	9.86	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	9.66	9.66	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	9.76	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	9.54	9.54	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	9.66	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	9.52	9.52	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	9.54	10.50	HGL Too H
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.50**	**9.50**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**9.52**	**10.50**	**HGL Too H**
P-48	MSS MH-08	MH-49	1.60	10.25	10.25	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	10.27	8.07	HGL Too H
P-50	B7 North	1.00	1.20	10.14	10.14	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.16	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	9.89	9.89	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.91	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	9.86	9.86	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	9.89	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	10.14	10.14	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.14	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	10.13	10.13	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	10.14	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	10.11	10.11	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	10.13	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	10.08	10.08	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	10.11	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	10.03	10.03	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	10.08	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	10.11	10.11	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.13	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	10.05	10.05	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.05	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.05	10.05	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	10.05	11.15	HGL ok
P-71	DI-71	DI-72	1.20	10.04	10.04	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	10.05	11.15	HGL ok
P-72	DI-72	DI-73	1.20	10.03	10.03	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	10.04	10.99	HGL Too H
P-73	DI-73	MH-74	1.20	10.02	10.02	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	10.03	10.84	HGL Too H
P-74	MH-74	DI-75	1.20	9.98	9.98	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	10.02	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.88	9.88	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	9.98	10.63	HGL Too H
P-76	DI-76	DI-77	1.20	9.76	9.76	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	9.88	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	10.05	10.05	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.05	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.02	10.02	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.03	11.00	HGL Too H
P-90	DI-90	DI-91	1.00	9.60	9.60	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.61	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	9.52	9.52	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	9.60	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	9.60	9.60	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	9.62	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	9.54	9.54	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.61	10.50	HGL Too H
P-38	DI-38	DI-39	1.00	9.67	9.67	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.67	10.67	HGL Too H
P-39	DI-39	DI-40	1.00	9.67	9.67	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.67	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	9.66	9.66	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	9.67	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	9.83	9.83	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	9.96	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.75	9.75	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	9.83	10.67	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add $H_c = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.66	9.66	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	9.75	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	9.96	9.96	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.96	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.18	10.18	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.19	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	10.17	10.17	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	10.18	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	10.14	10.14	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	10.17	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	10.10	10.10	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	10.14	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	10.06	10.06	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	10.10	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	10.01	10.01	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	10.06	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	10.14	10.14	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.15	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	10.18	10.18	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.19	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	10.17	10.17	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	10.18	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	10.14	10.14	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	10.17	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	10.10	10.10	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	10.14	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	10.06	10.06	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	10.10	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	10.01	10.01	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	10.06	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	9.96	9.96	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	10.01	10.61	HGL Too H
P-08	DI-08	MH-07	1.00	10.08	10.08	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.08	11.39	HGL ok
P-07	MH-07	DI-06	1.20	10.06	10.06	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	10.08	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	10.14	10.14	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.15	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	10.08	10.08	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.08	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	10.32	10.32	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	10.37	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	10.28	10.28	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	10.32	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	10.26	10.26	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	10.28	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	10.12	10.12	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	10.26	10.97	HGL Too H
P-24	MH-24	MH-35	1.20	9.96	9.96	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	10.12	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.28	10.28	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.28	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	10.26	10.26	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.27	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	10.26	10.26	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.28	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	10.12	10.12	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.12	10.95	HGL Too H
P-29	DI-29	MH-24	1.20	10.12	10.12	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.12	10.95	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 1

Date: 2/23/23
Date: 3/23/23
-year (50-year for sumps)

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q'V'for determining controlling inflow pipe	Q'V'for determining controlling inflow pipe	Q'V'for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^3/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.55	11.55	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	11.58	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	11.54	11.54	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	11.55	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	11.51	11.51	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	11.54	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	11.47	11.47	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	11.51	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	11.44	11.44	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	11.47	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	11.40	11.40	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	11.44	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	11.33	11.33	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	11.40	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	11.28	11.28	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	11.33	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	11.21	11.21	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	11.28	11.03	HGL Too H
P-62	DI-62	DI-63	2.40	11.16	11.16	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	11.21	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	11.06	11.06	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	11.16	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	10.96	10.96	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	11.06	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	10.84	10.84	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	10.96	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	10.82	10.82	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	10.84	10.50	HGL Too H
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.80**	**10.80**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**10.82**	**10.50**	**HGL Too H**
P-48	MSS MH-08	MH-49	1.60	11.55	11.55	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	11.57	8.07	HGL Too H
P-50	B7 North	1.00	1.20	11.44	11.44	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.46	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	11.19	11.19	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.21	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	11.16	11.16	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	11.19	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	11.44	11.44	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.44	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	11.43	11.43	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	11.44	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	11.41	11.41	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	11.43	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	11.38	11.38	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	11.41	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	11.33	11.33	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	11.38	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	11.41	11.41	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.43	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	11.35	11.35	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.35	11.60	HGL Too H
P-79	DI-79	DI-71	1.20	11.35	11.35	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	11.35	11.15	HGL Too H
P-71	DI-71	DI-72	1.20	11.34	11.34	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	11.35	11.15	HGL Too H
P-72	DI-72	DI-73	1.20	11.33	11.33	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	11.34	10.99	HGL Too H
P-73	DI-73	MH-74	1.20	11.32	11.32	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	11.33	10.84	HGL Too H
P-74	MH-74	DI-75	1.20	11.28	11.28	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	11.32	11.24	HGL Too H
P-75	DI-75	DI-76	1.20	11.18	11.18	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	11.28	10.63	HGL Too H
P-76	DI-76	DI-77	1.20	11.06	11.06	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	11.18	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	11.35	11.35	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.35	11.60	HGL Too H
P-80	DI-80	MH-74	1.20	11.32	11.32	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.33	11.00	HGL Too H
P-90	DI-90	DI-91	1.00	10.90	10.90	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.91	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	10.82	10.82	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	10.90	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	10.90	10.90	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	10.92	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	10.84	10.84	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.91	10.50	HGL Too H
P-38	DI-38	DI-39	1.00	10.97	10.97	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.97	10.67	HGL Too H
P-39	DI-39	DI-40	1.00	10.97	10.97	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.97	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	10.96	10.96	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	10.97	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	11.13	11.13	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	11.26	11.72	HGL Too H
P-36	DI-36	DI-37	2.40	11.05	11.05	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	11.13	10.67	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: 2 of 5
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Central Green Outfall — Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add $H_c = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.96	10.96	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	11.05	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	11.26	11.26	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.26	11.24	HGL Too H
P-11	DI-11	DI-12	1.00	11.48	11.48	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.49	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	11.47	11.47	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	11.48	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	11.44	11.44	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	11.47	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	11.40	11.40	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	11.44	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	11.36	11.36	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	11.40	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	11.31	11.31	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	11.36	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	11.44	11.44	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.45	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	11.48	11.48	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.49	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	11.47	11.47	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	11.48	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	11.44	11.44	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	11.47	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	11.40	11.40	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	11.44	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	11.36	11.36	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	11.40	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	11.31	11.31	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	11.36	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	11.26	11.26	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	11.31	10.61	HGL Too H
P-08	DI-08	MH-07	1.00	11.38	11.38	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.38	11.39	HGL Too H
P-07	MH-07	DI-06	1.20	11.36	11.36	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	11.38	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	11.44	11.44	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.45	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	11.38	11.38	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.38	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	11.62	11.62	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	11.67	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	11.58	11.58	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	11.62	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	11.56	11.56	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	11.58	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	11.42	11.42	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	11.56	10.97	HGL Too H
P-24	MH-24	MH-35	1.20	11.26	11.26	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	11.42	11.20	HGL Too H
P-25	DI-25	MH-22	1.00	11.58	11.58	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.58	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	11.56	11.56	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.57	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	11.56	11.56	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.58	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	11.42	11.42	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.42	10.95	HGL Too H
P-29	DI-29	MH-24	1.20	11.42	11.42	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.42	10.95	HGL Too H

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County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q'V'for determining controlling inflow pipe	Q''V''for determining controlling inflow pipe	Q'''V'''for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	6.49	6.49	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	6.52	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	6.48	6.48	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	6.49	7.86	HGL ok
P-43	DI-43	DI-44	2.00	6.45	6.45	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	6.48	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	6.41	6.41	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	6.45	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	6.38	6.38	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	6.41	7.59	HGL ok
P-46	MH-46	DI-47	2.00	6.34	6.34	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	6.38	8.54	HGL ok
P-47	DI-47	MH-60	2.40	6.27	6.27	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	6.34	9.09	HGL ok
P-60	MH-60	MH-61	2.40	6.22	6.22	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	6.27	9.84	HGL ok
P-61	MH-61	DI-62	2.40	6.15	6.15	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	6.22	11.03	HGL ok
P-62	DI-62	DI-63	2.40	6.10	6.10	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	6.15	10.34	HGL ok
P-63	DI-63	DI-77	1.93	6.00	6.00	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	6.10	10.08	HGL ok
P-77	DI-77	DI-85	3.20	5.90	5.90	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	6.00	10.08	HGL ok
P-85	DI-85	MH-86	4.00	5.78	5.78	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	5.90	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.76	5.76	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	5.78	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.74**	**5.74**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**5.76**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	6.49	6.49	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	6.51	8.07	HGL ok
P-50	B7 North	1.00	1.20	6.38	6.38	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	6.40	10.00	HGL ok
P-65	B7 West	MH-64	1.20	6.13	6.13	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.15	10.00	HGL ok
P-64	MH-64	DI-63	1.20	6.10	6.10	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	6.13	10.14	HGL ok
P-51	DI-51	DI-52	1.00	6.38	6.38	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.38	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	6.37	6.37	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	6.38	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	6.35	6.35	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	6.37	7.59	HGL ok
P-54	MH-54	DI-55	1.60	6.32	6.32	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	6.35	8.54	HGL ok
P-55	DI-55	MH-60	1.60	6.27	6.27	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	6.32	9.09	HGL ok
P-56	B5 South	MH-54	1.20	6.35	6.35	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.37	10.00	HGL ok
P-78	DI-78	DI-79	1.00	6.29	6.44	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.44	11.60	HGL ok
P-79	DI-79	DI-71	1.20	6.29	6.29	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	6.29	11.15	HGL ok
P-71	DI-71	DI-72	1.20	6.28	6.28	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	6.29	11.15	HGL ok
P-72	DI-72	DI-73	1.20	6.27	6.27	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	6.28	10.99	HGL ok
P-73	DI-73	MH-74	1.20	6.26	6.26	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	6.27	10.84	HGL ok
P-74	MH-74	DI-75	1.20	6.22	6.22	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	6.26	11.24	HGL ok
P-75	DI-75	DI-76	1.20	6.12	6.12	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	6.22	10.63	HGL ok
P-76	DI-76	DI-77	1.20	6.00	6.00	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	6.12	10.34	HGL ok
P-70	DI-70	DI-71	1.00	6.29	6.29	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.29	11.60	HGL ok
P-80	DI-80	MH-74	1.20	6.26	6.26	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	6.27	11.00	HGL ok
P-90	DI-90	DI-91	1.00	5.84	5.84	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.85	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.76	5.76	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	5.84	8.33	HGL ok
P-92	B6 North	DI-91	1.20	5.84	5.84	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	5.86	10.00	HGL ok
P-95	TD-04	MH-86	0.80	5.78	8.00	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.07	10.50	HGL ok
P-38	DI-38	DI-39	1.00	5.91	5.91	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.91	10.67	HGL ok
P-39	DI-39	DI-40	1.00	5.91	5.91	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	5.91	10.16	HGL ok
P-40	DI-40	DI-85	1.20	5.90	5.90	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	5.91	9.98	HGL ok
P-35	MH-35	DI-36	2.40	6.07	6.07	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	6.20	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.06	5.99	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	6.07	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	5.90	5.90	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	5.99	10.16	HGL ok
P-30	DI-30	MH-35	1.20	6.20	6.20	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.20	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.42	6.42	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.43	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	6.41	6.41	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	6.42	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	6.38	6.38	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	6.41	7.91	HGL ok
P-14	MH-14	DI-15	1.60	6.34	6.34	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	6.38	8.68	HGL ok
P-15	DI-15	DI-16	1.60	6.30	6.30	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	6.34	9.01	HGL ok
P-16	DI-16	MH-17	1.60	6.25	6.25	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	6.30	9.77	HGL ok
P-18	B7 South	MH-14	1.20	6.38	6.38	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.39	10.00	HGL ok
P-01	DI-01	DI-02	1.00	6.42	6.42	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.43	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	6.41	6.41	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	6.42	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	6.38	6.38	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	6.41	7.91	HGL ok
P-04	MH-04	DI-05	1.20	6.34	6.34	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	6.38	8.60	HGL ok
P-05	DI-05	DI-06	1.60	6.30	6.30	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	6.34	9.01	HGL ok
P-06	DI-06	MH-17	1.60	6.25	6.25	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	6.30	9.87	HGL ok
P-17	MH-17	MH-35	1.60	6.20	6.20	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	6.25	10.61	HGL ok
P-08	DI-08	MH-07	1.00	6.32	6.32	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.32	11.39	HGL ok
P-07	MH-07	DI-06	1.20	6.30	6.30	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	6.32	10.19	HGL ok
P-09	B9/J	MH-04	1.20	6.38	6.38	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.39	10.00	HGL ok
P-10	B9/J	MH-07	1.20	6.32	6.32	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.32	10.00	HGL ok
P-20	TD-05	DI-21	0.53	6.56	7.08	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	7.13	10.50	HGL ok
P-21	DI-21	MH-22	1.00	6.52	6.52	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	6.56	9.46	HGL ok
P-22	MH-22	MH-23	1.20	6.50	6.50	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	6.52	9.72	HGL ok
P-23	MH-23	MH-24	1.20	6.36	6.36	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	6.50	10.97	HGL ok
P-24	MH-24	MH-35	1.20	6.20	6.20	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	6.36	11.20	HGL ok
P-25	DI-25	MH-22	1.00	6.52	6.52	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.52	9.46	HGL ok
P-26	B8/K	MH-23	1.20	6.50	6.50	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.51	10.00	HGL ok
P-27	B6 South	MH-23	1.20	6.50	6.50	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.52	10.00	HGL ok
P-28	DI-28	MH-24	1.20	6.36	6.36	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.36	10.95	HGL ok
P-29	DI-29	MH-24	1.20	6.36	6.36	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.36	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR — Date: 2/23/23 — Sheet No.: 2 of 5
Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Design Freq.: 1 -year (50-year for sumps)

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	6.69	6.69	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	6.72	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	6.68	6.68	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	6.69	7.86	HGL ok
P-43	DI-43	DI-44	2.00	6.65	6.65	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	6.68	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	6.61	6.61	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	6.65	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	6.58	6.58	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	6.61	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	6.54	6.54	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	6.58	8.54	HGL ok
P-47	DI-47	MH-60	2.40	6.47	6.47	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	6.54	9.09	HGL ok
P-60	MH-60	MH-61	2.40	6.42	6.42	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	6.47	9.84	HGL ok
P-61	MH-61	DI-62	2.40	6.35	6.35	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	6.42	11.03	HGL ok
P-62	DI-62	DI-63	2.40	6.30	6.30	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	6.35	10.34	HGL ok
P-63	DI-63	DI-77	1.93	6.20	6.20	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	6.30	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.10	6.10	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	6.20	10.08	HGL ok
P-85	DI-85	MH-86	4.00	5.98	5.98	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	6.10	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.96	5.96	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	5.98	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.94**	**5.94**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**5.96**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	6.69	6.69	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	6.71	8.07	HGL ok
P-50	B7 North	1.00	1.20	6.58	6.58	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	6.60	10.00	HGL ok
P-65	B7 West	MH-64	1.20	6.33	6.33	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.35	10.00	HGL ok
P-64	MH-64	DI-63	1.20	6.30	6.30	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	6.33	10.14	HGL ok
P-51	DI-51	DI-52	1.00	6.58	6.58	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.58	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	6.57	6.57	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	6.58	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	6.55	6.55	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	6.57	7.59	HGL ok
P-54	MH-54	DI-55	1.60	6.52	6.52	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	6.55	8.54	HGL ok
P-55	DI-55	MH-60	1.60	6.47	6.47	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	6.52	9.09	HGL ok
P-56	B5 South	MH-54	1.20	6.55	6.55	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.57	10.00	HGL ok
P-78	DI-78	DI-79	1.00	6.49	6.49	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.49	11.60	HGL ok
P-79	DI-79	DI-71	1.20	6.49	6.49	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	6.49	11.15	HGL ok
P-71	DI-71	DI-72	1.20	6.48	6.48	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	6.49	11.15	HGL ok
P-72	DI-72	DI-73	1.20	6.47	6.47	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	6.48	10.99	HGL ok
P-73	DI-73	MH-74	1.20	6.46	6.46	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	6.47	10.84	HGL ok
P-74	MH-74	DI-75	1.20	6.42	6.42	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	6.46	11.24	HGL ok
P-75	DI-75	DI-76	1.20	6.32	6.32	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	6.42	10.63	HGL ok
P-76	DI-76	DI-77	1.20	6.20	6.20	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	6.32	10.34	HGL ok
P-70	DI-70	DI-71	1.00	6.49	6.49	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.49	11.60	HGL ok
P-80	DI-80	MH-74	1.20	6.46	6.46	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	6.47	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.04	6.04	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.05	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.96	5.96	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	6.04	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.04	6.04	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	6.06	10.00	HGL ok
P-95	TD-04	MH-86	0.80	5.98	8.00	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.07	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.11	6.11	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.11	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.11	6.11	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	6.11	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.10	6.10	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	6.11	9.98	HGL ok
P-35	MH-35	DI-36	2.40	6.27	6.27	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	6.40	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.19	6.19	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	6.27	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.10	6.10	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	6.19	10.16	HGL ok
P-30	DI-30	MH-35	1.20	6.40	6.40	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.40	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.62	6.62	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.63	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	6.61	6.61	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	6.62	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	6.58	6.58	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	6.61	7.91	HGL ok
P-14	MH-14	DI-15	1.60	6.54	6.54	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	6.58	8.68	HGL ok
P-15	DI-15	DI-16	1.60	6.50	6.50	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	6.54	9.01	HGL ok
P-16	DI-16	MH-17	1.60	6.45	6.45	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	6.50	9.77	HGL ok
P-18	B7 South	MH-14	1.20	6.58	6.58	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.59	10.00	HGL ok
P-01	DI-01	DI-02	1.00	6.62	6.62	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.63	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	6.61	6.61	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	6.62	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	6.58	6.58	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	6.61	7.91	HGL ok
P-04	MH-04	DI-05	1.20	6.54	6.54	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	6.58	8.60	HGL ok
P-05	DI-05	DI-06	1.60	6.50	6.50	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	6.54	9.01	HGL ok
P-06	DI-06	MH-17	1.60	6.45	6.45	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	6.50	9.87	HGL ok
P-17	MH-17	MH-35	1.60	6.40	6.40	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	6.45	10.61	HGL ok
P-08	DI-08	MH-07	1.00	6.52	6.52	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.52	11.39	HGL ok
P-07	MH-07	DI-06	1.20	6.50	6.50	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	6.52	10.19	HGL ok
P-09	B9/J	MH-04	1.20	6.58	6.58	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.59	10.00	HGL ok
P-10	B9/J	MH-07	1.20	6.52	6.52	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.52	10.00	HGL ok
P-20	TD-05	DI-21	0.53	6.76	7.08	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	7.13	10.50	HGL ok
P-21	DI-21	MH-22	1.00	6.72	6.72	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	6.76	9.46	HGL ok
P-22	MH-22	MH-23	1.20	6.70	6.70	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	6.72	9.72	HGL ok
P-23	MH-23	MH-24	1.20	6.56	6.56	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	6.70	10.97	HGL ok
P-24	MH-24	MH-35	1.20	6.40	6.40	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	6.56	11.20	HGL ok
P-25	DI-25	MH-22	1.00	6.72	6.72	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.72	9.46	HGL ok
P-26	B8/K	MH-23	1.20	6.70	6.70	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.71	10.00	HGL ok
P-27	B6 South	MH-23	1.20	6.70	6.70	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.72	10.00	HGL ok
P-28	DI-28	MH-24	1.20	6.56	6.56	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.56	10.95	HGL ok
P-29	DI-29	MH-24	1.20	6.56	6.56	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.56	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR — Date: 2/23/23 — Sheet No.: 2 of 5
Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Design Freq.: 1 -year (50-year for sumps)

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H=H_f+H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	10.19	10.19	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	10.22	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	10.18	10.18	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	10.19	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	10.15	10.15	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	10.18	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	10.11	10.11	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	10.15	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	10.08	10.08	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	10.11	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	10.04	10.04	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	10.08	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	9.97	9.97	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	10.04	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	9.92	9.92	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	9.97	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	9.85	9.85	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	9.92	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.80	9.80	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	9.85	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	9.70	9.70	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	9.80	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	9.60	9.60	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	9.70	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	9.48	9.48	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	9.60	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	9.46	9.46	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	9.48	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.44**	**9.44**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**9.46**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.19	10.19	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	10.21	8.07	HGL Too H
P-50	B7 North	1.00	1.20	10.08	10.08	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.10	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	9.83	9.83	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.85	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	9.80	9.80	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	9.83	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	10.08	10.08	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.08	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	10.07	10.07	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	10.08	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	10.05	10.05	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	10.07	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	10.02	10.02	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	10.05	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	9.97	9.97	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	10.02	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	10.05	10.05	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.07	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	9.99	9.99	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.99	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.99	9.99	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	9.99	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.98	9.98	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	9.99	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.97	9.97	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	9.98	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.96	9.96	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	9.97	10.84	HGL Too H
P-74	MH-74	DI-75	1.20	9.92	9.92	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	9.96	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.82	9.82	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	9.92	10.63	HGL Too H
P-76	DI-76	DI-77	1.20	9.70	9.70	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	9.82	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	9.99	9.99	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.99	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.96	9.96	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.97	11.00	HGL ok
P-90	DI-90	DI-91	1.00	9.54	9.54	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.55	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	9.46	9.46	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	9.54	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	9.54	9.54	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	9.56	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	9.48	9.48	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.55	10.50	HGL Too H
P-38	DI-38	DI-39	1.00	9.61	9.61	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.61	10.67	HGL ok
P-39	DI-39	DI-40	1.00	9.61	9.61	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	9.61	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	9.60	9.60	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	9.61	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	9.77	9.77	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	9.90	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.69	9.69	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	9.77	10.67	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, ilnk to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add Hc = 0.002*O*V_o^2/2g	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.60	9.60	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	9.69	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	9.90	9.90	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.90	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.12	10.12	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.13	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	10.11	10.11	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	10.12	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	10.08	10.08	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	10.11	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	10.04	10.04	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	10.08	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	10.00	10.00	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	10.04	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	9.95	9.95	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	10.00	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	10.08	10.08	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.09	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	10.12	10.12	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.13	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	10.11	10.11	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	10.12	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	10.08	10.08	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	10.11	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	10.04	10.04	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	10.08	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	10.00	10.00	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	10.04	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	9.95	9.95	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	10.00	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	9.90	9.90	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	9.95	10.61	HGL Too H
P-08	DI-08	MH-07	1.00	10.02	10.02	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.02	11.39	HGL ok
P-07	MH-07	DI-06	1.20	10.00	10.00	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	10.02	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	10.08	10.08	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.09	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	10.02	10.02	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.02	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	10.26	10.26	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	10.31	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	10.22	10.22	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	10.26	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	10.20	10.20	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	10.22	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	10.06	10.06	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	10.20	10.97	HGL Too H
P-24	MH-24	MH-35	1.20	9.90	9.90	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	10.06	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.22	10.22	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.22	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	10.20	10.20	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.21	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	10.20	10.20	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.22	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	10.06	10.06	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.06	10.95	HGL Too H
P-29	DI-29	MH-24	1.20	10.06	10.06	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.06	10.95	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q'V'for determining controlling Inflow pipe	Q'V'for determining controlling Inflow pipe	Q'V'for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	10.69	10.69	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	10.72	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	10.68	10.68	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	10.69	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	10.65	10.65	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	10.68	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	10.61	10.61	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	10.65	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	10.58	10.58	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	10.61	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	10.54	10.54	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	10.58	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	10.47	10.47	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	10.54	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	10.42	10.42	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	10.47	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	10.35	10.35	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	10.42	11.03	HGL Too H
P-62	DI-62	DI-63	2.40	10.30	10.30	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	10.35	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	10.20	10.20	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	10.30	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	10.10	10.10	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	10.20	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	9.98	9.98	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	10.10	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	9.96	9.96	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	9.98	10.50	HGL Too H
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.94**	**9.94**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**9.96**	**10.50**	**HGL Too H**
P-48	MSS MH-08	MH-49	1.60	10.69	10.69	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	10.71	8.07	HGL Too H
P-50	B7 North	1.00	1.20	10.58	10.58	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.60	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	10.33	10.33	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.35	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	10.30	10.30	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	10.33	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	10.58	10.58	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.58	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	10.57	10.57	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	10.58	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	10.55	10.55	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	10.57	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	10.52	10.52	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	10.55	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	10.47	10.47	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	10.52	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	10.55	10.55	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.57	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	10.49	10.49	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.49	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.49	10.49	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	10.49	11.15	HGL Too H
P-71	DI-71	DI-72	1.20	10.48	10.48	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	10.49	11.15	HGL Too H
P-72	DI-72	DI-73	1.20	10.47	10.47	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	10.48	10.99	HGL Too H
P-73	DI-73	MH-74	1.20	10.46	10.46	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	10.47	10.84	HGL Too H
P-74	MH-74	DI-75	1.20	10.42	10.42	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	10.46	11.24	HGL Too H
P-75	DI-75	DI-76	1.20	10.32	10.32	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	10.42	10.63	HGL Too H
P-76	DI-76	DI-77	1.20	10.20	10.20	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	10.32	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	10.49	10.49	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.49	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.46	10.46	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.47	11.00	HGL Too H
P-90	DI-90	DI-91	1.00	10.04	10.04	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.05	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	9.96	9.96	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	10.04	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	10.04	10.04	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	10.06	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	9.98	9.98	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.05	10.50	HGL Too H
P-38	DI-38	DI-39	1.00	10.11	10.11	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.11	10.67	HGL Too H
P-39	DI-39	DI-40	1.00	10.11	10.11	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.11	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	10.10	10.10	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	10.11	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	10.27	10.27	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	10.40	11.72	HGL ok
P-36	DI-36	DI-37	2.40	10.19	10.19	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	10.27	10.67	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add H_c = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.10	10.10	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	10.19	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	10.40	10.40	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.40	11.24	HGL Too H
P-11	DI-11	DI-12	1.00	10.62	10.62	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.63	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	10.61	10.61	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	10.62	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	10.58	10.58	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	10.61	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	10.54	10.54	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	10.58	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	10.50	10.50	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	10.54	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	10.45	10.45	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	10.50	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	10.58	10.58	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.59	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	10.62	10.62	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.63	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	10.61	10.61	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	10.62	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	10.58	10.58	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	10.61	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	10.54	10.54	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	10.58	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	10.50	10.50	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	10.54	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	10.45	10.45	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	10.50	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	10.40	10.40	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	10.45	10.61	HGL Too H
P-08	DI-08	MH-07	1.00	10.52	10.52	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.52	11.39	HGL Too H
P-07	MH-07	DI-06	1.20	10.50	10.50	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	10.52	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	10.58	10.58	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.59	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	10.52	10.52	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.52	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	10.76	10.76	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	10.81	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	10.72	10.72	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	10.76	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	10.70	10.70	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	10.72	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	10.56	10.56	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	10.70	10.97	HGL Too H
P-24	MH-24	MH-35	1.20	10.40	10.40	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	10.56	11.20	HGL Too H
P-25	DI-25	MH-22	1.00	10.72	10.72	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.72	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	10.70	10.70	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.71	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	10.70	10.70	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.72	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	10.56	10.56	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.56	10.95	HGL Too H
P-29	DI-29	MH-24	1.20	10.56	10.56	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.56	10.95	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q'V'for determining controlling Inflow pipe	Q''V''for determining controlling Inflow pipe	Q'''V'''for determining controlling Inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.09	11.09	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	11.12	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	11.08	11.08	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	11.09	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	11.05	11.05	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	11.08	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	11.01	11.01	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	11.05	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	10.98	10.98	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	11.01	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	10.94	10.94	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	10.98	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	10.87	10.87	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	10.94	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	10.82	10.82	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	10.87	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	10.75	10.75	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	10.82	11.03	HGL Too H
P-62	DI-62	DI-63	2.40	10.70	10.70	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	10.75	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	10.60	10.60	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	10.70	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	10.50	10.50	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	10.60	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	10.38	10.38	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	10.50	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	10.36	10.36	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	10.38	10.50	HGL Too H
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.34**	**10.34**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**10.36**	**10.50**	**HGL Too H**
P-48	MSS MH-08	MH-49	1.60	11.09	11.09	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	11.11	8.07	HGL Too H
P-50	B7 North	1.00	1.20	10.98	10.98	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.00	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	10.73	10.73	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.75	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	10.70	10.70	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	10.73	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	10.98	10.98	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.98	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	10.97	10.97	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	10.98	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	10.95	10.95	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	10.97	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	10.92	10.92	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	10.95	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	10.87	10.87	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	10.92	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	10.95	10.95	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.97	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	10.89	10.89	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.89	11.60	HGL Too H
P-79	DI-79	DI-71	1.20	10.89	10.89	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	10.89	11.15	HGL Too H
P-71	DI-71	DI-72	1.20	10.88	10.88	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	10.89	11.15	HGL Too H
P-72	DI-72	DI-73	1.20	10.87	10.87	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	10.88	10.99	HGL Too H
P-73	DI-73	MH-74	1.20	10.86	10.86	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	10.87	10.84	HGL Too H
P-74	MH-74	DI-75	1.20	10.82	10.82	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	10.86	11.24	HGL Too H
P-75	DI-75	DI-76	1.20	10.72	10.72	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	10.82	10.63	HGL Too H
P-76	DI-76	DI-77	1.20	10.60	10.60	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	10.72	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	10.89	10.89	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.89	11.60	HGL Too H
P-80	DI-80	MH-74	1.20	10.86	10.86	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.87	11.00	HGL Too H
P-90	DI-90	DI-91	1.00	10.44	10.44	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.45	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	10.36	10.36	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	10.44	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	10.44	10.44	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	10.46	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	10.38	10.38	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.45	10.50	HGL Too H
P-38	DI-38	DI-39	1.00	10.51	10.51	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.51	10.67	HGL Too H
P-39	DI-39	DI-40	1.00	10.51	10.51	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	10.51	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	10.50	10.50	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	10.51	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	10.67	10.67	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	10.80	11.72	HGL Too H
P-36	DI-36	DI-37	2.40	10.59	10.59	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	10.67	10.67	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add H_c = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.50	10.50	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	10.59	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	10.80	10.80	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.80	11.24	HGL Too H
P-11	DI-11	DI-12	1.00	11.02	11.02	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.03	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	11.01	11.01	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	11.02	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	10.98	10.98	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	11.01	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	10.94	10.94	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	10.98	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	10.90	10.90	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	10.94	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	10.85	10.85	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	10.90	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	10.98	10.98	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.99	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	11.02	11.02	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.03	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	11.01	11.01	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	11.02	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	10.98	10.98	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	11.01	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	10.94	10.94	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	10.98	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	10.90	10.90	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	10.94	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	10.85	10.85	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	10.90	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	10.80	10.80	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	10.85	10.61	HGL Too H
P-08	DI-08	MH-07	1.00	10.92	10.92	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.92	11.39	HGL Too H
P-07	MH-07	DI-06	1.20	10.90	10.90	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	10.92	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	10.98	10.98	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.99	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	10.92	10.92	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.92	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	11.16	11.16	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	11.21	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	11.12	11.12	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	11.16	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	11.10	11.10	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	11.12	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	10.96	10.96	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	11.10	10.97	HGL Too H
P-24	MH-24	MH-35	1.20	10.80	10.80	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	10.96	11.20	HGL Too H
P-25	DI-25	MH-22	1.00	11.12	11.12	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.12	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	11.10	11.10	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.11	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	11.10	11.10	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.12	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	10.96	10.96	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.96	10.95	HGL Too H
P-29	DI-29	MH-24	1.20	10.96	10.96	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.96	10.95	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR Date: 2/23/23 Sheet No.: 2 of 5
Checked by: TMC Date: 3/23/23 Cm. No.: 20077
Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.59	11.59	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	11.62	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	11.58	11.58	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	11.59	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	11.55	11.55	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	11.58	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	11.51	11.51	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	11.55	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	11.48	11.48	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	11.51	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	11.44	11.44	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	11.48	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	11.37	11.37	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	11.44	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	11.32	11.32	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	11.37	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	11.25	11.25	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	11.32	11.03	HGL Too H
P-62	DI-62	DI-63	2.40	11.20	11.20	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	11.25	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	11.10	11.10	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	11.20	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	11.00	11.00	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	11.10	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	10.88	10.88	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	11.00	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	10.86	10.86	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	10.88	10.50	HGL Too H
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.84**	**10.84**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**10.86**	**10.50**	**HGL Too H**
P-48	MSS MH-08	MH-49	1.60	11.59	11.59	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	11.61	8.07	HGL Too H
P-50	B7 North	1.00	1.20	11.48	11.48	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.50	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	11.23	11.23	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.25	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	11.20	11.20	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	11.23	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	11.48	11.48	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.48	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	11.47	11.47	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	11.48	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	11.45	11.45	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	11.47	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	11.42	11.42	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	11.45	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	11.37	11.37	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	11.42	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	11.45	11.45	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.47	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	11.39	11.39	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.39	11.60	HGL Too H
P-79	DI-79	DI-71	1.20	11.39	11.39	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	11.39	11.15	HGL Too H
P-71	DI-71	DI-72	1.20	11.38	11.38	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	11.39	11.15	HGL Too H
P-72	DI-72	DI-73	1.20	11.37	11.37	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	11.38	10.99	HGL Too H
P-73	DI-73	MH-74	1.20	11.36	11.36	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	11.37	10.84	HGL Too H
P-74	MH-74	DI-75	1.20	11.32	11.32	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	11.36	11.24	HGL Too H
P-75	DI-75	DI-76	1.20	11.22	11.22	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	11.32	10.63	HGL Too H
P-76	DI-76	DI-77	1.20	11.10	11.10	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	11.22	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	11.39	11.39	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.39	11.60	HGL Too H
P-80	DI-80	MH-74	1.20	11.36	11.36	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.37	11.00	HGL Too H
P-90	DI-90	DI-91	1.00	10.94	10.94	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.95	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	10.86	10.86	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	10.94	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	10.94	10.94	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	10.96	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	10.88	10.88	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.95	10.50	HGL Too H
P-38	DI-38	DI-39	1.00	11.01	11.01	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.01	10.67	HGL Too H
P-39	DI-39	DI-40	1.00	11.01	11.01	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.01	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	11.00	11.00	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	11.01	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	11.17	11.17	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	11.30	11.72	HGL Too H
P-36	DI-36	DI-37	2.40	11.09	11.09	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	11.17	10.67	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add $H_c = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.00	11.00	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	11.09	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	11.30	11.30	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.30	11.24	HGL Too H
P-11	DI-11	DI-12	1.00	11.52	11.52	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.53	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	11.51	11.51	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	*1.3*	1.0	0.00	0.02	11.52	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	11.48	11.48	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	*1.3*	1.0	0.01	0.03	11.51	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	11.44	11.44	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	*0.5*	0.02	0.03	11.48	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	11.40	11.40	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	11.44	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	11.35	11.35	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	11.40	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	11.48	11.48	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.02	11.49	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	11.52	11.52	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.53	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	11.51	11.51	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	*1.3*	1.0	0.01	0.01	11.52	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	11.48	11.48	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	*1.3*	1.0	0.01	0.03	11.51	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	11.44	11.44	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	*0.5*	0.01	0.05	11.48	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	11.40	11.40	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	11.44	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	11.35	11.35	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	11.40	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	11.30	11.30	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	*0.5*	0.03	0.05	11.35	10.61	HGL Too H
P-08	DI-08	MH-07	1.00	11.42	11.42	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.42	11.39	HGL Too H
P-07	MH-07	DI-06	1.20	11.40	11.40	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	*0.5*	0.01	0.02	11.42	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	11.48	11.48	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	11.49	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	11.42	11.42	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	11.42	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	11.66	11.66	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	11.71	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	11.62	11.62	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	*1.3*	1.0	0.03	0.04	11.66	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	11.60	11.60	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	*0.5*	0.01	0.02	11.62	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	11.46	11.46	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	*0.5*	0.02	0.14	11.60	10.97	HGL Too H
P-24	MH-24	MH-35	1.20	11.30	11.30	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	*0.5*	0.04	0.16	11.46	11.20	HGL Too H
P-25	DI-25	MH-22	1.00	11.62	11.62	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.62	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	11.60	11.60	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	11.61	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	11.60	11.60	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	11.62	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	11.46	11.46	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.46	10.95	HGL Too H
P-29	DI-29	MH-24	1.20	11.46	11.46	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.46	10.95	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 1 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe TW (ft)	Outlet W. S. Elevation HGL Dn (ft)	Outflow Pipe Diameter D_o (in)	Outflow Pipe Design Flow Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$ V_o (fps)	Skew angle vs. Δ_o (deg)	Outflow Pipe Length L (ft)	Friction Slope S_{fo} (ft/ft)	Friction Loss H_f (ft)	Angle of Curvature O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c (ft)	Contraction Loss H_o (ft)	Q*V for determining controlling inflow pipe Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q3V3 (ft^4/s^2)	Controlling Inflow Velocity Vi	Expansion Loss Hi (ft)	Controlling In-flow skew Δ_i (deg)	Bend Loss H_Δ (ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ (ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ H (ft)	Inlet W. S. Elevation HGL Up (ft)	Top of Grate T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	12.29	12.29	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	12.32	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	12.28	12.28	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	12.29	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	12.25	12.25	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	12.28	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	12.21	12.21	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	12.25	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	12.18	12.18	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	12.21	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	12.14	12.14	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	12.18	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	12.07	12.07	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	12.14	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	12.02	12.02	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	12.07	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	11.95	11.95	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	12.02	11.03	HGL Too H
P-62	DI-62	DI-63	2.40	11.90	11.90	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	11.95	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	11.80	11.80	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	11.90	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	11.70	11.70	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	11.80	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	11.58	11.58	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	11.70	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	11.56	11.56	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	11.58	10.50	HGL Too H
P-87	**MH-87**	**OUTFALL**	**4.00**	**11.54**	**11.54**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**11.56**	**10.50**	**HGL Too H**
P-48	MSS MH-08	MH-49	1.60	12.29	12.29	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	12.31	8.07	HGL Too H
P-50	B7 North	1.00	1.20	12.18	12.18	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	12.20	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	11.93	11.93	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.95	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	11.90	11.90	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	11.93	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	12.18	12.18	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.18	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	12.17	12.17	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	12.18	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	12.15	12.15	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	12.17	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	12.12	12.12	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	12.15	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	12.07	12.07	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	12.12	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	12.15	12.15	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.17	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	12.09	12.09	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.09	11.60	HGL Too H
P-79	DI-79	DI-71	1.20	12.09	12.09	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	12.09	11.15	HGL Too H
P-71	DI-71	DI-72	1.20	12.08	12.08	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	12.09	11.15	HGL Too H
P-72	DI-72	DI-73	1.20	12.07	12.07	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	12.08	10.99	HGL Too H
P-73	DI-73	MH-74	1.20	12.06	12.06	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	12.07	10.84	HGL Too H
P-74	MH-74	DI-75	1.20	12.02	12.02	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	12.06	11.24	HGL Too H
P-75	DI-75	DI-76	1.20	11.92	11.92	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	12.02	10.63	HGL Too H
P-76	DI-76	DI-77	1.20	11.80	11.80	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	11.92	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	12.09	12.09	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.09	11.60	HGL Too H
P-80	DI-80	MH-74	1.20	12.06	12.06	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	12.07	11.00	HGL Too H
P-90	DI-90	DI-91	1.00	11.64	11.64	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.65	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	11.56	11.56	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	11.64	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	11.64	11.64	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	11.66	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	11.58	11.58	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	11.65	10.50	HGL Too H
P-38	DI-38	DI-39	1.00	11.71	11.71	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.71	10.67	HGL Too H
P-39	DI-39	DI-40	1.00	11.71	11.71	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	11.71	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	11.70	11.70	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	11.71	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	11.87	11.87	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	12.00	11.72	HGL Too H
P-36	DI-36	DI-37	2.40	11.79	11.79	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	11.87	10.67	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add $H_c = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.70	11.70	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	11.79	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	12.00	12.00	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.00	11.24	HGL Too H
P-11	DI-11	DI-12	1.00	12.22	12.22	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.23	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	12.21	12.21	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	12.22	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	12.18	12.18	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	12.21	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	12.14	12.14	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	12.18	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	12.10	12.10	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	12.14	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	12.05	12.05	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	12.10	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	12.18	12.18	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.19	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	12.22	12.22	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.23	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	12.21	12.21	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	12.22	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	12.18	12.18	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	12.21	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	12.14	12.14	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	12.18	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	12.10	12.10	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	12.14	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	12.05	12.05	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	12.10	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	12.00	12.00	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	12.05	10.61	HGL Too H
P-08	DI-08	MH-07	1.00	12.12	12.12	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.12	11.39	HGL Too H
P-07	MH-07	DI-06	1.20	12.10	12.10	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	12.12	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	12.18	12.18	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.19	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	12.12	12.12	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.12	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	12.36	12.36	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	12.41	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	12.32	12.32	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	12.36	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	12.30	12.30	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	12.32	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	12.16	12.16	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	12.30	10.97	HGL Too H
P-24	MH-24	MH-35	1.20	12.00	12.00	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	12.16	11.20	HGL Too H
P-25	DI-25	MH-22	1.00	12.32	12.32	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.32	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	12.30	12.30	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.31	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	12.30	12.30	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.32	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	12.16	12.16	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.16	10.95	HGL Too H
P-29	DI-29	MH-24	1.20	12.16	12.16	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.16	10.95	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H=H_f+H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	12.79	12.79	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	12.82	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	12.78	12.78	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	12.79	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	12.75	12.75	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	12.78	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	12.71	12.71	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	12.75	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	12.68	12.68	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	12.71	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	12.64	12.64	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	12.68	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	12.57	12.57	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	12.64	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	12.52	12.52	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	12.57	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	12.45	12.45	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	12.52	11.03	HGL Too H
P-62	DI-62	DI-63	2.40	12.40	12.40	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	12.45	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	12.30	12.30	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	12.40	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	12.20	12.20	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	12.30	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	12.08	12.08	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	12.20	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	12.06	12.06	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	12.08	10.50	HGL Too H
P-87	**MH-87**	**OUTFALL**	**4.00**	**12.04**	**12.04**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	**0.5**	**0.02**	**0.02**	**12.06**	**10.50**	**HGL Too H**
P-48	MSS MH-08	MH-49	1.60	12.79	12.79	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	12.81	8.07	HGL Too H
P-50	B7 North	1.00	1.20	12.68	12.68	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	12.70	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	12.43	12.43	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.45	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	12.40	12.40	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	12.43	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	12.68	12.68	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.68	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	12.67	12.67	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	12.68	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	12.65	12.65	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	12.67	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	12.62	12.62	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	12.65	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	12.57	12.57	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	12.62	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	12.65	12.65	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.67	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	12.59	12.59	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.59	11.60	HGL Too H
P-79	DI-79	DI-71	1.20	12.59	12.59	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	12.59	11.15	HGL Too H
P-71	DI-71	DI-72	1.20	12.58	12.58	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	12.59	11.15	HGL Too H
P-72	DI-72	DI-73	1.20	12.57	12.57	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	12.58	10.99	HGL Too H
P-73	DI-73	MH-74	1.20	12.56	12.56	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	12.57	10.84	HGL Too H
P-74	MH-74	DI-75	1.20	12.52	12.52	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	12.56	11.24	HGL Too H
P-75	DI-75	DI-76	1.20	12.42	12.42	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	12.52	10.63	HGL Too H
P-76	DI-76	DI-77	1.20	12.30	12.30	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	12.42	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	12.59	12.59	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.59	11.60	HGL Too H
P-80	DI-80	MH-74	1.20	12.56	12.56	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	12.57	11.00	HGL Too H
P-90	DI-90	DI-91	1.00	12.14	12.14	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.15	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	12.06	12.06	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	12.14	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	12.14	12.14	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	12.16	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	12.08	12.08	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.15	10.50	HGL Too H
P-38	DI-38	DI-39	1.00	12.21	12.21	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.21	10.67	HGL Too H
P-39	DI-39	DI-40	1.00	12.21	12.21	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	12.21	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	12.20	12.20	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	12.21	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	12.37	12.37	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	12.50	11.72	HGL Too H
P-36	DI-36	DI-37	2.40	12.29	12.29	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	12.37	10.67	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.20	12.20	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	12.29	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	12.50	12.50	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.50	11.24	HGL Too H
P-11	DI-11	DI-12	1.00	12.72	12.72	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.73	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	12.71	12.71	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	12.72	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	12.68	12.68	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	12.71	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	12.64	12.64	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	12.68	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	12.60	12.60	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	12.64	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	12.55	12.55	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	12.60	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	12.68	12.68	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.69	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	12.72	12.72	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.73	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	12.71	12.71	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	12.72	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	12.68	12.68	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	12.71	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	12.64	12.64	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	12.68	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	12.60	12.60	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	12.64	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	12.55	12.55	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	12.60	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	12.50	12.50	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	12.55	10.61	HGL Too H
P-08	DI-08	MH-07	1.00	12.62	12.62	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.62	11.39	HGL Too H
P-07	MH-07	DI-06	1.20	12.60	12.60	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	12.62	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	12.68	12.68	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.69	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	12.62	12.62	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.62	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	12.86	12.86	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	12.91	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	12.82	12.82	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	12.86	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	12.80	12.80	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	12.82	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	12.66	12.66	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	12.80	10.97	HGL Too H
P-24	MH-24	MH-35	1.20	12.50	12.50	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	12.66	11.20	HGL Too H
P-25	DI-25	MH-22	1.00	12.82	12.82	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.82	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	12.80	12.80	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.81	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	12.80	12.80	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.82	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	12.66	12.66	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.66	10.95	HGL Too H
P-29	DI-29	MH-24	1.20	12.66	12.66	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.66	10.95	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	14.09	14.09	24	3.3	1.0	69	92	0.0002	0.02	0	0.00	0.00	3.4	0.0	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.03	14.12	7.00	HGL Too H
P-42	MH-42	DI-43	2.00	14.08	14.08	30	6.4	1.3	13	30	0.0002	0.01	0	0.00	0.01	3.4	3.6	0.0	1.1	0.0	51.7	0.01	0.02	1.0	0.5	0.01	0.02	14.09	7.86	HGL Too H
P-43	DI-43	DI-44	2.00	14.05	14.05	30	6.7	1.4	0	25	0.0002	0.01	0	0.00	0.01	8.4	0.0	0.0	1.3	0.0	13	0.01	0.02	1.0	1.0	0.02	0.03	14.08	7.11	HGL Too H
P-44	DI-44	DI-45	2.00	14.01	14.01	30	7.0	1.4	6	69	0.0003	0.02	0	0.00	0.01	9.1	0.0	0.0	1.4	0.0	0	0.00	0.02	1.0	1.0	0.02	0.04	14.05	7.03	HGL Too H
P-45	DI-45	MH-46	2.00	13.98	13.98	30	7.3	1.5	13	52	0.0003	0.01	0	0.00	0.01	10.1	0.0	0.0	1.4	0.0	6	0.00	0.02	1.0	1.0	0.02	0.04	14.01	7.59	HGL Too H
P-46	MH-46	DI-47	2.00	13.94	13.94	30	9.7	2.0	83	42	0.0005	0.02	0	0.00	0.02	10.9	4.4	0.0	1.5	0.0	13	0.01	0.03	1.0	0.5	0.02	0.04	13.98	8.54	HGL Too H
P-47	DI-47	MH-60	2.40	13.87	13.87	36	9.9	1.4	90	23	0.0002	0.00	0	0.00	0.01	19.1	0.0	0.0	2.0	0.0	83	0.04	0.07	1.0	1.0	0.07	0.07	13.94	9.09	HGL Too H
P-60	MH-60	MH-61	2.40	13.82	13.82	36	13.7	1.9	82	75	0.0004	0.03	0	0.00	0.01	13.9	5.9	0.0	1.4	0.0	90	0.02	0.05	1.0	0.5	0.02	0.05	13.87	9.84	HGL Too H
P-61	MH-61	DI-62	2.40	13.75	13.75	36	13.6	1.9	7	76	0.0004	0.03	0	0.00	0.01	26.7	0.0	0.0	1.9	0.0	82	0.04	0.07	1.0	0.5	0.04	0.06	13.82	11.03	HGL Too H
P-62	DI-62	DI-63	2.40	13.70	13.70	36	13.6	1.9	89	50	0.0004	0.02	0	0.00	0.01	26.2	0.0	0.0	1.9	0.0	7	0.01	0.04	1.0	1.0	0.04	0.06	13.75	10.34	HGL Too H
P-63	DI-63	DI-77	1.93	13.60	13.60	36	15.9	2.3	92	25	0.0005	0.01	0	0.00	0.02	26.1	4.5	0.0	1.9	0.0	89	0.04	0.08	1.0	1.0	0.08	0.09	13.70	10.08	HGL Too H
P-77	DI-77	DI-85	3.20	13.50	13.50	48	19.5	1.6	91	50	0.0002	0.01	0	0.00	0.01	36.0	9.1	0.0	2.3	0.0	92	0.06	0.09	1.0	1.0	0.09	0.10	13.60	10.08	HGL Too H
P-85	DI-85	MH-86	4.00	13.38	13.38	60	34.6	1.8	17	186	0.0002	0.03	0	0.00	0.01	30.3	0.4	33.8	2.2	0.0	90	0.05	0.09	1.0	1.0	0.09	0.12	13.50	9.98	HGL Too H
P-86	MH-86	MH-87	4.00	13.36	13.36	60	36.0	1.8	0	45	0.0002	0.01	0	0.00	0.01	61.0	7.3	0.0	1.8	0.0	17	0.01	0.04	1.0	0.5	0.02	0.03	13.38	10.50	HGL Too H
P-87	**MH-87**	**OUTFALL**	**4.00**	**13.34**	**13.34**	**60**	**38.0**	**1.9**	**0**	**9**	**0.0002**	**0.00**	**0**	**0.00**	**0.01**	**65.9**	**4.6**	**0.0**	**1.8**	**0.0**	**0**	**0.00**	**0.03**	**1.0**	0.5	**0.02**	**0.02**	**13.36**	**10.50**	**HGL Too H**
P-48	MSS MH-08	MH-49	1.60	14.09	14.09	24	3.4	1.1	51.7	64	0.0002	0.01	0	0.00	0.00	2.1	0.6	0.0	0.8	0.0	51	0.01	0.01	1.0	0.5	0.01	0.02	14.11	8.07	HGL Too H
P-50	B7 North	1.00	1.20	13.98	13.98	18	2.8	1.6	83	16	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.00	10.00	HGL Too H
P-65	B7 West	MH-64	1.20	13.73	13.73	18	2.8	1.6	75	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.75	10.00	HGL Too H
P-64	MH-64	DI-63	1.20	13.70	13.70	18	2.8	1.6	74	20	0.0006	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	75	0.03	0.05	1.0	0.5	0.02	0.04	13.73	10.14	HGL Too H
P-51	DI-51	DI-52	1.00	13.98	13.98	15	0.3	0.2	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.98	7.11	HGL Too H
P-52	DI-52	DI-53	1.00	13.97	13.97	15	0.7	0.6	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	13.98	7.03	HGL Too H
P-53	DI-53	MH-54	1.00	13.95	13.95	15	1.1	0.9	13	51	0.0002	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	7	0.00	0.01	1.3	1.0	0.01	0.02	13.97	7.59	HGL Too H
P-54	MH-54	DI-55	1.60	13.92	13.92	24	3.9	1.2	83	41	0.0002	0.01	0	0.00	0.01	0.9	4.9	0.0	1.7	0.0	83	0.03	0.05	1.0	0.5	0.02	0.04	13.95	8.54	HGL Too H
P-55	DI-55	MH-60	1.60	13.87	13.87	24	4.3	1.4	90	23	0.0003	0.01	0	0.00	0.01	4.8	0.0	0.0	1.2	0.0	83	0.02	0.03	1.3	1.0	0.04	0.05	13.92	9.09	HGL Too H
P-56	B5 South	MH-54	1.20	13.95	13.95	18	2.9	1.7	83	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.97	10.00	HGL Too H
P-78	DI-78	DI-79	1.00	13.89	13.89	15	0.3	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.89	11.60	HGL Too H
P-79	DI-79	DI-71	1.20	13.89	13.89	18	0.6	0.3	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	13.89	11.15	HGL Too H
P-71	DI-71	DI-72	1.20	13.88	13.88	18	1.3	0.7	2	42	0.0001	0.01	0	0.00	0.00	0.2	0.1	0.0	0.3	0.0	82	0.00	0.00	1.3	1.0	0.00	0.01	13.89	11.15	HGL Too H
P-72	DI-72	DI-73	1.20	13.87	13.87	18	1.4	0.8	8	29	0.0002	0.00	0	0.00	0.00	0.9	0.0	0.0	0.7	0.0	2	0.00	0.01	1.3	1.0	0.01	0.01	13.88	10.99	HGL Too H
P-73	DI-73	MH-74	1.20	13.86	13.86	18	1.5	0.9	8	17	0.0002	0.00	0	0.00	0.00	1.1	0.0	0.0	0.8	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	13.87	10.84	HGL Too H
P-74	MH-74	DI-75	1.20	13.82	13.82	18	3.7	2.1	5	17	0.0011	0.02	0	0.00	0.02	1.3	2.9	0.0	1.3	0.0	82	0.02	0.04	1.0	0.5	0.02	0.04	13.86	11.24	HGL Too H
P-75	DI-75	DI-76	1.20	13.72	13.72	18	3.9	2.2	9	43	0.0011	0.05	0	0.00	0.02	7.7	0.0	0.0	2.1	0.0	5	0.01	0.05	1.0	1.0	0.05	0.10	13.82	10.63	HGL Too H
P-76	DI-76	DI-77	1.20	13.60	13.60	18	4.0	2.3	2	51	0.0012	0.06	0	0.00	0.02	8.4	0.0	0.0	2.2	0.0	9	0.01	0.05	1.0	1.0	0.05	0.12	13.72	10.34	HGL Too H
P-70	DI-70	DI-71	1.00	13.89	13.89	15	0.3	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.89	11.60	HGL Too H
P-80	DI-80	MH-74	1.20	13.86	13.86	18	2.3	1.3	82	24	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.87	11.00	HGL Too H
P-90	DI-90	DI-91	1.00	13.44	13.44	15	0.6	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.45	9.20	HGL Too H
P-91	DI-91	MH-87	1.20	13.36	13.36	18	2.8	1.6	86	81	0.0006	0.05	0	0.00	0.01	0.3	1.7	0.0	1.0	0.0	90	0.01	0.03	1.3	1.0	0.03	0.08	13.44	8.33	HGL Too H
P-92	B6 North	DI-91	1.20	13.44	13.44	18	1.7	1.0	90	63	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.02	13.46	10.00	HGL Too H
P-95	TD-04	MH-86	0.80	13.38	13.38	12	2.4	3.1	90	16	0.0032	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	13.45	10.50	HGL Too H
P-38	DI-38	DI-39	1.00	13.51	13.51	15	0.1	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.51	10.67	HGL Too H
P-39	DI-39	DI-40	1.00	13.51	13.51	15	0.5	0.4	89	70	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.00	13.51	10.16	HGL Too H
P-40	DI-40	DI-85	1.20	13.50	13.50	18	0.9	0.5	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	13.51	9.98	HGL Too H
P-35	MH-35	DI-36	2.40	13.67	13.67	36	15.3	2.2	2	94	0.0005	0.04	0	0.00	0.02	0.0	15.0	16.6	3.1	0.1	78	0.10	0.17	1.0	0.5	0.08	0.12	13.80	11.72	HGL Too H
P-36	DI-36	DI-37	2.40	13.59	13.59	36	15.3	2.2	3	98	0.0004	0.04	0	0.00	0.02	33.3	0.0	0.0	2.2	0.0	2	0.00	0.04	1.0	1.0	0.04	0.09	13.67	10.67	HGL Too H

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	1	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvat	Curved align: add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	13.50	13.50	36	15.4	2.2	90	70	0.0005	0.03	0	0.00	0.02	33.0	0.0	0.0	2.2	0.0	3	0.01	0.05	1.0	1.0	0.05	0.08	13.59	10.16	HGL Too H
P-30	DI-30	MH-35	1.20	13.80	13.80	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.80	11.24	HGL Too H
P-11	DI-11	DI-12	1.00	14.02	14.02	15	0.4	0.3	5	20	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.03	6.84	HGL Too H
P-12	DI-12	DI-13	1.00	14.01	14.01	15	0.9	0.7	6	92	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	5	0.00	0.00	1.3	1.0	0.00	0.02	14.02	6.99	HGL Too H
P-13	DI-13	MH-14	1.00	13.98	13.98	15	1.3	1.1	14	54	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	6	0.00	0.01	1.3	1.0	0.01	0.03	14.01	7.91	HGL Too H
P-14	MH-14	DI-15	1.60	13.94	13.94	24	4.0	1.3	9	38	0.0003	0.01	0	0.00	0.01	1.4	4.4	0.0	1.6	0.0	82	0.03	0.05	1.0	0.5	0.02	0.03	13.98	8.68	HGL Too H
P-15	DI-15	DI-16	1.60	13.90	13.90	24	4.3	1.4	91	73	0.0003	0.02	0	0.00	0.01	5.1	0.0	0.0	1.3	0.0	9	0.00	0.02	1.0	1.0	0.02	0.04	13.94	9.01	HGL Too H
P-16	DI-16	MH-17	1.60	13.85	13.85	24	4.7	1.5	90	31	0.0004	0.01	0	0.00	0.01	5.9	0.0	0.0	1.4	0.0	91	0.02	0.04	1.0	1.0	0.04	0.05	13.90	9.77	HGL Too H
P-18	B7 South	MH-14	1.20	13.98	13.98	18	2.8	1.6	82	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.99	10.00	HGL Too H
P-01	DI-01	DI-02	1.00	14.02	14.02	15	0.7	0.6	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.03	6.84	HGL Too H
P-02	DI-02	DI-03	1.00	14.01	14.01	15	0.9	0.7	11	38	0.0001	0.01	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	4	0.00	0.00	1.3	1.0	0.01	0.01	14.02	7.35	HGL Too H
P-03	DI-03	MH-04	1.00	13.98	13.98	15	1.3	1.1	14	46	0.0003	0.02	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	11	0.00	0.01	1.3	1.0	0.01	0.03	14.01	7.91	HGL Too H
P-04	MH-04	DI-05	1.20	13.94	13.94	18	3.0	1.7	7	46	0.0007	0.03	0	0.00	0.01	1.4	1.8	0.0	1.0	0.0	83	0.01	0.03	1.0	0.5	0.01	0.05	13.98	8.60	HGL Too H
P-05	DI-05	DI-06	1.60	13.90	13.90	24	3.3	1.1	90	73	0.0002	0.01	0	0.00	0.00	5.1	0.0	0.0	1.7	0.0	7	0.00	0.02	1.0	1.0	0.02	0.04	13.94	9.01	HGL Too H
P-06	DI-06	MH-17	1.60	13.85	13.85	24	5.7	1.8	90	30	0.0005	0.02	0	0.00	0.01	3.5	2.4	0.0	1.1	0.0	90	0.01	0.03	1.0	1.0	0.03	0.05	13.90	9.87	HGL Too H
P-17	MH-17	MH-35	1.60	13.80	13.80	36	10.3	1.5	102	115	0.0002	0.02	0	0.00	0.01	10.2	7.0	0.0	1.8	0.0	90	0.04	0.06	1.0	0.5	0.03	0.05	13.85	10.61	HGL Too H
P-08	DI-08	MH-07	1.00	13.92	13.92	15	0.1	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.92	11.39	HGL Too H
P-07	MH-07	DI-06	1.20	13.90	13.90	18	2.0	1.2	67	14	0.0003	0.00	0	0.00	0.01	0.0	2.1	0.0	1.1	0.0	67	0.01	0.02	1.0	0.5	0.01	0.02	13.92	10.19	HGL Too H
P-09	B9/J	MH-04	1.20	13.98	13.98	18	1.8	1.0	83	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.99	10.00	HGL Too H
P-10	B9/J	MH-07	1.20	13.92	13.92	18	1.9	1.1	67	17	0.0003	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.92	10.00	HGL Too H
P-20	TD-05	DI-21	0.53	14.16	14.16	8	0.5	1.4	47	39	0.0011	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	14.21	10.50	HGL Too H
P-21	DI-21	MH-22	1.00	14.12	14.12	15	1.1	0.9	90	31	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	1.4	0.0	47	0.01	0.03	1.3	1.0	0.03	0.04	14.16	9.46	HGL Too H
P-22	MH-22	MH-23	1.20	14.10	14.10	18	1.7	1.0	0	42	0.0002	0.01	0	0.00	0.00	0.9	0.3	0.0	0.9	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	14.12	9.72	HGL Too H
P-23	MH-23	MH-24	1.20	13.96	13.96	18	4.8	2.7	0	66	0.0018	0.12	0	0.00	0.03	1.6	1.2	1.6	1.0	0.0	90	0.01	0.04	1.0	0.5	0.02	0.14	14.10	10.97	HGL Too H
P-24	MH-24	MH-35	1.20	13.80	13.80	18	5.4	3.1	78	56	0.0023	0.13	0	0.00	0.04	12.9	0.1	0.1	2.7	0.0	0	0.00	0.08	1.0	0.5	0.04	0.16	13.96	11.20	HGL Too H
P-25	DI-25	MH-22	1.00	14.12	14.12	15	0.6	0.5	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.12	9.46	HGL Too H
P-26	B8/K	MH-23	1.20	14.10	14.10	18	1.4	0.8	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.11	10.00	HGL Too H
P-27	B6 South	MH-23	1.20	14.10	14.10	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.12	10.00	HGL Too H
P-28	DI-28	MH-24	1.20	13.96	13.96	18	0.3	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.96	10.95	HGL Too H
P-29	DI-29	MH-24	1.20	13.96	13.96	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.96	10.95	HGL Too H

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) Storm Frequency: 1 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
RELOCATED INLET IN SMR																										
P4	**DI19**	**MH1**	CP-1	2405	0	2405	0.06	0.95	0.05	0.05	6.0	0.00	4.01	0.2	15	27.3	0.012	0.000009	0.005	4.1	5.0	2.0	0.23	6.23	4.49	4.35	Q ok
P5	MH1	MH2	CP-1	1	0	1	0.00	0.95	0.00	0.05	6.0	6.23	3.98	0.2	18	82.7	0.012	0.000003	0.005	4.5	8.0	2.2	0.62	6.85	4.25	3.84	Q ok
P7	MH2	MH3	CP-1	1	0	1	0.00	0.95	0.00	0.05	6.0	6.85	3.88	0.2	18	73.8	0.012	0.000003	0.005	4.6	8.1	2.2	0.55	7.40	3.81	3.44	Q ok
P10	MH3	MH4	CP-2	1	0	1	0.00	0.95	0.00	0.25	6.0	7.40	3.78	0.9	18	53.7	0.012	0.000068	0.005	4.6	8.1	2.7	0.33	7.72	3.34	3.07	Q ok
P13	MH4	MH5	CP-2	1	0	1	0.00	0.95	0.00	0.56	6.0	7.72	3.73	2.1	18	59.3	0.012	0.000341	0.005	4.3	7.7	3.6	0.28	8.00	2.97	2.70	Q ok
P15	MH5	MH41	CP-2	1	0	1	0.00	0.95	0.00	0.89	6.0	8.00	3.68	3.3	*24*	**50.0**	0.012	0.000179	0.020	11.0	34.7	6.6	0.13	8.13	2.60	1.60	Q ok
P9	DI3	MH3	CP-1	4110	3259	7369	0.17	0.61	0.10	0.10	6.0	0.00	4.01	0.4	15	18.3	0.012	0.000035	0.005	4.0	4.9	2.4	0.13	6.13	3.68	3.59	Q ok
P8	DI17	MH3	CP-1	3878	2100	5978	0.14	0.68	0.09	0.09	6.0	0.00	4.01	0.4	15	31.3	0.012	0.000029	0.005	4.2	5.2	2.1	0.25	6.25	3.71	3.54	Q ok
P12	DI4	MH4	CP-1	7109	2561	9670	0.22	0.75	0.17	0.17	6.0	0.00	6.73	1.1	15	20.1	0.012	0.000254	0.005	4.0	4.9	3.3	0.10	6.10	3.48	3.38	Q ok
P11	DI18	MH4	CP-1	6435	2210	8645	0.20	0.75	0.15	0.15	6.0	0.00	6.70	1.0	15	28.4	0.012	0.000205	0.005	4.1	5.1	3.1	0.15	6.15	3.48	3.33	Q ok
P14	DI5	MH5	CP-1	4974	2549	7523	0.17	0.69	0.12	0.12	6.0	0.00	4.01	0.5	15	22.6	0.012	0.000047	0.005	4.0	4.9	2.4	0.16	6.16	3.68	3.57	Q ok
P18	DI6	MH6	CP-1	6937	1863	8800	0.20	0.79	0.16	0.16	6.0	0.00	4.01	0.6	15	38.0	0.012	0.000083	0.005	4.0	4.9	2.8	0.22	6.22	4.57	4.38	Q ok
P16	MH6	MH5	CP-2	1	0	1	0.00	0.95	0.00	0.21	6.0	6.22	3.98	0.8	18	40.0	0.012	0.000053	0.011	6.8	12.1	3.3	0.20	6.42	3.77	3.32	Q ok
RELOCATED INLET IN SMR																											
P17	**DI49**	**MH6**	CP-2	2236	105	2341	0.05	0.92	0.05	0.05	6.0	0.00	4.01	0.2	15	33.0	0.012	0.000008	0.005	4.0	4.9	2.0	0.28	6.28	4.19	4.02	Q ok
P32	DI23	MH12	CP-2	5495	1914	7409	0.17	0.75	0.13	0.13	6.0	0.00	4.01	0.5	15	33.31	0.012	0.0001	0.005	4.1	5.0	2.4	0.23	6.23	3.98	3.81	Q ok
P31	DI9	MH12	CP-2	4483	551	5034	0.12	0.87	0.10	0.10	6.0	0.00	4.01	0.4	15	18.3	0.012	0.0000	0.005	4.0	4.9	2.4	0.13	6.13	3.86	3.77	Q ok
P30	MH12	MH11	CP-2	1	0	1	0.00	0.95	0.00	0.23	6.0	6.23	3.98	0.9	18	50.1	0.012	0.0001	0.005	4.5	8.0	2.7	0.31	6.53	3.67	3.42	Q ok
P27	MH11	MH10	CP-2	1	0	1	0.00	0.95	0.00	0.47	6.0	6.53	3.93	1.9	18	73.2	0.012	0.0003	0.005	4.6	8.1	3.8	0.32	6.86	3.39	3.02	Q ok
P25	MH10	MH9	CP-2	1	0	1	0.00	0.95	0.00	0.54	6.0	6.86	3.86	2.1	24	69.68	0.012	0.0001	0.006	6.3	19.7	3.8	0.31	7.17	2.92	2.47	Q ok
P22	MH9	MH8	CP-2	1	0	1	0.00	0.95	0.00	0.68	6.0	7.17	3.81	2.6	24	108.3	0.012	0.0001	0.005	5.5	17.3	3.9	0.47	7.63	2.47	1.93	Q ok
P-80	DI-80	MH-08		9967	0	9967	0.23	0.95	0.22	0.22	6.0	0.00	4.01	0.9	15	49	0.012	0.0002	0.009	5.5	6.8	3.9	0.21	6.21	4.53	4.07	Q ok
P28	DI22	MH11	CP-1	5555	1955	7510	0.17	0.75	0.13	0.13	6.0	0.00	4.01	0.5	15	30.3	0.012	0.0001	0.005	4.0	4.9	2.4	0.21	6.21	3.64	3.49	Q ok
P29	DI8	MH11	CP-1	5120	570	5690	0.13	0.87	0.11	0.11	6.0	0.00	4.01	0.5	15	18.3	0.012	0.0000	0.005	4.0	4.9	2.4	0.13	6.13	3.64	3.55	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) Storm Frequency: 1 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P26	DI21	MH10	CP-1	2755	930	3685	0.08	0.76	0.06	0.06	6.0	0.00	4.01	0.3	15	18.3	0.012	0.0000	0.005	4.0	4.9	2.0	0.16	6.16	4.02	3.93	Q ok
P23	DI20	MH9	CP-2	3213	1102	4315	0.10	0.75	0.07	0.07	6.0	0.00	4.01	0.3	15	29.3	0.012	0.0000	0.005	4.0	4.9	2.0	0.25	6.25	4.53	4.38	Q ok
P24	DI7	MH9	CP-2	3164	527	3691	0.08	0.84	0.07	0.07	6.0	0.00	4.01	0.3	15	28.02	0.012	0.0000	0.005	4.0	4.9	2.0	0.24	6.24	4.38	4.24	Q ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	5.04	5.35	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	7.41	
P5	MH1	MH2	1.20	4.64	5.04	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	5.04	7.93	HGL ok
P7	MH2	MH3	1.20	4.28	4.64	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.64	7.65	HGL ok
P10	MH3	MH4	1.20	4.03	4.27	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	4.28	7.28	HGL ok
P13	MH4	MH5	1.20	4.00	4.00	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	4.03	7.09	HGL ok
P15	MH5	MH41	1.60	3.98	3.98	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	4.00	7.40	HGL ok
P9	DI3	MH3	1.00	4.28	4.59	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.59	6.62	HGL ok
P8	DI17	MH3	1.00	4.28	4.54	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.54	6.96	HGL ok
P12	DI4	MH4	1.00	4.03	4.38	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.39	6.48	HGL ok
P11	DI18	MH4	1.00	4.03	4.33	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.34	6.56	HGL ok
P14	DI5	MH5	1.00	4.00	4.57	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.57	6.61	HGL ok
P18	DI6	MH6	1.00	4.52	5.38	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.38	7.13	HGL ok
P16	MH6	MH5	1.20	4.00	4.52	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	4.52	7.55	HGL ok
P17	DI49	MH6	1.00	4.52	5.02	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.08	HGL ok
P32	DI23	MH12	1.00	5.02	5.02	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.11	HGL ok
P31	DI9	MH12	1.00	5.02	5.02	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.13	HGL ok
P30	MH12	MH11	1.60	4.64	5.02	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	5.02	7.48	HGL ok
P27	MH11	MH10	1.60	4.08	4.62	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	4.64	7.21	HGL ok
P25	MH10	MH9	1.60	3.99	4.07	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	4.08	7.54	HGL ok
P22	MH9	MH8	1.60	3.97	3.97	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	3.99	7.85	HGL ok
P-80	DI-80	MH-08	1.00	3.97	5.07	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	5.08	7.34	HGL ok
P28	DI22	MH11	1.00	4.64	4.64	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.64	6.74	HGL ok
P29	DI8	MH11	1.00	4.64	4.64	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.64	6.92	HGL ok
P26	DI21	MH10	1.00	4.08	4.93	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.93	7.23	HGL ok
P23	DI20	MH9	1.00	3.99	5.38	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	5.38	7.38	HGL ok
P24	DI7	MH9	1.00	3.99	5.24	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.24	7.48	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	5.04	5.35	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	7.41	
P5	MH1	MH2	1.20	4.64	5.04	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	5.04	7.93	HGL ok
P7	MH2	MH3	1.20	4.28	4.64	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.64	7.65	HGL ok
P10	MH3	MH4	1.20	4.23	4.27	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	4.28	7.28	HGL ok
P13	MH4	MH5	1.20	4.20	4.20	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	4.23	7.09	HGL ok
P15	MH5	MH41	1.60	4.18	4.18	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	4.20	7.40	HGL ok
P9	DI3	MH3	1.00	4.28	4.59	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.59	6.62	HGL ok
P8	DI17	MH3	1.00	4.28	4.54	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.54	6.96	HGL ok
P12	DI4	MH4	1.00	4.23	4.38	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.39	6.48	HGL ok
P11	DI18	MH4	1.00	4.23	4.33	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.34	6.56	HGL ok
P14	DI5	MH5	1.00	4.20	4.57	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.57	6.61	HGL ok
P18	DI6	MH6	1.00	4.52	5.38	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.38	7.13	HGL ok
P16	MH6	MH5	1.20	4.20	4.52	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	4.52	7.55	HGL ok
P17	DI49	MH6	1.00	4.52	5.02	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.08	HGL ok
P32	DI23	MH12	1.00	5.02	5.02	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.11	HGL ok
P31	DI9	MH12	1.00	5.02	5.02	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.13	HGL ok
P30	MH12	MH11	1.60	4.64	5.02	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	5.02	7.48	HGL ok
P27	MH11	MH10	1.60	4.20	4.62	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	4.64	7.21	HGL ok
P25	MH10	MH9	1.60	4.19	4.19	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	4.20	7.54	HGL ok
P22	MH9	MH8	1.60	4.17	4.17	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	4.19	7.85	HGL ok
P-80	DI-80	MH-08	1.00	4.17	5.07	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	5.08	7.34	HGL ok
P28	DI22	MH11	1.00	4.64	4.64	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.64	6.74	HGL ok
P29	DI8	MH11	1.00	4.64	4.64	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.64	6.92	HGL ok
P26	DI21	MH10	1.00	4.20	4.93	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.93	7.23	HGL ok
P23	DI20	MH9	1.00	4.19	5.38	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	5.38	7.38	HGL ok
P24	DI7	MH9	1.00	4.19	5.24	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.24	7.48	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	7.74	7.74	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.74	7.41	
P5	MH1	MH2	1.20	7.74	7.74	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	7.74	7.93	HGL Too High!
P7	MH2	MH3	1.20	7.74	7.74	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.74	7.65	HGL Too High!
P10	MH3	MH4	1.20	7.73	7.73	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	7.74	7.28	HGL Too High!
P13	MH4	MH5	1.20	7.70	7.70	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	7.73	7.09	HGL Too High!
P15	MH5	MH41	1.60	7.68	7.68	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	7.70	7.40	HGL Too High!
P9	DI3	MH3	1.00	7.74	7.74	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.74	6.62	HGL Too High!
P8	DI17	MH3	1.00	7.74	7.74	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.74	6.96	HGL Too High!
P12	DI4	MH4	1.00	7.73	7.73	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.74	6.48	HGL Too High!
P11	DI18	MH4	1.00	7.73	7.73	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.74	6.56	HGL Too High!
P14	DI5	MH5	1.00	7.70	7.70	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.71	6.61	HGL Too High!
P18	DI6	MH6	1.00	7.71	7.71	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.71	7.13	HGL Too High!
P16	MH6	MH5	1.20	7.70	7.70	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	7.71	7.55	HGL Too High!
P17	DI49	MH6	1.00	7.71	7.71	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.71	7.08	HGL Too High!
P32	DI23	MH12	1.00	7.72	7.72	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.72	7.11	HGL Too High!
P31	DI9	MH12	1.00	7.72	7.72	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.72	7.13	HGL Too High!
P30	MH12	MH11	1.60	7.72	7.72	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	7.72	7.48	HGL Too High!
P27	MH11	MH10	1.60	7.70	7.70	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	7.72	7.21	HGL Too High!
P25	MH10	MH9	1.60	7.69	7.69	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	7.70	7.54	HGL Too High!
P22	MH9	MH8	1.60	7.67	7.67	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	7.69	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	7.67	7.67	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	7.68	7.34	HGL Too High!
P28	DI22	MH11	1.00	7.72	7.72	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.72	6.74	HGL Too High!
P29	DI8	MH11	1.00	7.72	7.72	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.72	6.92	HGL Too High!
P26	DI21	MH10	1.00	7.70	7.70	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.70	7.23	HGL Too High!
P23	DI20	MH9	1.00	7.69	7.69	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	7.69	7.38	HGL Too High!
P24	DI7	MH9	1.00	7.69	7.69	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.69	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	8.24	8.24	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.24	7.41	
P5	MH1	MH2	1.20	8.24	8.24	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	8.24	7.93	HGL Too High!
P7	MH2	MH3	1.20	8.24	8.24	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.24	7.65	HGL Too High!
P10	MH3	MH4	1.20	8.23	8.23	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	8.24	7.28	HGL Too High!
P13	MH4	MH5	1.20	8.20	8.20	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	8.23	7.09	HGL Too High!
P15	MH5	MH41	1.60	8.18	8.18	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	8.20	7.40	HGL Too High!
P9	DI3	MH3	1.00	8.24	8.24	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.24	6.62	HGL Too High!
P8	DI17	MH3	1.00	8.24	8.24	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.24	6.96	HGL Too High!
P12	DI4	MH4	1.00	8.23	8.23	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.24	6.48	HGL Too High!
P11	DI18	MH4	1.00	8.23	8.23	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.24	6.56	HGL Too High!
P14	DI5	MH5	1.00	8.20	8.20	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.21	6.61	HGL Too High!
P18	DI6	MH6	1.00	8.21	8.21	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.21	7.13	HGL Too High!
P16	MH6	MH5	1.20	8.20	8.20	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	8.21	7.55	HGL Too High!
P17	DI49	MH6	1.00	8.21	8.21	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.21	7.08	HGL Too High!
P32	DI23	MH12	1.00	8.22	8.22	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.22	7.11	HGL Too High!
P31	DI9	MH12	1.00	8.22	8.22	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.22	7.13	HGL Too High!
P30	MH12	MH11	1.60	8.22	8.22	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	8.22	7.48	HGL Too High!
P27	MH11	MH10	1.60	8.20	8.20	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	8.22	7.21	HGL Too High!
P25	MH10	MH9	1.60	8.19	8.19	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	8.20	7.54	HGL Too High!
P22	MH9	MH8	1.60	8.17	8.17	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	8.19	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	8.17	8.17	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	8.18	7.34	HGL Too High!
P28	DI22	MH11	1.00	8.22	8.22	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.22	6.74	HGL Too High!
P29	DI8	MH11	1.00	8.22	8.22	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.22	6.92	HGL Too High!
P26	DI21	MH10	1.00	8.20	8.20	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.20	7.23	HGL Too High!
P23	DI20	MH9	1.00	8.19	8.19	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	8.19	7.38	HGL Too High!
P24	DI7	MH9	1.00	8.19	8.19	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.19	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q'V for determining controlling inflow pipe	Q'V for determining controlling inflow pipe	Q'V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	8.64	8.64	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.64	7.41	
P5	MH1	MH2	1.20	8.64	8.64	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	8.64	7.93	HGL Too High!
P7	MH2	MH3	1.20	8.64	8.64	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.64	7.65	HGL Too High!
P10	MH3	MH4	1.20	8.63	8.63	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	8.64	7.28	HGL Too High!
P13	MH4	MH5	1.20	8.60	8.60	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	8.63	7.09	HGL Too High!
P15	MH5	MH41	1.60	8.58	8.58	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	8.60	7.40	HGL Too High!
P9	DI3	MH3	1.00	8.64	8.64	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.64	6.62	HGL Too High!
P8	DI17	MH3	1.00	8.64	8.64	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.64	6.96	HGL Too High!
P12	DI4	MH4	1.00	8.63	8.63	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.64	6.48	HGL Too High!
P11	DI18	MH4	1.00	8.63	8.63	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.64	6.56	HGL Too High!
P14	DI5	MH5	1.00	8.60	8.60	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.61	6.61	HGL Too High!
P18	DI6	MH6	1.00	8.61	8.61	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.61	7.13	HGL Too High!
P16	MH6	MH5	1.20	8.60	8.60	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	8.61	7.55	HGL Too High!
P17	DI49	MH6	1.00	8.61	8.61	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.61	7.08	HGL Too High!
P32	DI23	MH12	1.00	8.62	8.62	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.62	7.11	HGL Too High!
P31	DI9	MH12	1.00	8.62	8.62	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.62	7.13	HGL Too High!
P30	MH12	MH11	1.60	8.62	8.62	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	8.62	7.48	HGL Too High!
P27	MH11	MH10	1.60	8.60	8.60	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	8.62	7.21	HGL Too High!
P25	MH10	MH9	1.60	8.59	8.59	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	8.60	7.54	HGL Too High!
P22	MH9	MH8	1.60	8.57	8.57	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	8.59	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	8.57	8.57	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	8.58	7.34	HGL Too High!
P28	DI22	MH11	1.00	8.62	8.62	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.62	6.74	HGL Too High!
P29	DI8	MH11	1.00	8.62	8.62	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.62	6.92	HGL Too High!
P26	DI21	MH10	1.00	8.60	8.60	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.60	7.23	HGL Too High!
P23	DI20	MH9	1.00	8.59	8.59	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	8.59	7.38	HGL Too High!
P24	DI7	MH9	1.00	8.59	8.59	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.59	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.14	9.14	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.14	7.41	
P5	MH1	MH2	1.20	9.14	9.14	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.14	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.14	9.14	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.14	7.65	HGL Too High!
P10	MH3	MH4	1.20	9.13	9.13	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	9.14	7.28	HGL Too High!
P13	MH4	MH5	1.20	9.10	9.10	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	9.13	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.08	9.08	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	9.10	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.14	9.14	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.14	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.14	9.14	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.14	6.96	HGL Too High!
P12	DI4	MH4	1.00	9.13	9.13	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.14	6.48	HGL Too High!
P11	DI18	MH4	1.00	9.13	9.13	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.14	6.56	HGL Too High!
P14	DI5	MH5	1.00	9.10	9.10	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.11	6.61	HGL Too High!
P18	DI6	MH6	1.00	9.11	9.11	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.11	7.13	HGL Too High!
P16	MH6	MH5	1.20	9.10	9.10	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	9.11	7.55	HGL Too High!
P17	DI49	MH6	1.00	9.11	9.11	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.11	7.08	HGL Too High!
P32	DI23	MH12	1.00	9.12	9.12	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.12	7.11	HGL Too High!
P31	DI9	MH12	1.00	9.12	9.12	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.12	7.13	HGL Too High!
P30	MH12	MH11	1.60	9.12	9.12	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	9.12	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.10	9.10	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	9.12	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.09	9.09	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	9.10	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.07	9.07	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	9.09	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.07	9.07	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	9.08	7.34	HGL Too High!
P28	DI22	MH11	1.00	9.12	9.12	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.12	6.74	HGL Too High!
P29	DI8	MH11	1.00	9.12	9.12	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.12	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.10	9.10	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.10	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.09	9.09	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.09	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.09	9.09	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.09	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.84	9.84	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.84	7.41	
P5	MH1	MH2	1.20	9.84	9.84	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.84	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.84	9.84	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.84	7.65	HGL Too High!
P10	MH3	MH4	1.20	9.83	9.83	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	9.84	7.28	HGL Too High!
P13	MH4	MH5	1.20	9.80	9.80	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	9.83	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.78	9.78	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	9.80	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.84	9.84	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.84	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.84	9.84	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.84	6.96	HGL Too High!
P12	DI4	MH4	1.00	9.83	9.83	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.84	6.48	HGL Too High!
P11	DI18	MH4	1.00	9.83	9.83	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.84	6.56	HGL Too High!
P14	DI5	MH5	1.00	9.80	9.80	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.81	6.61	HGL Too High!
P18	DI6	MH6	1.00	9.81	9.81	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.81	7.13	HGL Too High!
P16	MH6	MH5	1.20	9.80	9.80	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	9.81	7.55	HGL Too High!
P17	DI49	MH6	1.00	9.81	9.81	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.81	7.08	HGL Too High!
P32	DI23	MH12	1.00	9.82	9.82	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	7.11	HGL Too High!
P31	DI9	MH12	1.00	9.82	9.82	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	7.13	HGL Too High!
P30	MH12	MH11	1.60	9.82	9.82	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	9.82	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.80	9.80	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	9.82	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.79	9.79	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	9.80	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.77	9.77	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	9.79	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.77	9.77	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	9.78	7.34	HGL Too High!
P28	DI22	MH11	1.00	9.82	9.82	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	6.74	HGL Too High!
P29	DI8	MH11	1.00	9.82	9.82	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.80	9.80	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.80	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.79	9.79	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.79	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.79	9.79	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.79	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.34	10.34	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.34	7.41	
P5	MH1	MH2	1.20	10.34	10.34	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.34	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.34	10.34	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.34	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.33	10.33	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	10.34	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.30	10.30	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	10.33	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.28	10.28	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	10.30	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.34	10.34	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.34	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.34	10.34	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.34	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.33	10.33	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.34	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.33	10.33	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.34	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.30	10.30	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.31	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.31	10.31	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.31	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.30	10.30	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	10.31	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.31	10.31	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.31	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.32	10.32	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.32	10.32	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.32	10.32	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	10.32	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.30	10.30	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	10.32	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.29	10.29	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	10.30	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.27	10.27	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	10.29	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.27	10.27	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	10.28	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.32	10.32	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.32	10.32	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.30	10.30	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.30	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.29	10.29	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.29	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.29	10.29	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.29	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.64	11.64	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.64	7.41	
P5	MH1	MH2	1.20	11.64	11.64	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.64	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.64	11.64	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.64	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.63	11.63	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	11.64	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.60	11.60	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	11.63	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.58	11.58	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	11.60	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.64	11.64	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.64	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.64	11.64	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.64	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.63	11.63	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.64	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.63	11.63	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.64	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.60	11.60	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.61	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.61	11.61	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.61	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.60	11.60	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	11.61	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.61	11.61	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.61	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.62	11.62	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.62	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.62	11.62	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.62	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.62	11.62	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	11.62	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.60	11.60	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	11.62	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.59	11.59	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	11.60	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.57	11.57	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	11.59	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.57	11.57	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	11.58	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.62	11.62	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.62	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.62	11.62	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.62	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.60	11.60	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.60	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.59	11.59	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.59	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.59	11.59	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.59	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	6.58	6.58	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.58	7.41	
P5	MH1	MH2	1.20	6.58	6.58	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	6.58	7.93	HGL ok
P7	MH2	MH3	1.20	6.58	6.58	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.58	7.65	HGL ok
P10	MH3	MH4	1.20	6.57	6.57	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	6.58	7.28	HGL Too High!
P13	MH4	MH5	1.20	6.54	6.54	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	6.57	7.09	HGL Too High!
P15	MH5	MH41	1.60	6.52	6.52	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	6.54	7.40	HGL Too High!
P9	DI3	MH3	1.00	6.58	6.58	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.58	6.62	HGL Too High!
P8	DI17	MH3	1.00	6.58	6.58	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.58	6.96	HGL Too High!
P12	DI4	MH4	1.00	6.57	6.57	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.58	6.48	HGL Too High!
P11	DI18	MH4	1.00	6.57	6.57	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.58	6.56	HGL Too High!
P14	DI5	MH5	1.00	6.54	6.54	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.55	6.61	HGL Too High!
P18	DI6	MH6	1.00	6.55	6.55	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.55	7.13	HGL Too High!
P16	MH6	MH5	1.20	6.54	6.54	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	6.55	7.55	HGL ok
P17	DI49	MH6	1.00	6.55	6.55	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.55	7.08	HGL Too High!
P32	DI23	MH12	1.00	6.56	6.56	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.56	7.11	HGL Too High!
P31	DI9	MH12	1.00	6.56	6.56	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.56	7.13	HGL Too High!
P30	MH12	MH11	1.60	6.56	6.56	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	6.56	7.48	HGL Too High!
P27	MH11	MH10	1.60	6.54	6.54	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	6.56	7.21	HGL Too High!
P25	MH10	MH9	1.60	6.53	6.53	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	6.54	7.54	HGL ok
P22	MH9	MH8	1.60	6.51	6.51	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	6.53	7.85	HGL ok
P-80	DI-80	MH-08	1.00	6.51	6.51	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	6.52	7.34	HGL Too High!
P28	DI22	MH11	1.00	6.56	6.56	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.56	6.74	HGL Too High!
P29	DI8	MH11	1.00	6.56	6.56	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.56	6.92	HGL Too High!
P26	DI21	MH10	1.00	6.54	6.54	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.54	7.23	HGL Too High!
P23	DI20	MH9	1.00	6.53	6.53	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	6.53	7.38	HGL Too High!
P24	DI7	MH9	1.00	6.53	6.53	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.53	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q'V for determining controlling inflow pipe	Q'V for determining controlling inflow pipe	Q'V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	6.78	6.78	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.78	7.41	
P5	MH1	MH2	1.20	6.78	6.78	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	6.78	7.93	HGL ok
P7	MH2	MH3	1.20	6.78	6.78	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.78	7.65	HGL Too High!
P10	MH3	MH4	1.20	6.77	6.77	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	6.78	7.28	HGL Too High!
P13	MH4	MH5	1.20	6.74	6.74	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	6.77	7.09	HGL Too High!
P15	MH5	MH41	1.60	6.72	6.72	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	6.74	7.40	HGL Too High!
P9	DI3	MH3	1.00	6.78	6.78	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.78	6.62	HGL Too High!
P8	DI17	MH3	1.00	6.78	6.78	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.78	6.96	HGL Too High!
P12	DI4	MH4	1.00	6.77	6.77	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.78	6.48	HGL Too High!
P11	DI18	MH4	1.00	6.77	6.77	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.78	6.56	HGL Too High!
P14	DI5	MH5	1.00	6.74	6.74	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.75	6.61	HGL Too High!
P18	DI6	MH6	1.00	6.75	6.75	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.75	7.13	HGL Too High!
P16	MH6	MH5	1.20	6.74	6.74	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	6.75	7.55	HGL Too High!
P17	DI49	MH6	1.00	6.75	6.75	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.75	7.08	HGL Too High!
P32	DI23	MH12	1.00	6.76	6.76	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.76	7.11	HGL Too High!
P31	DI9	MH12	1.00	6.76	6.76	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.76	7.13	HGL Too High!
P30	MH12	MH11	1.60	6.76	6.76	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	6.76	7.48	HGL Too High!
P27	MH11	MH10	1.60	6.74	6.74	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	6.76	7.21	HGL Too High!
P25	MH10	MH9	1.60	6.73	6.73	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	6.74	7.54	HGL Too High!
P22	MH9	MH8	1.60	6.71	6.71	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	6.73	7.85	HGL ok
P-80	DI-80	MH-08	1.00	6.71	6.71	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	6.72	7.34	HGL Too High!
P28	DI22	MH11	1.00	6.76	6.76	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.76	6.74	HGL Too High!
P29	DI8	MH11	1.00	6.76	6.76	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.76	6.92	HGL Too High!
P26	DI21	MH10	1.00	6.74	6.74	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.74	7.23	HGL Too High!
P23	DI20	MH9	1.00	6.73	6.73	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	6.73	7.38	HGL Too High!
P24	DI7	MH9	1.00	6.73	6.73	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.73	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.28	10.28	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.28	7.41	
P5	MH1	MH2	1.20	10.28	10.28	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.28	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.28	10.28	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.28	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.27	10.27	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	10.28	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.24	10.24	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	10.27	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.22	10.22	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	10.24	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.28	10.28	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.28	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.28	10.28	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.28	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.27	10.27	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.28	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.27	10.27	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.28	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.24	10.24	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.25	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.25	10.25	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.25	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.24	10.24	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	10.25	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.25	10.25	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.25	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.26	10.26	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.26	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.26	10.26	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.26	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.26	10.26	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	10.26	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.24	10.24	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	10.26	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.23	10.23	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	10.24	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.21	10.21	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	10.23	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.21	10.21	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	10.22	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.26	10.26	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.26	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.26	10.26	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.26	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.24	10.24	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.24	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.23	10.23	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.23	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.23	10.23	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.23	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.78	10.78	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.78	7.41	
P5	MH1	MH2	1.20	10.78	10.78	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.78	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.78	10.78	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.78	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.77	10.77	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	10.78	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.74	10.74	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	10.77	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.72	10.72	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	10.74	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.78	10.78	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.78	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.78	10.78	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.78	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.77	10.77	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.78	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.77	10.77	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.78	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.74	10.74	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.75	10.75	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.74	10.74	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	10.75	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.75	10.75	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.76	10.76	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.76	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.76	10.76	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.76	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.76	10.76	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	10.76	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.74	10.74	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	10.76	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.73	10.73	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	10.74	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.71	10.71	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	10.73	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.71	10.71	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	10.72	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.76	10.76	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.76	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.76	10.76	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.76	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.74	10.74	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.74	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.73	10.73	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.73	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.73	10.73	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.73	7.48	HGL Too High!

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Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q'V for determining controlling inflow pipe	Q'V for determining controlling inflow pipe	Q'V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.18	11.18	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.18	7.41	
P5	MH1	MH2	1.20	11.18	11.18	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.18	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.18	11.18	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.18	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.17	11.17	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	11.18	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.14	11.14	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	11.17	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.12	11.12	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	11.14	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.18	11.18	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.18	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.18	11.18	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.18	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.17	11.17	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.18	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.17	11.17	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.18	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.14	11.14	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.15	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.15	11.15	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.15	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.14	11.14	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	11.15	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.15	11.15	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.15	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.16	11.16	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.16	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.16	11.16	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.16	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.16	11.16	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	11.16	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.14	11.14	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	11.16	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.13	11.13	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	11.14	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.11	11.11	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	11.13	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.11	11.11	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	11.12	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.16	11.16	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.16	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.16	11.16	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.16	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.14	11.14	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.14	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.13	11.13	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.13	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.13	11.13	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.13	7.48	HGL Too High!

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No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.68	11.68	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.68	7.41	
P5	MH1	MH2	1.20	11.68	11.68	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.68	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.68	11.68	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.68	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.67	11.67	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	11.68	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.64	11.64	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	11.67	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.62	11.62	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	11.64	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.68	11.68	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.68	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.68	11.68	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.68	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.67	11.67	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.68	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.67	11.67	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.68	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.64	11.64	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.65	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.65	11.65	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.65	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.64	11.64	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	11.65	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.65	11.65	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.65	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.66	11.66	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.66	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.66	11.66	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.66	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.66	11.66	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	11.66	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.64	11.64	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	11.66	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.63	11.63	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	11.64	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.61	11.61	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	11.63	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.61	11.61	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	11.62	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.66	11.66	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.66	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.66	11.66	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.66	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.64	11.64	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.64	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.63	11.63	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.63	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.63	11.63	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.63	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.38	12.38	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.38	7.41	
P5	MH1	MH2	1.20	12.38	12.38	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.38	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.38	12.38	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.38	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.37	12.37	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	12.38	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.34	12.34	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	12.37	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.32	12.32	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	12.34	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.38	12.38	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.38	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.38	12.38	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.38	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.37	12.37	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.38	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.37	12.37	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.38	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.34	12.34	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.35	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.35	12.35	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.35	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.34	12.34	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	12.35	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.35	12.35	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.35	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.36	12.36	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.36	12.36	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.36	12.36	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	12.36	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.34	12.34	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	12.36	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.33	12.33	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	12.34	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.31	12.31	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	12.33	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.31	12.31	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	12.32	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.36	12.36	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.36	12.36	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.34	12.34	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.34	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.33	12.33	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.33	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.33	12.33	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.33	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.88	12.88	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.88	7.41	
P5	MH1	MH2	1.20	12.88	12.88	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.88	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.88	12.88	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.88	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.87	12.87	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	12.88	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.84	12.84	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	12.87	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.82	12.82	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	12.84	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.88	12.88	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.88	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.88	12.88	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.88	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.87	12.87	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.88	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.87	12.87	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.88	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.84	12.84	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.85	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.85	12.85	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.85	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.84	12.84	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	12.85	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.85	12.85	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.85	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.86	12.86	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.86	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.86	12.86	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.86	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.86	12.86	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	12.86	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.84	12.84	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	12.86	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.83	12.83	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	12.84	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.81	12.81	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	12.83	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.81	12.81	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	12.82	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.86	12.86	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.86	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.86	12.86	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.86	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.84	12.84	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.84	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.83	12.83	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.83	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.83	12.83	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.83	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 1 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q'V' for determining controlling inflow pipe	Q'V' for determining controlling inflow pipe	Q'V' for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	14.18	14.18	15	0.2	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.18	7.41	
P5	MH1	MH2	1.20	14.18	14.18	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	14.18	7.93	HGL Too High!
P7	MH2	MH3	1.20	14.18	14.18	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	14.18	7.65	HGL Too High!
P10	MH3	MH4	1.20	14.17	14.17	18	0.9	0.5	8	53.7	0.0001	0.00	0	0.00	0.00	0.0	0.1	0.1	0.3	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	14.18	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.14	14.14	18	2.1	1.2	84	59.3	0.0003	0.02	0	0.00	0.01	0.5	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.03	14.17	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.12	14.12	24	3.3	1.0	90	50	0.0002	0.01	0	0.00	0.00	2.5	0.2	0.4	1.2	0.0	84	0.01	0.03	1.0	0.5	0.01	0.02	14.14	7.40	HGL Too High!
P9	DI3	MH3	1.00	14.18	14.18	15	0.4	0.3	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.18	6.62	HGL Too High!
P8	DI17	MH3	1.00	14.18	14.18	15	0.4	0.3	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.18	6.96	HGL Too High!
P12	DI4	MH4	1.00	14.17	14.17	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.18	6.48	HGL Too High!
P11	DI18	MH4	1.00	14.17	14.17	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.18	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.14	14.14	15	0.5	0.4	21	22.6	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.15	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.15	14.15	15	0.6	0.5	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.15	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.14	14.14	18	0.8	0.5	86	40	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	23	0.00	0.00	1.0	0.5	0.00	0.00	14.15	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.15	14.15	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.15	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.16	14.16	15	0.5	0.4	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.16	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.16	14.16	15	0.4	0.3	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.16	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.16	14.16	24	0.9	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.1	0.2	0.0	0.4	0.0	64	0.00	0.00	1.0	0.5	0.00	0.00	14.16	7.48	HGL Too High!
P27	MH11	MH10	1.60	14.14	14.14	24	1.9	0.6	5	73.2	0.0003	0.02	0	0.00	0.00	0.3	0.2	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.02	14.16	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.13	14.13	24	2.1	0.7	5	69.7	0.0001	0.00	0	0.00	0.00	1.1	0.1	0.0	0.6	0.0	5	0.00	0.00	1.0	0.5	0.00	0.01	14.14	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.11	14.11	24	2.6	0.8	51	108	0.0001	0.01	0	0.00	0.00	1.4	0.1	0.1	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	14.13	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.11	14.11	15	0.9	0.7	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	14.12	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.16	14.16	15	0.5	0.4	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.16	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.16	14.16	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.16	6.92	HGL Too High!
P26	DI21	MH10	1.00	14.14	14.14	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.14	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.13	14.13	15	0.3	0.2	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.13	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.13	14.13	15	0.3	0.2	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.13	7.48	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 2 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-41	MH-41	MH-42	1	0	1	0.00	0.95	0.00	0.89	6.0	8.06	4.35	3.88	24	92	0.012	0.000250	0.0033	4.5	14.0	3.8	0.40	8.46	1.50	1.20	Q ok
P-42	MH-42	DI-43	1	0	1	0.00	0.95	0.00	1.79	6.0	8.46	4.27	7.64	30	30	0.012	0.000296	0.0030	5.0	24.3	4.2	0.12	8.58	1.10	1.01	Q ok
P-43	DI-43	DI-44	4208	31	4239	0.10	0.94	0.09	1.88	6.0	8.58	4.25	8.00	30	25	0.012	0.000324	0.0032	5.1	25.1	4.4	0.10	8.68	0.91	0.83	Q ok
P-44	DI-44	DI-45	4675	523	5198	0.12	0.87	0.10	1.99	6.0	8.68	4.23	8.40	30	69	0.012	0.000357	0.0030	5.0	24.5	4.5	0.26	8.93	0.73	0.52	Q ok
P-45	DI-45	MH-46	4490	535	5025	0.12	0.87	0.10	2.09	6.0	8.93	4.19	8.74	30	52	0.012	0.000387	0.0031	5.0	24.6	4.5	0.19	9.12	0.42	0.26	Q ok
P-46	MH-46	DI-47	1	0	1	0.00	0.95	0.00	2.78	6.0	9.12	4.15	11.56	30	42	0.012	0.000676	0.0031	5.0	24.7	4.9	0.14	9.27	0.16	0.03	Q ok
P-47	DI-47	MH-60	4551	287	4838	0.11	0.90	0.10	2.88	6.0	9.27	4.11	11.86	36	23	0.012	0.000269	0.0030	5.6	39.9	4.8	0.08	9.35	-0.07	-0.14	Q ok
P-60	MH-60	MH-61	1	0	1	0.00	0.95	0.00	4.01	6.0	9.35	4.11	16.49	36	75	0.012	0.000521	0.0039	6.4	44.9	5.7	0.22	9.57	-0.24	-0.53	Q ok
P-61	MH-61	DI-62	1	0	1	0.00	0.95	0.00	4.01	6.0	9.57	4.05	16.25	36	76	0.012	0.000506	0.0039	6.4	45.4	5.8	0.22	9.78	-0.63	-0.93	Q ok
P-62	DI-62	DI-63	1435	40	1475	0.03	0.93	0.03	4.04	6.0	9.78	4.01	16.21	36	50	0.012	0.000503	0.0040	6.5	45.7	5.8	0.14	9.93	-1.03	-1.23	Q ok
P-63	DI-63	DI-77	1999	107	2106	0.05	0.91	0.04	4.79	6.0	9.93	3.99	19.11	36	25	0.012	0.000700	0.0036	6.1	43.4	5.9	0.07	10.00	-1.33	-1.42	Q ok
P-77	DI-77	DI-85	2311	122	2433	0.06	0.91	0.05	5.88	6.0	10.00	3.97	23.34	48	50	0.012	0.000225	0.0030	6.8	85.2	5.6	0.15	10.15	-1.52	-1.67	Q ok
P-85	DI-85	MH-86	5006	304	5310	0.12	0.91	0.11	10.47	6.0	10.15	3.96	41.43	60	186	0.012	0.000216	0.0030	7.9	154.8	6.5	0.48	10.63	-1.77	-2.33	Q ok
P-86	MH-86	MH-87	1	0	1	0.00	0.95	0.00	11.07	6.0	10.63	3.89	43.09	60	45	0.012	0.000233	0.0031	8.0	157.4	6.6	0.11	10.74	-2.43	-2.57	Q ok
P-87	**MH-87**	**OUTFALL**	**1**	**0**	**1**	**0.00**	**0.95**	**0.00**	**11.79**	**6.0**	**10.74**	**3.88**	**45.74**	**60**	**9**	**0.012**	**0.000263**	**0.0033**	**8.3**	**162.9**	**7.1**	**0.02**	**10.76**	**-2.67**	**-2.70**	**Q ok**
P-48	MSS MH-08	MH-49	1	0	1	0.00	0.95	0.00	0.90	6.0	7.52	4.47	4.01	24	64	0.012	0.000268	0.0070	6.5	20.6	4.9	0.22	7.73	1.65	1.20	Q ok
P-50	B7 North	1.00	32048	0	32048	0.74	0.95	0.70	0.70	6.0	0.00	4.77	3.33	18	16	0.012	0.000858	0.0050	4.6	8.0	4.2	0.06	6.06	0.35	0.27	Q ok
P-65	B7 West	MH-64	32234	0	32234	0.74	0.95	0.70	0.70	6.0	0.00	4.77	3.35	18	17	0.012	0.000868	0.0047	4.4	7.8	4.3	0.07	6.07	-0.95	-1.03	Q ok
P-64	MH-64	DI-63	1	0	1	0.00	0.95	0.00	0.70	6.0	6.07	4.75	3.34	18	20	0.012	0.000861	0.0050	4.6	8.0	4.2	0.08	6.15	-1.13	-1.23	Q ok
P-51	DI-51	DI-52	3030	31	3061	0.07	0.94	0.07	0.07	6.0	0.00	4.77	0.32	15	26	0.012	0.000020	0.0050	4.0	4.9	2.0	0.22	6.22	3.70	3.57	Q ok
P-52	DI-52	DI-53	4699	521	5220	0.12	0.87	0.10	0.17	6.0	6.22	4.73	0.81	15	69	0.012	0.000133	0.0049	4.0	4.9	2.8	0.41	6.63	3.37	3.03	Q ok
P-53	DI-53	MH-54	4484	537	5021	0.12	0.87	0.10	0.27	6.0	6.63	4.65	1.26	15	51	0.012	0.000324	0.0051	4.1	5.0	3.3	0.25	6.88	2.83	2.57	Q ok
P-54	MH-54	DI-55	1	0	1	0.00	0.95	0.00	1.00	6.0	6.88	4.59	4.59	24	41	0.012	0.000352	0.0049	5.4	17.1	4.5	0.15	7.04	2.37	2.17	Q ok
P-55	DI-55	MH-60	5685	291	5976	0.14	0.91	0.13	1.13	6.0	7.04	4.57	5.15	24	23	0.012	0.000441	0.0052	5.6	17.7	4.8	0.08	7.12	1.97	1.85	Q ok
P-56	B5 South	MH-54	33482	0	33482	0.77	0.95	0.73	0.73	6.0	0.00	4.77	3.48	18	17	0.012	0.000937	0.0053	4.7	8.3	4.3	0.07	6.07	2.56	2.47	Q ok
P-78	DI-78	DI-79	3667	223	3890	0.09	0.91	0.08	0.08	6.0	0.00	4.77	0.39	15	84	0.012	0.000030	0.0200	8.1	9.9	4.0	0.35	6.35	7.12	5.44	Q ok
P-79	DI-79	DI-71	3253	204	3457	0.08	0.90	0.07	0.15	6.0	6.35	4.69	0.72	18	29	0.012	0.000040	0.0200	9.1	16.1	4.5	0.11	6.46	5.24	4.66	Q ok
P-71	DI-71	DI-72	3698	198	3896	0.09	0.91	0.08	0.32	6.0	6.46	4.67	1.49	18	42	0.012	0.000171	0.0200	9.1	16.1	5.5	0.13	6.59	4.46	3.62	Q ok
P-72	DI-72	DI-73	2021	16	2037	0.05	0.94	0.04	0.36	6.0	6.59	4.65	1.69	18	29	0.012	0.000219	0.0200	9.1	16.1	5.5	0.09	6.68	3.42	2.84	Q ok
P-73	DI-73	MH-74	1071	0	1071	0.02	0.95	0.02	0.39	6.0	6.68	4.63	1.79	18	17	0.012	0.000247	0.0200	9.1	16.1	5.5	0.05	6.73	2.64	2.30	Q ok
P-74	MH-74	DI-75	1	0	1	0.00	0.95	0.00	0.95	6.0	6.73	4.63	4.39	18	17	0.012	0.001488	0.0200	9.1	16.1	7.5	0.04	6.77	2.10	1.76	Q ok
P-75	DI-75	DI-76	2135	0	2135	0.05	0.95	0.05	0.99	6.0	6.77	4.61	4.59	18	43	0.012	0.001624	0.0200	9.1	16.1	7.7	0.09	6.86	1.56	0.70	Q ok
P-76	DI-76	DI-77	1993	48	2041	0.05	0.93	0.04	1.04	6.0	6.86	4.59	4.77	18	51	0.012	0.001754	0.0200	9.1	16.1	7.7	0.11	6.97	0.50	-0.52	Q ok
P-70	DI-70	DI-71	3812	274	4086	0.09	0.90	0.08	0.08	6.0	0.00	4.77	0.40	15	86	0.012	0.000033	0.0200	8.1	9.9	4.0	0.36	6.36	6.38	4.66	Q ok
P-80	DI-80	MH-74	22886	15258	38144	0.88	0.64	0.56	0.56	6.0	0.00	4.77	2.68	18	24	0.012	0.000555	0.0050	4.6	8.0	4.1	0.10	6.10	2.42	2.30	Q ok
P-90	DI-90	DI-91	6026	1962	7988	0.18	0.76	0.14	0.14	6.0	0.00	4.77	0.67	15	79	0.012	0.000090	0.0200	8.1	9.9	4.0	0.33	6.33	2.54	0.96	Q ok
P-91	DI-91	MH-87	6475	2667	9142	0.21	0.73	0.15	0.72	6.0	6.33	4.71	3.38	18	81	0.012	0.000884	0.0200	9.1	16.1	6.8	0.20	6.53	-0.04	-1.66	Q ok
P-92	B6 North	DI-91	19569	0	19569	0.45	0.95	0.43	0.43	6.0	0.00	4.77	2.04	18	63	0.012	0.000320	0.0049	4.5	8.0	3.7	0.28	6.28	0.47	0.16	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 2 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-95	TD-04	MH-86	21353	32030	53383	1.23	0.49	0.60	0.60	6.0	0.00	4.77	2.85	12	16	0.011	0.004590	0.0506	12.1	9.5	10.3	0.03	6.03	8.01	7.20	Q ok
P-38	DI-38	DI-39	1483	0	1483	0.03	0.95	0.03	0.03	6.0	0.00	4.77	0.15	15	99	0.012	0.000005	0.0200	8.1	9.9	4.0	0.42	6.42	2.75	0.77	Q ok
P-39	DI-39	DI-40	3833	220	4053	0.09	0.91	0.08	0.12	6.0	6.42	4.69	0.55	15	70	0.012	0.000061	0.0200	8.1	9.9	4.0	0.30	6.71	0.57	-0.83	Q ok
P-40	DI-40	DI-85	4668	293	4961	0.11	0.90	0.10	0.22	6.0	6.71	4.63	1.02	18	26	0.012	0.000080	0.0208	9.3	16.4	4.5	0.10	6.81	-1.03	-1.57	Q ok
P-35	MH-35	DI-36	1	0	1	0.00	0.95	0.00	4.13	6.0	7.69	4.43	18.32	**36**	94	0.012	0.000643	0.0050	7.2	51.1	6.5	0.24	7.93	-0.16	-0.63	Q ok
P-36	DI-36	DI-37	1851	0	1851	0.04	0.95	0.04	4.17	6.0	7.93	4.39	18.33	**36**	98	0.012	0.000643	0.0050	7.2	51.1	6.5	0.25	8.18	-0.73	-1.22	Q ok
P-37	DI-37	DI-85	3893	195	4088	0.09	0.91	0.09	4.26	6.0	8.18	4.33	18.45	36	70	0.012	0.000652	0.0050	7.2	51.1	6.5	0.18	8.36	-1.32	-1.67	Q ok
P-30	DI-30	MH-35	1403	0	1403	0.03	0.95	0.03	0.03	6.0	0.00	4.77	0.15	18	47	0.012	0.000002	0.0200	9.1	16.1	4.5	0.18	6.18	0.98	0.04	Q ok
P-11	DI-11	DI-12	4746	684	5430	0.12	0.85	0.11	0.11	6.0	0.00	4.77	0.51	15	20	0.012	0.000053	0.0065	4.6	5.6	2.8	0.12	6.12	2.91	2.78	Q ok
P-12	DI-12	DI-13	4957	1287	6244	0.14	0.79	0.11	0.22	6.0	6.12	4.75	1.04	15	92	0.012	0.000222	0.0065	4.6	5.7	3.5	0.44	6.56	2.68	2.08	Q ok
P-13	DI-13	MH-14	4947	1296	6243	0.14	0.79	0.11	0.33	6.0	6.56	4.65	1.55	15	54	0.012	0.000490	0.0065	4.6	5.6	3.8	0.24	6.80	1.98	1.63	Q ok
P-14	MH-14	DI-15	1	0	1	0.00	0.95	0.00	1.03	6.0	6.80	4.61	4.75	24	38	0.012	0.000375	0.0066	6.3	19.9	5.2	0.12	6.93	1.53	1.28	Q ok
P-15	DI-15	DI-16	3998	870	4868	0.11	0.81	0.09	1.12	6.0	6.93	4.59	5.14	24	73	0.012	0.000440	0.0064	6.3	19.7	5.1	0.24	7.16	1.18	0.71	Q ok
P-16	DI-16	MH-17	5113	501	5614	0.13	0.88	0.11	1.23	6.0	7.16	4.53	5.59	24	31	0.012	0.000520	0.0071	6.6	20.6	5.4	0.10	7.26	0.61	0.39	Q ok
P-18	B7 South	MH-14	31929	0	31929	0.73	0.95	0.70	0.70	6.0	0.00	4.77	3.32	18	17	0.012	0.000852	0.0053	4.7	8.3	4.3	0.07	6.07	1.72	1.63	Q ok
P-01	DI-01	DI-02	7520	1261	8781	0.20	0.84	0.17	0.17	6.0	0.00	4.77	0.81	15	77	0.012	0.000133	0.0065	4.6	5.6	3.2	0.40	6.40	2.91	2.41	Q ok
P-02	DI-02	DI-03	2113	487	2600	0.06	0.81	0.05	0.22	6.0	6.40	4.69	1.02	15	38	0.012	0.000212	0.0066	4.6	5.7	3.5	0.18	6.58	2.31	2.06	Q ok
P-03	DI-03	MH-04	4989	1312	6301	0.14	0.79	0.11	0.33	6.0	6.58	4.65	1.54	15	46	0.012	0.000485	0.0065	4.6	5.7	3.8	0.20	6.78	1.96	1.66	Q ok
P-04	MH-04	DI-05	1	0	1	0.00	0.95	0.00	0.78	6.0	6.78	4.61	3.60	18	46	0.012	0.001000	0.0065	5.2	9.2	4.8	0.16	6.94	1.56	1.26	Q ok
P-05	DI-05	DI-06	3831	995	4826	0.11	0.79	0.09	0.87	6.0	6.94	4.59	3.98	24	73	0.012	0.000264	0.0064	6.3	19.7	4.7	0.26	7.20	1.16	0.69	Q ok
P-06	DI-06	MH-17	5161	592	5753	0.13	0.87	0.12	1.49	6.0	7.20	4.53	6.76	24	30	0.012	0.000761	0.0067	6.4	20.0	5.7	0.09	7.29	0.59	0.39	Q ok
P-17	MH-17	MH-35	1	0	1	0.00	0.95	0.00	2.73	6.0	7.29	4.51	12.30	*36*	115	0.012	0.000290	0.0030	5.6	39.9	4.8	0.40	7.69	0.29	-0.06	Q ok
Check P-17 for Sanitary Crossing for Conflict																										Check P-1
P-08	DI-08	MH-07	1526	0	1526	0.04	0.95	0.03	0.03	6.0	0.00	4.77	0.16	15	58	0.012	0.000005	0.0066	4.6	5.7	2.3	0.43	6.43	1.36	0.98	Q ok
P-07	MH-07	DI-06	1	0	1	0.00	0.95	0.00	0.51	6.0	0.00	4.77	2.43	18	14	0.012	0.000456	0.0064	5.2	9.1	4.2	0.06	6.06	0.88	0.79	Q ok
P-09	B9/J	MH-04	20585	0	20585	0.47	0.95	0.45	0.45	6.0	0.00	4.77	2.14	18	17	0.012	0.000354	0.0053	4.7	8.3	3.8	0.07	6.07	1.75	1.66	Q ok
P-10	B9/J	MH-07	21845	0	21845	0.50	0.95	0.48	0.48	6.0	0.00	4.77	2.27	18	17	0.012	0.000399	0.0053	4.7	8.3	3.8	0.07	6.07	1.07	0.98	Q ok
P-20	TD-05	DI-21	5394	0	5394	0.12	0.95	0.12	0.12	6.0	0.00	4.77	0.56	8	39	0.011	0.001544	0.0500	9.1	3.2	6.9	0.09	6.09	8.50	6.55	Q ok
P-21	DI-21	MH-22	6185	3410	9595	0.22	0.68	0.15	0.27	6.0	6.09	4.75	1.27	15	31	0.012	0.000327	0.0200	8.1	9.9	5.6	0.09	6.19	4.54	3.92	Q ok
P-22	MH-22	MH-23	1	0	1	0.00	0.95	0.00	0.42	6.0	6.19	4.73	2.01	18	42	0.012	0.000311	0.0200	9.1	16.1	5.5	0.13	6.31	3.72	2.88	Q ok
P-23	MH-23	MH-24	1	0	1	0.00	0.95	0.00	1.20	6.0	6.31	4.71	5.67	18	66	0.012	0.002486	0.0200	9.1	16.1	8.2	0.13	6.45	2.68	1.36	Q ok
P-24	MH-24	MH-35	1	0	1	0.00	0.95	0.00	1.38	6.0	6.45	4.69	6.46	18	56	0.012	0.003222	0.0200	9.1	16.1	8.4	0.11	6.56	1.16	0.04	Q ok
P-25	DI-25	MH-22	6504	3883	10387	0.24	0.66	0.16	0.16	6.0	0.00	4.77	0.75	15	31	0.012	0.000116	0.0200	8.1	9.9	4.8	0.11	6.11	4.54	3.92	Q ok
P-26	B8/K	MH-23	16317	0	16317	0.37	0.95	0.36	0.36	6.0	0.00	4.77	1.70	18	56	0.012	0.000222	0.0050	4.6	8.0	3.4	0.27	6.27	3.06	2.78	Q ok
P-27	B6 South	MH-23	19451	0	19451	0.45	0.95	0.42	0.42	6.0	0.00	4.77	2.02	18	56	0.012	0.000316	0.0050	4.6	8.0	3.7	0.25	6.25	3.06	2.78	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/2023 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/2023 | Cm. No.: 20077.000
Segment: Central Green Outfall | Storm Frequency: 2 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-28	DI-28	MH-24	3596	533	4129	0.09	0.85	0.08	0.08	6.0	0.00	4.77	0.38	18	34	0.012	0.000011	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok
P-29	DI-29	MH-24	4110	551	4661	0.11	0.86	0.09	0.09	6.0	0.00	4.77	0.44	18	34	0.012	0.000015	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok

KEY

	Upsized from Semi-Final Design to have capacity for 50-yr design storm
	Optional Upsize-50-yr design storm results in >85% Full
	No Change from Semi-Final Design

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvatu O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	4.28	4.28	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	4.32	7.00	HGL ok
P-42	MH-42	DI-43	2.00	4.25	4.25	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	4.28	7.86	HGL ok
P-43	DI-43	DI-44	2.00	4.22	4.22	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	4.25	7.11	HGL ok
P-44	DI-44	DI-45	2.00	4.17	4.17	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	4.22	7.03	HGL ok
P-45	DI-45	MH-46	2.00	4.11	4.11	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	4.17	7.59	HGL ok
P-46	MH-46	DI-47	2.00	4.06	4.06	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	4.11	8.54	HGL ok
P-47	DI-47	MH-60	2.40	3.95	3.95	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	4.06	9.09	HGL ok
P-60	MH-60	MH-61	2.40	3.88	3.88	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	3.95	9.84	HGL ok
P-61	MH-61	DI-62	2.40	3.79	3.79	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	3.88	11.03	HGL ok
P-62	DI-62	DI-63	2.40	3.71	3.71	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	3.79	10.34	HGL ok
P-63	DI-63	DI-77	1.93	3.58	3.58	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	3.71	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.43	3.43	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	3.58	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.26	3.26	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	3.43	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.23	3.23	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	3.26	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.20**	**3.20**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	*0.5*	**0.02**	**0.03**	**3.23**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	4.28	4.28	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	4.31	8.07	HGL ok
P-50	B7 North	1.00	1.20	4.11	4.11	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	4.14	10.00	HGL ok
P-65	B7 West	MH-64	1.20	3.76	3.76	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.78	10.00	HGL ok
P-64	MH-64	DI-63	1.20	3.71	3.71	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	3.76	10.14	HGL ok
P-51	DI-51	DI-52	1.00	4.11	4.57	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.57	7.11	HGL ok
P-52	DI-52	DI-53	1.00	4.10	4.10	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	4.11	7.03	HGL ok
P-53	DI-53	MH-54	1.00	4.07	4.07	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	4.10	7.59	HGL ok
P-54	MH-54	DI-55	1.60	4.02	4.02	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	4.07	8.54	HGL ok
P-55	DI-55	MH-60	1.60	3.95	3.95	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	4.02	9.09	HGL ok
P-56	B5 South	MH-54	1.20	4.07	4.07	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	4.10	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.86	6.44	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.44	11.60	HGL ok
P-79	DI-79	DI-71	1.20	4.83	5.86	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	5.86	11.15	HGL ok
P-71	DI-71	DI-72	1.20	4.06	4.82	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	4.83	11.15	HGL ok
P-72	DI-72	DI-73	1.20	3.95	4.04	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	4.06	10.99	HGL ok
P-73	DI-73	MH-74	1.20	3.94	3.94	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	3.95	10.84	HGL ok
P-74	MH-74	DI-75	1.20	3.88	3.88	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	3.94	11.24	HGL ok
P-75	DI-75	DI-76	1.20	3.74	3.74	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	3.88	10.63	HGL ok
P-76	DI-76	DI-77	1.20	3.58	3.58	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	3.74	10.34	HGL ok
P-70	DI-70	DI-71	1.00	4.83	5.66	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.66	11.60	HGL ok
P-80	DI-80	MH-74	1.20	3.94	3.94	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	3.96	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.34	3.34	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.35	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.23	3.23	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	3.34	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.34	3.34	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.37	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.26	8.00	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	8.10	10.50	HGL ok
P-38	DI-38	DI-39	1.00	3.45	3.45	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.45	10.67	HGL ok
P-39	DI-39	DI-40	1.00	3.44	3.44	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	3.45	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.43	3.43	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	3.44	9.98	HGL ok
P-35	MH-35	DI-36	2.40	3.68	3.68	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	3.86	11.72	HGL ok
P-36	DI-36	DI-37	2.40	3.55	3.55	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	3.68	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.43	3.43	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	3.55	10.16	HGL ok
P-30	DI-30	MH-35	1.20	3.86	3.86	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.86	11.24	HGL ok
P-11	DI-11	DI-12	1.00	4.18	4.18	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.18	6.84	HGL ok
P-12	DI-12	DI-13	1.00	4.15	4.15	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	*1.3*	1.0	0.01	0.03	4.18	6.99	HGL ok
P-13	DI-13	MH-14	1.00	4.11	4.11	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	*1.3*	1.0	0.01	0.04	4.15	7.91	HGL ok
P-14	MH-14	DI-15	1.60	4.06	4.06	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	*0.5*	0.03	0.05	4.11	8.68	HGL ok
P-15	DI-15	DI-16	1.60	4.00	4.00	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	4.06	9.01	HGL ok
P-16	DI-16	MH-17	1.60	3.93	3.93	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	4.00	9.77	HGL ok
P-18	B7 South	MH-14	1.20	4.11	4.11	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.01	0.02	4.13	10.00	HGL ok
P-01	DI-01	DI-02	1.00	4.17	4.17	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.18	6.84	HGL ok
P-02	DI-02	DI-03	1.00	4.16	4.16	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	*1.3*	1.0	0.01	0.02	4.17	7.35	HGL ok
P-03	DI-03	MH-04	1.00	4.12	4.12	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	*1.3*	1.0	0.01	0.04	4.16	7.91	HGL ok
P-04	MH-04	DI-05	1.20	4.05	4.05	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	*0.5*	0.02	0.07	4.12	8.60	HGL ok
P-05	DI-05	DI-06	1.60	4.00	4.00	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	4.05	9.01	HGL ok
P-06	DI-06	MH-17	1.60	3.93	3.93	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	4.00	9.87	HGL ok
P-17	MH-17	MH-35	1.60	3.86	3.86	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	*0.5*	0.04	0.08	3.93	10.61	HGL ok
P-08	DI-08	MH-07	1.00	4.02	4.02	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.02	11.39	HGL ok
P-07	MH-07	DI-06	1.20	4.00	4.00	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	*0.5*	0.02	0.02	4.02	10.19	HGL ok
P-09	B9/J	MH-04	1.20	4.12	4.12	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	4.13	10.00	HGL ok
P-10	B9/J	MH-07	1.20	4.02	4.02	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	4.03	10.00	HGL ok
P-20	TD-05	DI-21	0.53	4.98	7.08	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	7.15	10.50	HGL ok
P-21	DI-21	MH-22	1.00	4.31	4.92	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	*1.3*	1.0	0.05	0.06	4.98	9.46	HGL ok
P-22	MH-22	MH-23	1.20	4.28	4.28	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	*0.5*	0.01	0.02	4.31	9.72	HGL ok
P-23	MH-23	MH-24	1.20	4.09	4.09	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	*0.5*	0.03	0.19	4.28	10.97	HGL ok
P-24	MH-24	MH-35	1.20	3.86	3.86	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	*0.5*	0.05	0.23	4.09	11.20	HGL ok
P-25	DI-25	MH-22	1.00	4.31	4.92	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.93	9.46	HGL ok
P-26	B8/K	MH-23	1.20	4.28	4.28	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	4.30	10.00	HGL ok
P-27	B6 South	MH-23	1.20	4.28	4.28	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.02	4.31	10.00	HGL ok
P-28	DI-28	MH-24	1.20	4.09	4.09	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.09	10.95	HGL ok
P-29	DI-29	MH-24	1.20	4.09	4.09	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.09	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5	
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\ adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	4.48	4.48	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	4.52	7.00	HGL ok
P-42	MH-42	DI-43	2.00	4.45	4.45	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	4.48	7.86	HGL ok
P-43	DI-43	DI-44	2.00	4.42	4.42	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	4.45	7.11	HGL ok
P-44	DI-44	DI-45	2.00	4.37	4.37	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	4.42	7.03	HGL ok
P-45	DI-45	MH-46	2.00	4.31	4.31	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	4.37	7.59	HGL ok
P-46	MH-46	DI-47	2.00	4.26	4.26	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	4.31	8.54	HGL ok
P-47	DI-47	MH-60	2.40	4.15	4.15	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	4.26	9.09	HGL ok
P-60	MH-60	MH-61	2.40	4.08	4.08	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	4.15	9.84	HGL ok
P-61	MH-61	DI-62	2.40	3.99	3.99	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	4.08	11.03	HGL ok
P-62	DI-62	DI-63	2.40	3.91	3.91	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	3.99	10.34	HGL ok
P-63	DI-63	DI-77	1.93	3.78	3.78	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	3.91	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.63	3.63	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	3.78	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.46	3.46	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	3.63	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.43	3.43	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	3.46	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.40**	**3.40**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	0.5	**0.02**	**0.03**	**3.43**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	4.48	4.48	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	4.51	8.07	HGL ok
P-50	B7 North	1.00	1.20	4.31	4.31	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	4.34	10.00	HGL ok
P-65	B7 West	MH-64	1.20	3.96	3.96	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	3.98	10.00	HGL ok
P-64	MH-64	DI-63	1.20	3.91	3.91	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	3.96	10.14	HGL ok
P-51	DI-51	DI-52	1.00	4.31	4.57	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.57	7.11	HGL ok
P-52	DI-52	DI-53	1.00	4.30	4.30	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	4.31	7.03	HGL ok
P-53	DI-53	MH-54	1.00	4.27	4.27	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	4.30	7.59	HGL ok
P-54	MH-54	DI-55	1.60	4.22	4.22	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	4.27	8.54	HGL ok
P-55	DI-55	MH-60	1.60	4.15	4.15	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	4.22	9.09	HGL ok
P-56	B5 South	MH-54	1.20	4.27	4.27	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	4.30	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.86	6.44	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.44	11.60	HGL ok
P-79	DI-79	DI-71	1.20	4.83	5.86	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	5.86	11.15	HGL ok
P-71	DI-71	DI-72	1.20	4.17	4.82	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	4.83	11.15	HGL ok
P-72	DI-72	DI-73	1.20	4.15	4.15	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	4.17	10.99	HGL ok
P-73	DI-73	MH-74	1.20	4.14	4.14	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	4.15	10.84	HGL ok
P-74	MH-74	DI-75	1.20	4.08	4.08	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	4.14	11.24	HGL ok
P-75	DI-75	DI-76	1.20	3.94	3.94	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	4.08	10.63	HGL ok
P-76	DI-76	DI-77	1.20	3.78	3.78	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	3.94	10.34	HGL ok
P-70	DI-70	DI-71	1.00	4.83	5.66	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.66	11.60	HGL ok
P-80	DI-80	MH-74	1.20	4.14	4.14	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	4.16	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.54	3.54	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.55	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.43	3.43	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	3.54	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.54	3.54	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	3.57	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.46	8.00	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	8.10	10.50	HGL ok
P-38	DI-38	DI-39	1.00	3.65	3.65	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.65	10.67	HGL ok
P-39	DI-39	DI-40	1.00	3.64	3.64	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	3.65	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.63	3.63	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	3.64	9.98	HGL ok
P-35	MH-35	DI-36	2.40	3.88	3.88	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	4.06	11.72	HGL ok
P-36	DI-36	DI-37	2.40	3.75	3.75	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	3.88	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.63	3.63	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	3.75	10.16	HGL ok
P-30	DI-30	MH-35	1.20	4.06	4.06	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.06	11.24	HGL ok
P-11	DI-11	DI-12	1.00	4.38	4.38	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.38	6.84	HGL ok
P-12	DI-12	DI-13	1.00	4.35	4.35	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	4.38	6.99	HGL ok
P-13	DI-13	MH-14	1.00	4.31	4.31	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	4.35	7.91	HGL ok
P-14	MH-14	DI-15	1.60	4.26	4.26	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	4.31	8.68	HGL ok
P-15	DI-15	DI-16	1.60	4.20	4.20	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	4.26	9.01	HGL ok
P-16	DI-16	MH-17	1.60	4.13	4.13	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	4.20	9.77	HGL ok
P-18	B7 South	MH-14	1.20	4.31	4.31	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	4.33	10.00	HGL ok
P-01	DI-01	DI-02	1.00	4.37	4.37	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.38	6.84	HGL ok
P-02	DI-02	DI-03	1.00	4.36	4.36	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	4.37	7.35	HGL ok
P-03	DI-03	MH-04	1.00	4.32	4.32	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	4.36	7.91	HGL ok
P-04	MH-04	DI-05	1.20	4.25	4.25	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	4.32	8.60	HGL ok
P-05	DI-05	DI-06	1.60	4.20	4.20	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	4.25	9.01	HGL ok
P-06	DI-06	MH-17	1.60	4.13	4.13	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	4.20	9.87	HGL ok
P-17	MH-17	MH-35	1.60	4.06	4.06	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	4.13	10.61	HGL ok
P-08	DI-08	MH-07	1.00	4.22	4.22	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.22	11.39	HGL ok
P-07	MH-07	DI-06	1.20	4.20	4.20	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	4.22	10.19	HGL ok
P-09	B9/J	MH-04	1.20	4.32	4.32	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.33	10.00	HGL ok
P-10	B9/J	MH-07	1.20	4.22	4.22	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.23	10.00	HGL ok
P-20	TD-05	DI-21	0.53	4.98	7.08	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	7.15	10.50	HGL ok
P-21	DI-21	MH-22	1.00	4.51	4.92	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	4.98	9.46	HGL ok
P-22	MH-22	MH-23	1.20	4.48	4.48	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	4.51	9.72	HGL ok
P-23	MH-23	MH-24	1.20	4.29	4.29	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	4.48	10.97	HGL ok
P-24	MH-24	MH-35	1.20	4.06	4.06	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	4.29	11.20	HGL ok
P-25	DI-25	MH-22	1.00	4.51	4.92	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.93	9.46	HGL ok
P-26	B8/K	MH-23	1.20	4.48	4.48	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	4.50	10.00	HGL ok
P-27	B6 South	MH-23	1.20	4.48	4.48	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	4.51	10.00	HGL ok
P-28	DI-28	MH-24	1.20	4.29	4.29	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.29	10.95	HGL ok
P-29	DI-29	MH-24	1.20	4.29	4.29	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.29	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	7.98	7.98	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	8.02	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	7.95	7.95	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	7.98	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	7.92	7.92	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	7.95	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	7.87	7.87	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	7.92	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	7.81	7.81	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	7.87	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	7.76	7.76	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	7.81	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	7.65	7.65	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	7.76	9.09	HGL ok
P-60	MH-60	MH-61	2.40	7.58	7.58	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	7.65	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.49	7.49	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	7.58	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.41	7.41	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	7.49	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.28	7.28	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	7.41	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.13	7.13	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	7.28	10.08	HGL ok
P-85	DI-85	MH-86	4.00	6.96	6.96	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	7.13	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.93	6.93	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	6.96	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**6.90**	**6.90**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**6.93**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	7.98	7.98	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	8.01	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	7.81	7.81	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	7.84	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.46	7.46	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.48	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.41	7.41	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	7.46	10.14	HGL ok
P-51	DI-51	DI-52	1.00	7.81	7.81	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.81	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	7.80	7.80	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	7.81	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	7.77	7.77	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	7.80	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	7.72	7.72	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	7.77	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	7.65	7.65	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	7.72	9.09	HGL ok
P-56	B5 South	MH-54	1.20	7.77	7.77	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	7.80	10.00	HGL ok
P-78	DI-78	DI-79	1.00	7.68	7.68	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.69	11.60	HGL ok
P-79	DI-79	DI-71	1.20	7.68	7.68	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	7.68	11.15	HGL ok
P-71	DI-71	DI-72	1.20	7.67	7.67	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	7.68	11.15	HGL ok
P-72	DI-72	DI-73	1.20	7.65	7.65	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	7.67	10.99	HGL ok
P-73	DI-73	MH-74	1.20	7.64	7.64	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	7.65	10.84	HGL ok
P-74	MH-74	DI-75	1.20	7.58	7.58	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	7.64	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.44	7.44	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	7.58	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.28	7.28	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	7.44	10.34	HGL ok
P-70	DI-70	DI-71	1.00	7.68	7.68	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.68	11.60	HGL ok
P-80	DI-80	MH-74	1.20	7.64	7.64	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	7.66	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.04	7.04	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.05	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.93	6.93	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	7.04	8.33	HGL ok
P-92	B6 North	DI-91	1.20	7.04	7.04	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.07	10.00	HGL ok
P-95	TD-04	MH-86	0.80	6.96	8.00	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	8.10	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.15	7.15	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.15	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.14	7.14	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	7.15	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.13	7.13	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	7.14	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.38	7.38	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	7.56	11.72	HGL ok
P-36	DI-36	DI-37	2.40	7.25	7.25	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	7.38	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.13	7.13	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	7.25	10.16	HGL ok
P-30	DI-30	MH-35	1.20	7.56	7.56	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.56	11.24	HGL ok
P-11	DI-11	DI-12	1.00	7.88	7.88	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.88	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	7.85	7.85	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	7.88	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	7.81	7.81	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	7.85	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	7.76	7.76	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	7.81	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	7.70	7.70	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	7.76	9.01	HGL ok
P-16	DI-16	MH-17	1.60	7.63	7.63	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	7.70	9.77	HGL ok
P-18	B7 South	MH-14	1.20	7.81	7.81	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.83	10.00	HGL ok
P-01	DI-01	DI-02	1.00	7.87	7.87	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.88	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	7.86	7.86	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	7.87	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	7.82	7.82	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	7.86	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	7.75	7.75	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	7.82	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	7.70	7.70	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	7.75	9.01	HGL ok
P-06	DI-06	MH-17	1.60	7.63	7.63	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	7.70	9.87	HGL ok
P-17	MH-17	MH-35	1.60	7.56	7.56	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	7.63	10.61	HGL ok
P-08	DI-08	MH-07	1.00	7.72	7.72	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.72	11.39	HGL ok
P-07	MH-07	DI-06	1.20	7.70	7.70	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	7.72	10.19	HGL ok
P-09	B9/J	MH-04	1.20	7.82	7.82	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.83	10.00	HGL ok
P-10	B9/J	MH-07	1.20	7.72	7.72	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.73	10.00	HGL ok
P-20	TD-05	DI-21	0.53	8.07	8.07	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	8.14	10.50	HGL ok
P-21	DI-21	MH-22	1.00	8.01	8.01	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	8.07	9.46	HGL ok
P-22	MH-22	MH-23	1.20	7.98	7.98	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	8.01	9.72	HGL ok
P-23	MH-23	MH-24	1.20	7.79	7.79	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	7.98	10.97	HGL ok
P-24	MH-24	MH-35	1.20	7.56	7.56	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	7.79	11.20	HGL ok
P-25	DI-25	MH-22	1.00	8.01	8.01	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.01	9.46	HGL ok
P-26	B8/K	MH-23	1.20	7.98	7.98	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.00	10.00	HGL ok
P-27	B6 South	MH-23	1.20	7.98	7.98	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.01	10.00	HGL ok
P-28	DI-28	MH-24	1.20	7.79	7.79	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.79	10.95	HGL ok
P-29	DI-29	MH-24	1.20	7.79	7.79	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.79	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvatu O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ ft	Tot. H Loss, $H = H_f + H_{t\,adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	**HGL Check**
P-41	MH-41	MH-42	1.60	8.48	8.48	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	8.52	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	8.45	8.45	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	8.48	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	8.42	8.42	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	8.45	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	8.37	8.37	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	8.42	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	8.31	8.31	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	8.37	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	8.26	8.26	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	8.31	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.15	8.15	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	8.26	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.08	8.08	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	8.15	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.99	7.99	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	8.08	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.91	7.91	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	7.99	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.78	7.78	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	7.91	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.63	7.63	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	7.78	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.46	7.46	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	7.63	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.43	7.43	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	7.46	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.40**	**7.40**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**7.43**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	8.48	8.48	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	8.51	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	8.31	8.31	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	8.34	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.96	7.96	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.98	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.91	7.91	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	7.96	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.31	8.31	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.31	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	8.30	8.30	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	8.31	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.27	8.27	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	8.30	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.22	8.22	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	8.27	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.15	8.15	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	8.22	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	8.27	8.27	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	8.30	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.18	8.18	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.19	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.18	8.18	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	8.18	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.17	8.17	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	8.18	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.15	8.15	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	8.17	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.14	8.14	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	8.15	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.08	8.08	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	8.14	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.94	7.94	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	8.08	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.78	7.78	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	7.94	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.18	8.18	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.18	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.14	8.14	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	8.16	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.54	7.54	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.55	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.43	7.43	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	7.54	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	7.54	7.54	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.57	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.46	8.00	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	8.10	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.65	7.65	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.65	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.64	7.64	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	7.65	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.63	7.63	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	7.64	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.88	7.88	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	8.06	11.72	HGL ok
P-36	DI-36	DI-37	2.40	7.75	7.75	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	7.88	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.63	7.63	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	7.75	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.06	8.06	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.06	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.38	8.38	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.38	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	8.35	8.35	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	8.38	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	8.31	8.31	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	8.35	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.26	8.26	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	8.31	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.20	8.20	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	8.26	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.13	8.13	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	8.20	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.31	8.31	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.33	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.37	8.37	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.38	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	8.36	8.36	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	8.37	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	8.32	8.32	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	8.36	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.25	8.25	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	8.32	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.20	8.20	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	8.25	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.13	8.13	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	8.20	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.06	8.06	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	8.13	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.22	8.22	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.22	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.20	8.20	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	8.22	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.32	8.32	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.33	10.00	HGL ok
P-10	B9/J	MH-07	1.20	8.22	8.22	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.23	10.00	HGL ok
P-20	TD-05	DI-21	0.53	8.57	8.57	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	8.64	10.50	HGL ok
P-21	DI-21	MH-22	1.00	8.51	8.51	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	8.57	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	8.48	8.48	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	8.51	9.72	HGL ok
P-23	MH-23	MH-24	1.20	8.29	8.29	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	8.48	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.06	8.06	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	8.29	11.20	HGL ok
P-25	DI-25	MH-22	1.00	8.51	8.51	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.51	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	8.48	8.48	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.50	10.00	HGL ok
P-27	B6 South	MH-23	1.20	8.48	8.48	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.51	10.00	HGL ok
P-28	DI-28	MH-24	1.20	8.29	8.29	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.29	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.29	8.29	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.29	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D — 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe — TW (ft)	Outlet W. S. Elevation — HGL Dn (ft)	Outflow Pipe Diameter — D_o (in)	Outflow Pipe Design Flow — Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$ — V_o (fps)	Skew angle vs. — Δ_o (deg)	Outflow Pipe Length — L (ft)	Friction Slope — S_{fo} (ft/ft)	Friction Loss — H_f (ft)	Angle of Curvature — O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ — H_c (ft)	Contraction Loss — H_o (ft)	Q*V for determining controlling inflow pipe — Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe — Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe — Q3V3 (ft^4/s^2)	Controlling Inflow Velocity — Vi	Expansion Loss — Hi (ft)	Controlling In-flow skew — Δ_i (deg)	Bend Loss — H_Δ (ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ — H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss — $H_{t\,adj}$ (ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ — H (ft)	Inlet W. S. Elevation — HGL Up (ft)	Top of Grate — T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	8.88	8.88	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	8.92	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	8.85	8.85	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	8.88	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	8.82	8.82	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	8.85	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	8.77	8.77	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	8.82	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	8.71	8.71	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	8.77	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	8.66	8.66	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	8.71	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.55	8.55	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	8.66	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.48	8.48	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	8.55	9.84	HGL ok
P-61	MH-61	DI-62	2.40	8.39	8.39	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	8.48	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.31	8.31	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	8.39	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.18	8.18	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	8.31	10.08	HGL ok
P-77	DI-77	DI-85	3.20	8.03	8.03	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	8.18	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.86	7.86	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	8.03	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.83	7.83	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	7.86	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.80**	**7.80**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**7.83**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	8.88	8.88	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	8.91	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	8.71	8.71	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	8.74	10.00	HGL ok
P-65	B7 West	MH-64	1.20	8.36	8.36	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.38	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.31	8.31	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	8.36	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.71	8.71	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.71	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	8.70	8.70	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	8.71	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.67	8.67	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	8.70	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.62	8.62	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	8.67	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.55	8.55	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	8.62	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	8.67	8.67	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	8.70	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.58	8.58	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.59	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.58	8.58	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	8.58	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.57	8.57	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	8.58	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.55	8.55	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	8.57	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.54	8.54	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	8.55	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.48	8.48	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	8.54	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.34	8.34	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	8.48	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.18	8.18	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	8.34	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.58	8.58	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.58	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.54	8.54	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	8.56	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.94	7.94	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.95	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.83	7.83	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	7.94	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	7.94	7.94	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.97	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.86	8.00	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	8.10	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.05	8.05	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.05	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.04	8.04	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.05	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.03	8.03	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	8.04	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.28	8.28	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	8.46	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.15	8.15	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	8.28	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.03	8.03	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	8.15	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.46	8.46	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.46	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.78	8.78	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.78	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	8.75	8.75	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	8.78	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	8.71	8.71	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	8.75	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.66	8.66	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	8.71	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.60	8.60	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	8.66	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.53	8.53	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	8.60	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.71	8.71	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.73	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.77	8.77	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.78	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	8.76	8.76	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	8.77	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	8.72	8.72	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	8.76	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.65	8.65	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	8.72	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.60	8.60	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	8.65	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.53	8.53	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	8.60	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.46	8.46	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	8.53	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.62	8.62	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.62	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.60	8.60	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	8.62	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.72	8.72	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.73	10.00	HGL ok
P-10	B9/J	MH-07	1.20	8.62	8.62	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.63	10.00	HGL ok
P-20	TD-05	DI-21	0.53	8.97	8.97	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	9.04	10.50	HGL ok
P-21	DI-21	MH-22	1.00	8.91	8.91	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	8.97	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	8.88	8.88	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	8.91	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	8.69	8.69	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	8.88	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.46	8.46	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	8.69	11.20	HGL ok
P-25	DI-25	MH-22	1.00	8.91	8.91	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.91	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	8.88	8.88	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	8.90	10.00	HGL ok
P-27	B6 South	MH-23	1.20	8.88	8.88	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.91	10.00	HGL ok
P-28	DI-28	MH-24	1.20	8.69	8.69	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.69	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.69	8.69	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.69	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add $Hc = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	9.38	9.38	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	9.42	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	9.35	9.35	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	9.38	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.32	9.32	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	9.35	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.27	9.27	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	9.32	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.21	9.21	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	9.27	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.16	9.16	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	9.21	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.05	9.05	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	9.16	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.98	8.98	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	9.05	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	8.89	8.89	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	8.98	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.81	8.81	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	8.89	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.68	8.68	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	8.81	10.08	HGL ok
P-77	DI-77	DI-85	3.20	8.53	8.53	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	8.68	10.08	HGL ok
P-85	DI-85	MH-86	4.00	8.36	8.36	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	8.53	9.98	HGL ok
P-86	MH-86	MH-87	4.00	8.33	8.33	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	8.36	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**8.30**	**8.30**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	*0.5*	**0.02**	**0.03**	**8.33**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.38	9.38	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	9.41	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.21	9.21	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	9.24	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	8.86	8.86	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.88	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.81	8.81	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	8.86	10.14	HGL ok
P-51	DI-51	DI-52	1.00	9.21	9.21	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.21	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.20	9.20	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	9.21	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.17	9.17	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	9.20	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.12	9.12	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	9.17	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.05	9.05	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	9.12	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.17	9.17	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	9.20	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.08	9.08	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.09	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.08	9.08	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	9.08	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.07	9.07	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	9.08	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.05	9.05	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	9.07	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.04	9.04	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	9.05	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.98	8.98	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	9.04	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.84	8.84	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	8.98	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.68	8.68	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	8.84	10.34	HGL ok
P-70	DI-70	DI-71	1.00	9.08	9.08	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.08	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.04	9.04	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.06	11.00	HGL ok
P-90	DI-90	DI-91	1.00	8.44	8.44	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.45	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	8.33	8.33	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	8.44	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.44	8.44	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.47	10.00	HGL ok
P-95	TD-04	MH-86	0.80	8.36	8.36	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	8.46	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.55	8.55	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.55	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.54	8.54	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.55	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.53	8.53	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	8.54	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.78	8.78	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	8.96	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.65	8.65	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	8.78	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.53	8.53	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	8.65	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.96	8.96	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.96	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.28	9.28	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.28	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.25	9.25	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	9.28	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.21	9.21	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	9.25	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.16	9.16	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	9.21	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.10	9.10	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	9.16	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.03	9.03	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	9.10	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.21	9.21	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.23	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.27	9.27	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.28	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.26	9.26	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	9.27	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.22	9.22	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	9.26	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.15	9.15	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	9.22	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.10	9.10	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	9.15	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.03	9.03	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	9.10	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	8.96	8.96	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	9.03	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.12	9.12	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.12	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.10	9.10	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	9.12	10.19	HGL ok
P-09	B9/J	MH-04	1.20	9.22	9.22	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.23	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.12	9.12	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.13	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	9.47	9.47	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	9.54	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	9.41	9.41	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	9.47	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.38	9.38	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	9.41	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.19	9.19	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	9.38	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.96	8.96	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	9.19	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.41	9.41	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.41	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.38	9.38	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	9.40	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.38	9.38	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.41	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.19	9.19	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.19	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.19	9.19	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.19	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR — Date: 2/23/23 — Sheet No.: 2 of 5
Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Design Freq.: 2 -year (50-year for sumps)

Location: No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	10.08	10.08	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	10.12	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.05	10.05	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	10.08	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.02	10.02	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	10.05	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.97	9.97	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	10.02	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.91	9.91	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	9.97	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.86	9.86	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	9.91	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.75	9.75	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	9.86	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.68	9.68	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	9.75	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.59	9.59	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	9.68	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.51	9.51	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	9.59	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.38	9.38	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	9.51	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.23	9.23	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	9.38	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.06	9.06	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	9.23	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.03	9.03	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	9.06	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.00**	**9.00**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**9.03**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.08	10.08	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	10.11	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.91	9.91	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	9.94	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.56	9.56	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.58	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.51	9.51	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	9.56	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	9.91	9.91	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.91	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.90	9.90	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	9.91	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.87	9.87	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	9.90	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.82	9.82	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	9.87	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.75	9.75	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	9.82	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.87	9.87	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	9.90	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.78	9.78	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.79	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.78	9.78	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	9.78	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.77	9.77	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	9.78	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.75	9.75	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	9.77	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.74	9.74	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	9.75	10.84	HGL ok
P-74	MH-74	DI-75	1.20	9.68	9.68	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	9.74	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.54	9.54	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	9.68	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.38	9.38	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	9.54	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	9.78	9.78	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.78	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.74	9.74	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.76	11.00	HGL ok
P-90	DI-90	DI-91	1.00	9.14	9.14	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.15	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.03	9.03	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	9.14	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.14	9.14	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.17	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.06	9.06	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	9.16	10.50	HGL ok
P-38	DI-38	DI-39	1.00	9.25	9.25	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.25	10.67	HGL ok
P-39	DI-39	DI-40	1.00	9.24	9.24	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.25	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.23	9.23	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	9.24	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	9.48	9.48	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	9.66	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.35	9.35	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	9.48	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.23	9.23	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	9.35	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	9.66	9.66	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.66	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.98	9.98	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.98	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.95	9.95	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	9.98	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.91	9.91	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	9.95	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.86	9.86	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	9.91	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.80	9.80	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	9.86	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.73	9.73	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	9.80	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.91	9.91	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.93	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.97	9.97	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.98	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.96	9.96	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	9.97	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.92	9.92	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	9.96	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.85	9.85	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	9.92	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.80	9.80	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	9.85	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.73	9.73	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	9.80	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.66	9.66	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	9.73	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	9.82	9.82	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.80	9.80	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	9.82	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	9.92	9.92	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.93	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.82	9.82	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.83	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.17	10.17	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	10.24	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.11	10.11	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	10.17	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.08	10.08	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	10.11	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.89	9.89	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	10.08	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.66	9.66	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	9.89	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.11	10.11	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.11	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.08	10.08	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.10	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.08	10.08	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.11	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.89	9.89	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.89	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.89	9.89	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.89	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	10.58	10.58	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	10.62	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.55	10.55	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	10.58	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.52	10.52	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	10.55	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.47	10.47	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	10.52	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.41	10.41	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	10.47	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.36	10.36	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	10.41	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.25	10.25	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	10.36	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.18	10.18	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	10.25	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.09	10.09	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	10.18	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.01	10.01	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	10.09	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.88	9.88	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	10.01	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.73	9.73	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	9.88	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.56	9.56	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	9.73	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.53	9.53	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	9.56	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.50**	**9.50**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	0.5	**0.02**	**0.03**	**9.53**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	10.58	10.58	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	10.61	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.41	10.41	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	10.44	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.06	10.06	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.08	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.01	10.01	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	10.06	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.41	10.41	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.41	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.40	10.40	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	10.41	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.37	10.37	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	10.40	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.32	10.32	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	10.37	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.25	10.25	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	10.32	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.37	10.37	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	10.40	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.28	10.28	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.29	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.28	10.28	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	10.28	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.27	10.27	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	10.28	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.25	10.25	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	10.27	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.24	10.24	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	10.25	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.18	10.18	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	10.24	11.24	HGL ok
P-75	DI-75	DI-76	1.20	10.04	10.04	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	10.18	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.88	9.88	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	10.04	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.28	10.28	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.28	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.24	10.24	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.26	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.64	9.64	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.65	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.53	9.53	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	9.64	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.64	9.64	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.67	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.56	9.56	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	9.66	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	9.75	9.75	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.75	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	9.74	9.74	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.75	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.73	9.73	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	9.74	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	9.98	9.98	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	10.16	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.85	9.85	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	9.98	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.73	9.73	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	9.85	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.16	10.16	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.16	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.48	10.48	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.48	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.45	10.45	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	10.48	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.41	10.41	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	10.45	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.36	10.36	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	10.41	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.30	10.30	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	10.36	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.23	10.23	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	10.30	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.41	10.41	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.43	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.47	10.47	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.48	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.46	10.46	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	10.47	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.42	10.42	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	10.46	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.35	10.35	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	10.42	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.30	10.30	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	10.35	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.23	10.23	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	10.30	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.16	10.16	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	10.23	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.32	10.32	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	11.39	HGL ok
P-07	MH-07	DI-06	1.20	10.30	10.30	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	10.32	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.42	10.42	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.43	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.32	10.32	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.33	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.67	10.67	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	10.74	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.61	10.61	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	10.67	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.58	10.58	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	10.61	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.39	10.39	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	10.58	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.16	10.16	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	10.39	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	10.61	10.61	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.61	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.58	10.58	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.60	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.58	10.58	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.61	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.39	10.39	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.39	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.39	10.39	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.39	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.88	11.88	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	11.92	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.85	11.85	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	11.88	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.82	11.82	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	11.85	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.77	11.77	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	11.82	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.71	11.71	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	11.77	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.66	11.66	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	11.71	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.55	11.55	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	11.66	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.48	11.48	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	11.55	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.39	11.39	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	11.48	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.31	11.31	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	11.39	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.18	11.18	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	11.31	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.03	11.03	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	11.18	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.86	10.86	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	11.03	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.83	10.83	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	10.86	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.80**	**10.80**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**10.83**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	11.88	11.88	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	11.91	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.71	11.71	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	11.74	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.36	11.36	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.38	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.31	11.31	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	11.36	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.71	11.71	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.71	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.70	11.70	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	11.71	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.67	11.67	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	11.70	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.62	11.62	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	11.67	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.55	11.55	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	11.62	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.67	11.67	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	11.70	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.58	11.58	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.59	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.58	11.58	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	11.58	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.57	11.57	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	11.58	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.55	11.55	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	11.57	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.54	11.54	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	11.55	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.48	11.48	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	11.54	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.34	11.34	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	11.48	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.18	11.18	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	11.34	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.58	11.58	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.58	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.54	11.54	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.56	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.94	10.94	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.95	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.83	10.83	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	10.94	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.94	10.94	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.97	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.86	10.86	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	10.96	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.05	11.05	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.05	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.04	11.04	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.05	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.03	11.03	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	11.04	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.28	11.28	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	11.46	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.15	11.15	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	11.28	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.03	11.03	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	11.15	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.46	11.46	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.46	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.78	11.78	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.78	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.75	11.75	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	*1.3*	1.0	0.01	0.03	11.78	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.71	11.71	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	*1.3*	1.0	0.01	0.04	11.75	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.66	11.66	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	*0.5*	0.03	0.05	11.71	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.60	11.60	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	11.66	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.53	11.53	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	11.60	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.71	11.71	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.01	0.02	11.73	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.77	11.77	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.78	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.76	11.76	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	*1.3*	1.0	0.01	0.02	11.77	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.72	11.72	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	*1.3*	1.0	0.01	0.04	11.76	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.65	11.65	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	*0.5*	0.02	0.07	11.72	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.60	11.60	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	11.65	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.53	11.53	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	11.60	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.46	11.46	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	*0.5*	0.04	0.08	11.53	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.62	11.62	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.62	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.60	11.60	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	*0.5*	0.02	0.02	11.62	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.72	11.72	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	11.73	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.62	11.62	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	11.63	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.97	11.97	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	12.04	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.91	11.91	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	*1.3*	1.0	0.05	0.06	11.97	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.88	11.88	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	*0.5*	0.01	0.02	11.91	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.69	11.69	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	*0.5*	0.03	0.19	11.88	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.46	11.46	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	*0.5*	0.05	0.23	11.69	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.91	11.91	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.91	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.88	11.88	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	*0.5*	0.00	0.01	11.90	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.88	11.88	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.02	11.91	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.69	11.69	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.69	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.69	11.69	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.69	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	6.82	6.82	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	6.86	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	6.79	6.79	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	6.82	7.86	HGL ok
P-43	DI-43	DI-44	2.00	6.76	6.76	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	6.79	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	6.71	6.71	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	6.76	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	6.65	6.65	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	6.71	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	6.60	6.60	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	6.65	8.54	HGL ok
P-47	DI-47	MH-60	2.40	6.49	6.49	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	6.60	9.09	HGL ok
P-60	MH-60	MH-61	2.40	6.42	6.42	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	6.49	9.84	HGL ok
P-61	MH-61	DI-62	2.40	6.33	6.33	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	6.42	11.03	HGL ok
P-62	DI-62	DI-63	2.40	6.25	6.25	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	6.33	10.34	HGL ok
P-63	DI-63	DI-77	1.93	6.12	6.12	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	6.25	10.08	HGL ok
P-77	DI-77	DI-85	3.20	5.97	5.97	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	6.12	10.08	HGL ok
P-85	DI-85	MH-86	4.00	5.80	5.80	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	5.97	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.77	5.77	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	5.80	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.74**	**5.74**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**5.77**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	6.82	6.82	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	6.85	8.07	HGL ok
P-50	B7 North	1.00	1.20	6.65	6.65	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	6.68	10.00	HGL ok
P-65	B7 West	MH-64	1.20	6.30	6.30	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.32	10.00	HGL ok
P-64	MH-64	DI-63	1.20	6.25	6.25	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	6.30	10.14	HGL ok
P-51	DI-51	DI-52	1.00	6.65	6.65	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.65	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	6.64	6.64	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	6.65	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	6.61	6.61	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	6.64	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	6.56	6.56	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	6.61	8.54	HGL ok
P-55	DI-55	MH-60	1.60	6.49	6.49	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	6.56	9.09	HGL ok
P-56	B5 South	MH-54	1.20	6.61	6.61	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	6.64	10.00	HGL ok
P-78	DI-78	DI-79	1.00	6.52	6.52	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.53	11.60	HGL ok
P-79	DI-79	DI-71	1.20	6.52	6.52	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	6.52	11.15	HGL ok
P-71	DI-71	DI-72	1.20	6.51	6.51	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	6.52	11.15	HGL ok
P-72	DI-72	DI-73	1.20	6.49	6.49	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	6.51	10.99	HGL ok
P-73	DI-73	MH-74	1.20	6.48	6.48	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	6.49	10.84	HGL ok
P-74	MH-74	DI-75	1.20	6.42	6.42	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	6.48	11.24	HGL ok
P-75	DI-75	DI-76	1.20	6.28	6.28	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	6.42	10.63	HGL ok
P-76	DI-76	DI-77	1.20	6.12	6.12	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	6.28	10.34	HGL ok
P-70	DI-70	DI-71	1.00	6.52	6.52	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.52	11.60	HGL ok
P-80	DI-80	MH-74	1.20	6.48	6.48	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	6.50	11.00	HGL ok
P-90	DI-90	DI-91	1.00	5.88	5.88	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.89	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.77	5.77	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	5.88	8.33	HGL ok
P-92	B6 North	DI-91	1.20	5.88	5.88	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	5.91	10.00	HGL ok
P-95	TD-04	MH-86	0.80	5.80	8.00	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	8.10	10.50	HGL ok
P-38	DI-38	DI-39	1.00	5.99	5.99	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.99	10.67	HGL ok
P-39	DI-39	DI-40	1.00	5.98	5.98	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	5.99	10.16	HGL ok
P-40	DI-40	DI-85	1.20	5.97	5.97	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	5.98	9.98	HGL ok
P-35	MH-35	DI-36	2.40	6.22	6.22	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	6.40	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.09	6.09	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	6.22	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	5.97	5.97	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	6.09	10.16	HGL ok
P-30	DI-30	MH-35	1.20	6.40	6.40	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.40	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.72	6.72	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.72	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	6.69	6.69	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	6.72	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	6.65	6.65	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	6.69	7.91	HGL ok
P-14	MH-14	DI-15	1.60	6.60	6.60	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	6.65	8.68	HGL ok
P-15	DI-15	DI-16	1.60	6.54	6.54	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	6.60	9.01	HGL ok
P-16	DI-16	MH-17	1.60	6.47	6.47	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	6.54	9.77	HGL ok
P-18	B7 South	MH-14	1.20	6.65	6.65	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.67	10.00	HGL ok
P-01	DI-01	DI-02	1.00	6.71	6.71	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.72	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	6.70	6.70	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	6.71	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	6.66	6.66	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	6.70	7.91	HGL ok
P-04	MH-04	DI-05	1.20	6.59	6.59	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	6.66	8.60	HGL ok
P-05	DI-05	DI-06	1.60	6.54	6.54	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	6.59	9.01	HGL ok
P-06	DI-06	MH-17	1.60	6.47	6.47	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	6.54	9.87	HGL ok
P-17	MH-17	MH-35	1.60	6.40	6.40	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	6.47	10.61	HGL ok
P-08	DI-08	MH-07	1.00	6.56	6.56	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.56	11.39	HGL ok
P-07	MH-07	DI-06	1.20	6.54	6.54	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	6.56	10.19	HGL ok
P-09	B9/J	MH-04	1.20	6.66	6.66	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.67	10.00	HGL ok
P-10	B9/J	MH-07	1.20	6.56	6.56	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.57	10.00	HGL ok
P-20	TD-05	DI-21	0.53	6.91	7.08	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	7.15	10.50	HGL ok
P-21	DI-21	MH-22	1.00	6.85	6.85	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	6.91	9.46	HGL ok
P-22	MH-22	MH-23	1.20	6.82	6.82	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	6.85	9.72	HGL ok
P-23	MH-23	MH-24	1.20	6.63	6.63	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	6.82	10.97	HGL ok
P-24	MH-24	MH-35	1.20	6.40	6.40	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	6.63	11.20	HGL ok
P-25	DI-25	MH-22	1.00	6.85	6.85	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.85	9.46	HGL ok
P-26	B8/K	MH-23	1.20	6.82	6.82	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	6.84	10.00	HGL ok
P-27	B6 South	MH-23	1.20	6.82	6.82	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.85	10.00	HGL ok
P-28	DI-28	MH-24	1.20	6.63	6.63	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.63	10.95	HGL ok
P-29	DI-29	MH-24	1.20	6.63	6.63	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.63	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)			

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe TW (ft)	Outlet W. S. Elevation HGL Dn (ft)	Outflow Pipe Diameter D_o (in)	Outflow Pipe Design Flow Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$ V_o (fps)	Skew angle vs. Δ_o (deg)	Outflow Pipe Length L (ft)	Friction Slope S_{fo} (ft/ft)	Friction Loss H_f (ft)	Angle of Curvature O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c (ft)	Contraction Loss H_o (ft)	Q*V for determining controlling inflow pipe Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q3V3 (ft^4/s^2)	Controlling Inflow Velocity Vi	Expansion Loss Hi (ft)	Controlling In-flow skew Δ_i (deg)	Bend Loss H_Δ (ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ (ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$ H (ft)	Inlet W. S. Elevation HGL Up (ft)	Top of Grate T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	7.02	7.02	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	7.06	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	6.99	6.99	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	7.02	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	6.96	6.96	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	6.99	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	6.91	6.91	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	6.96	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	6.85	6.85	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	6.91	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	6.80	6.80	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	6.85	8.54	HGL ok
P-47	DI-47	MH-60	2.40	6.69	6.69	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	6.80	9.09	HGL ok
P-60	MH-60	MH-61	2.40	6.62	6.62	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	6.69	9.84	HGL ok
P-61	MH-61	DI-62	2.40	6.53	6.53	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	6.62	11.03	HGL ok
P-62	DI-62	DI-63	2.40	6.45	6.45	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	6.53	10.34	HGL ok
P-63	DI-63	DI-77	1.93	6.32	6.32	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	6.45	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.17	6.17	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	6.32	10.08	HGL ok
P-85	DI-85	MH-86	4.00	6.00	6.00	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	6.17	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.97	5.97	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	6.00	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.94**	**5.94**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**5.97**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	7.02	7.02	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	7.05	8.07	HGL ok
P-50	B7 North	1.00	1.20	6.85	6.85	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	6.88	10.00	HGL ok
P-65	B7 West	MH-64	1.20	6.50	6.50	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.52	10.00	HGL ok
P-64	MH-64	DI-63	1.20	6.45	6.45	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	6.50	10.14	HGL ok
P-51	DI-51	DI-52	1.00	6.85	6.85	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.85	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	6.84	6.84	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	6.85	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	6.81	6.81	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	6.84	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	6.76	6.76	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	6.81	8.54	HGL ok
P-55	DI-55	MH-60	1.60	6.69	6.69	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	6.76	9.09	HGL ok
P-56	B5 South	MH-54	1.20	6.81	6.81	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	6.84	10.00	HGL ok
P-78	DI-78	DI-79	1.00	6.72	6.72	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.73	11.60	HGL ok
P-79	DI-79	DI-71	1.20	6.72	6.72	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	6.72	11.15	HGL ok
P-71	DI-71	DI-72	1.20	6.71	6.71	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	6.72	11.15	HGL ok
P-72	DI-72	DI-73	1.20	6.69	6.69	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	6.71	10.99	HGL ok
P-73	DI-73	MH-74	1.20	6.68	6.68	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	6.69	10.84	HGL ok
P-74	MH-74	DI-75	1.20	6.62	6.62	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	6.68	11.24	HGL ok
P-75	DI-75	DI-76	1.20	6.48	6.48	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	6.62	10.63	HGL ok
P-76	DI-76	DI-77	1.20	6.32	6.32	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	6.48	10.34	HGL ok
P-70	DI-70	DI-71	1.00	6.72	6.72	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.72	11.60	HGL ok
P-80	DI-80	MH-74	1.20	6.68	6.68	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	6.70	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.08	6.08	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.09	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.97	5.97	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	6.08	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.08	6.08	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	6.11	10.00	HGL ok
P-95	TD-04	MH-86	0.80	6.00	8.00	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	8.10	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.19	6.19	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.19	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.18	6.18	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.19	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.17	6.17	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	6.18	9.98	HGL ok
P-35	MH-35	DI-36	2.40	6.42	6.42	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	6.60	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.29	6.29	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	6.42	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 2 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.17	6.17	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	6.29	10.16	HGL ok
P-30	DI-30	MH-35	1.20	6.60	6.60	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.60	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.92	6.92	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.92	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	6.89	6.89	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	6.92	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	6.85	6.85	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	6.89	7.91	HGL ok
P-14	MH-14	DI-15	1.60	6.80	6.80	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	6.85	8.68	HGL ok
P-15	DI-15	DI-16	1.60	6.74	6.74	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	6.80	9.01	HGL ok
P-16	DI-16	MH-17	1.60	6.67	6.67	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	6.74	9.77	HGL ok
P-18	B7 South	MH-14	1.20	6.85	6.85	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.87	10.00	HGL ok
P-01	DI-01	DI-02	1.00	6.91	6.91	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.92	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	6.90	6.90	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	6.91	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	6.86	6.86	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	6.90	7.91	HGL ok
P-04	MH-04	DI-05	1.20	6.79	6.79	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	6.86	8.60	HGL ok
P-05	DI-05	DI-06	1.60	6.74	6.74	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	6.79	9.01	HGL ok
P-06	DI-06	MH-17	1.60	6.67	6.67	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	6.74	9.87	HGL ok
P-17	MH-17	MH-35	1.60	6.60	6.60	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	6.67	10.61	HGL ok
P-08	DI-08	MH-07	1.00	6.76	6.76	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.76	11.39	HGL ok
P-07	MH-07	DI-06	1.20	6.74	6.74	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	6.76	10.19	HGL ok
P-09	B9/J	MH-04	1.20	6.86	6.86	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.87	10.00	HGL ok
P-10	B9/J	MH-07	1.20	6.76	6.76	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	6.77	10.00	HGL ok
P-20	TD-05	DI-21	0.53	7.11	7.11	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	7.18	10.50	HGL ok
P-21	DI-21	MH-22	1.00	7.05	7.05	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	7.11	9.46	HGL ok
P-22	MH-22	MH-23	1.20	7.02	7.02	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	7.05	9.72	HGL ok
P-23	MH-23	MH-24	1.20	6.83	6.83	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	7.02	10.97	HGL ok
P-24	MH-24	MH-35	1.20	6.60	6.60	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	6.83	11.20	HGL ok
P-25	DI-25	MH-22	1.00	7.05	7.05	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.05	9.46	HGL ok
P-26	B8/K	MH-23	1.20	7.02	7.02	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	7.04	10.00	HGL ok
P-27	B6 South	MH-23	1.20	7.02	7.02	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.05	10.00	HGL ok
P-28	DI-28	MH-24	1.20	6.83	6.83	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.83	10.95	HGL ok
P-29	DI-29	MH-24	1.20	6.83	6.83	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.83	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	**HGL Check**
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	10.52	10.52	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	10.56	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.49	10.49	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	10.52	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.46	10.46	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	10.49	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.41	10.41	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	10.46	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.35	10.35	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	10.41	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.30	10.30	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	10.35	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.19	10.19	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	10.30	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.12	10.12	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	10.19	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.03	10.03	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	10.12	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	9.95	9.95	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	10.03	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.82	9.82	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	9.95	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.67	9.67	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	9.82	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.50	9.50	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	9.67	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.47	9.47	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	9.50	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.44**	**9.44**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	0.5	**0.02**	**0.03**	**9.47**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.52	10.52	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	10.55	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.35	10.35	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	10.38	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.00	10.00	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.02	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.95	9.95	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	10.00	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.35	10.35	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.35	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.34	10.34	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	10.35	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.31	10.31	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	10.34	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.26	10.26	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	10.31	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.19	10.19	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	10.26	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.31	10.31	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	10.34	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.22	10.22	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.23	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.22	10.22	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	10.22	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.21	10.21	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	10.22	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.19	10.19	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	10.21	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.18	10.18	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	10.19	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.12	10.12	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	10.18	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.98	9.98	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	10.12	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.82	9.82	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	9.98	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.22	10.22	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.22	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.18	10.18	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.20	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.58	9.58	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.59	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.47	9.47	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	9.58	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.58	9.58	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.61	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.50	9.50	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	9.60	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	9.69	9.69	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.69	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	9.68	9.68	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.69	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.67	9.67	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	9.68	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	9.92	9.92	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	10.10	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.79	9.79	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	9.92	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.67	9.67	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	9.79	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.10	10.10	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.10	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.42	10.42	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.42	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.39	10.39	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	10.42	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.35	10.35	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	10.39	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.30	10.30	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	10.35	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.24	10.24	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	10.30	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.17	10.17	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	10.24	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.35	10.35	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.37	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.41	10.41	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.42	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.40	10.40	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	10.41	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.36	10.36	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	10.40	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.29	10.29	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	10.36	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.24	10.24	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	10.29	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.17	10.17	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	10.24	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.10	10.10	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	10.17	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.26	10.26	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.26	11.39	HGL ok
P-07	MH-07	DI-06	1.20	10.24	10.24	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	10.26	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.36	10.36	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.37	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.26	10.26	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.27	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.61	10.61	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	10.68	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.55	10.55	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	10.61	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.52	10.52	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	10.55	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.33	10.33	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	10.52	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.10	10.10	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	10.33	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	10.55	10.55	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.55	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.52	10.52	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	10.54	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.52	10.52	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.55	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.33	10.33	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.33	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.33	10.33	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.33	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.02	11.02	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	11.06	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.99	10.99	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	11.02	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.96	10.96	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	10.99	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.91	10.91	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	10.96	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.85	10.85	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	10.91	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.80	10.80	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	10.85	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.69	10.69	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	10.80	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.62	10.62	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	10.69	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.53	10.53	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	10.62	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.45	10.45	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	10.53	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.32	10.32	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	10.45	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.17	10.17	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	10.32	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.00	10.00	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	10.17	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.97	9.97	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	10.00	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.94**	**9.94**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**9.97**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	11.02	11.02	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	11.05	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.85	10.85	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	10.88	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.50	10.50	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.52	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.45	10.45	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	10.50	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.85	10.85	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.85	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.84	10.84	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	10.85	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.81	10.81	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	10.84	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.76	10.76	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	10.81	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.69	10.69	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	10.76	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.81	10.81	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	10.84	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.72	10.72	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.73	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	10.72	10.72	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	10.72	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.71	10.71	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	10.72	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.69	10.69	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	10.71	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.68	10.68	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	10.69	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.62	10.62	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	10.68	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.48	10.48	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	10.62	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.32	10.32	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	10.48	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.72	10.72	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.72	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	10.68	10.68	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.70	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.08	10.08	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.09	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.97	9.97	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	10.08	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.08	10.08	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.11	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.00	10.00	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	10.10	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.19	10.19	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.19	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.18	10.18	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.19	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.17	10.17	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	10.18	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.42	10.42	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	10.60	11.72	HGL ok
P-36	DI-36	DI-37	2.40	10.29	10.29	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	10.42	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.17	10.17	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	10.29	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.60	10.60	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.60	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	10.92	10.92	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.92	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.89	10.89	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	10.92	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.85	10.85	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	10.89	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.80	10.80	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	10.85	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.74	10.74	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	10.80	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.67	10.67	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	10.74	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.85	10.85	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.87	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.91	10.91	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.92	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.90	10.90	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	10.91	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.86	10.86	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	10.90	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.79	10.79	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	10.86	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.74	10.74	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	10.79	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.67	10.67	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	10.74	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.60	10.60	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	10.67	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.76	10.76	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.76	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	10.74	10.74	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	10.76	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.86	10.86	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.87	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.76	10.76	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.77	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.11	11.11	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	11.18	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.05	11.05	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	11.11	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.02	11.02	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	11.05	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.83	10.83	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	11.02	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.60	10.60	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	10.83	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.05	11.05	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.05	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.02	11.02	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.04	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.02	11.02	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.05	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.83	10.83	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.83	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.83	10.83	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.83	10.95	HGL Too High!

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Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	11.42	11.42	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	11.46	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.39	11.39	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	11.42	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.36	11.36	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	11.39	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.31	11.31	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	11.36	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.25	11.25	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	11.31	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.20	11.20	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	11.25	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.09	11.09	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	11.20	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.02	11.02	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	11.09	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.93	10.93	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	11.02	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.85	10.85	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	10.93	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.72	10.72	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	10.85	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.57	10.57	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	10.72	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.40	10.40	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	10.57	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.37	10.37	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	10.40	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.34**	**10.34**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	*0.5*	**0.02**	**0.03**	**10.37**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	11.42	11.42	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	11.45	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.25	11.25	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	11.28	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.90	10.90	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.92	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.85	10.85	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	10.90	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.25	11.25	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.25	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.24	11.24	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	11.25	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.21	11.21	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	11.24	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.16	11.16	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	11.21	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.09	11.09	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	11.16	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.21	11.21	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	11.24	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.12	11.12	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.13	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.12	11.12	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	11.12	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.11	11.11	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	11.12	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.09	11.09	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	11.11	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.08	11.08	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	11.09	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.02	11.02	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	11.08	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.88	10.88	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	11.02	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.72	10.72	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	10.88	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.12	11.12	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.12	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.08	11.08	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.10	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.48	10.48	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.49	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.37	10.37	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	10.48	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.48	10.48	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.51	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.40	10.40	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	10.50	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.59	10.59	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.59	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.58	10.58	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.59	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.57	10.57	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	10.58	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.82	10.82	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	11.00	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.69	10.69	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	10.82	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.57	10.57	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	10.69	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.00	11.00	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.00	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.32	11.32	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.32	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.29	11.29	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	11.32	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.25	11.25	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	11.29	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.20	11.20	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	11.25	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.14	11.14	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	11.20	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.07	11.07	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	11.14	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.25	11.25	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.27	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.31	11.31	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.32	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.30	11.30	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	11.31	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.26	11.26	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	11.30	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.19	11.19	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	11.26	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.14	11.14	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	11.19	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.07	11.07	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	11.14	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.00	11.00	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	11.07	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.16	11.16	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.16	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.14	11.14	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	11.16	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.26	11.26	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.27	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.16	11.16	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.17	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.51	11.51	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	11.58	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.45	11.45	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	11.51	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.42	11.42	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	11.45	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.23	11.23	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	11.42	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.00	11.00	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	11.23	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.45	11.45	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.45	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.42	11.42	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.44	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.42	11.42	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.45	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.23	11.23	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.23	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.23	11.23	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.23	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)			

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\ adj}$, ft)	Tot. H Loss, $H=H_f+H_{t\ adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	11.92	11.92	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	11.96	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.89	11.89	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	11.92	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.86	11.86	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	11.89	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.81	11.81	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	11.86	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.75	11.75	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	11.81	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.70	11.70	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	11.75	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.59	11.59	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	11.70	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.52	11.52	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	11.59	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.43	11.43	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	11.52	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.35	11.35	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	11.43	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.22	11.22	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	11.35	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.07	11.07	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	11.22	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.90	10.90	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	11.07	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.87	10.87	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	10.90	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.84**	**10.84**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**10.87**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	11.92	11.92	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	11.95	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.75	11.75	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	11.78	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.40	11.40	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.42	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.35	11.35	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	11.40	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.75	11.75	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.75	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.74	11.74	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	11.75	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.71	11.71	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	11.74	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.66	11.66	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	11.71	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.59	11.59	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	11.66	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.71	11.71	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	11.74	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.62	11.62	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.63	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.62	11.62	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	11.62	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.61	11.61	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	11.62	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.59	11.59	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	11.61	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.58	11.58	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	11.59	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.52	11.52	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	11.58	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.38	11.38	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	11.52	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.22	11.22	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	11.38	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.62	11.62	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.62	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.58	11.58	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.60	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.98	10.98	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.99	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.87	10.87	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	10.98	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.98	10.98	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.01	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.90	10.90	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	11.00	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.09	11.09	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.09	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.08	11.08	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.09	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.07	11.07	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	11.08	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.32	11.32	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	11.50	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.19	11.19	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	11.32	10.67	HGL Too High!

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.07	11.07	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	11.19	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.50	11.50	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.50	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.82	11.82	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.82	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.79	11.79	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	11.82	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.75	11.75	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	11.79	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.70	11.70	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	11.75	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.64	11.64	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	11.70	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.57	11.57	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	11.64	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.75	11.75	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.77	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.81	11.81	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.82	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.80	11.80	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	11.81	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.76	11.76	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	11.80	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.69	11.69	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	11.76	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.64	11.64	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	11.69	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.57	11.57	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	11.64	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.50	11.50	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	11.57	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.66	11.66	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.66	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.64	11.64	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	11.66	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.76	11.76	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.77	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.66	11.66	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.67	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.01	12.01	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	12.08	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.95	11.95	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	12.01	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.92	11.92	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	11.95	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.73	11.73	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	11.92	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.50	11.50	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	11.73	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.95	11.95	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.95	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.92	11.92	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	11.94	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.92	11.92	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.95	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.73	11.73	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.73	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.73	11.73	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.73	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	12.62	12.62	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	12.66	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.59	12.59	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	12.62	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.56	12.56	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	12.59	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.51	12.51	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	12.56	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.45	12.45	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	12.51	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.40	12.40	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	12.45	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.29	12.29	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	12.40	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.22	12.22	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	12.29	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.13	12.13	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	12.22	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.05	12.05	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	12.13	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.92	11.92	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	12.05	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.77	11.77	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	11.92	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.60	11.60	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	11.77	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	11.57	11.57	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	11.60	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**11.54**	**11.54**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	0.5	**0.02**	**0.03**	**11.57**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.62	12.62	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	12.65	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.45	12.45	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	12.48	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.10	12.10	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.12	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.05	12.05	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	12.10	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.45	12.45	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.45	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.44	12.44	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	12.45	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.41	12.41	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	12.44	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.36	12.36	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	12.41	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.29	12.29	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	12.36	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.41	12.41	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	12.44	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.32	12.32	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.33	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.32	12.32	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	12.32	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.31	12.31	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	12.32	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.29	12.29	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	12.31	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.28	12.28	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	12.29	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.22	12.22	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	12.28	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.08	12.08	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	12.22	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.92	11.92	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	12.08	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.32	12.32	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.32	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.28	12.28	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	12.30	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.68	11.68	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.69	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	11.57	11.57	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	11.68	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.68	11.68	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.71	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.60	11.60	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	11.70	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.79	11.79	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.79	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.78	11.78	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.79	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.77	11.77	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	11.78	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.02	12.02	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	12.20	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.89	11.89	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	12.02	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.77	11.77	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	11.89	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.20	12.20	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.20	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.52	12.52	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.52	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.49	12.49	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	12.52	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.45	12.45	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	12.49	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.40	12.40	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	12.45	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.34	12.34	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	12.40	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.27	12.27	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	12.34	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.45	12.45	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.47	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.51	12.51	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.52	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.50	12.50	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	12.51	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.46	12.46	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	12.50	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.39	12.39	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	12.46	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.34	12.34	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	12.39	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.27	12.27	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	12.34	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.20	12.20	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	12.27	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.36	12.36	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.34	12.34	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	12.36	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.46	12.46	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.47	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.36	12.36	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.37	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.71	12.71	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	12.78	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.65	12.65	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	12.71	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.62	12.62	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	12.65	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.43	12.43	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	12.62	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.20	12.20	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	12.43	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.65	12.65	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.65	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.62	12.62	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	12.64	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.62	12.62	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.65	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.43	12.43	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.43	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.43	12.43	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.43	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	13.12	13.12	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	13.16	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.09	13.09	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	13.12	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.06	13.06	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	13.09	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.01	13.01	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	13.06	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.95	12.95	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	13.01	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.90	12.90	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	12.95	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.79	12.79	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	12.90	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.72	12.72	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	12.79	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.63	12.63	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	12.72	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.55	12.55	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	12.63	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.42	12.42	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	12.55	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.27	12.27	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	12.42	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	12.10	12.10	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	12.27	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	12.07	12.07	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	12.10	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**12.04**	**12.04**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**12.07**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.12	13.12	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	13.15	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.95	12.95	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	12.98	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.60	12.60	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.62	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.55	12.55	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	12.60	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.95	12.95	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.95	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.94	12.94	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	12.95	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.91	12.91	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	12.94	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.86	12.86	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	12.91	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.79	12.79	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	12.86	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.91	12.91	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	12.94	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.82	12.82	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.83	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.82	12.82	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	12.82	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.81	12.81	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	12.82	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.79	12.79	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	12.81	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.78	12.78	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	12.79	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.72	12.72	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	12.78	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.58	12.58	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	12.72	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.42	12.42	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	12.58	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.82	12.82	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.82	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.78	12.78	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	12.80	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	12.18	12.18	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.19	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	12.07	12.07	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	12.18	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	12.18	12.18	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.21	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	12.10	12.10	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	12.20	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.29	12.29	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.29	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.28	12.28	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.29	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.27	12.27	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	12.28	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.52	12.52	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	12.70	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.39	12.39	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	12.52	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.27	12.27	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	12.39	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.70	12.70	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.70	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.02	13.02	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.02	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.99	12.99	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	13.02	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.95	12.95	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	12.99	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.90	12.90	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	12.95	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.84	12.84	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	12.90	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.77	12.77	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	12.84	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.95	12.95	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.97	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.01	13.01	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.02	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.00	13.00	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	13.01	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.96	12.96	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	13.00	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.89	12.89	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	12.96	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.84	12.84	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	12.89	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.77	12.77	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	12.84	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.70	12.70	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	12.77	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.86	12.86	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.86	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.84	12.84	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	12.86	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.96	12.96	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.97	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.86	12.86	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.87	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.21	13.21	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	13.28	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.15	13.15	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	13.21	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.12	13.12	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	13.15	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.93	12.93	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	13.12	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.70	12.70	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	12.93	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.15	13.15	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.15	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.12	13.12	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	13.14	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.12	13.12	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.15	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.93	12.93	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.93	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.93	12.93	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.93	10.95	HGL Too High!

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H=H_f+H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	14.42	14.42	24	3.9	1.2	69	92	0.0003	0.02	0	0.00	0.01	4.9	0.0	0.0	1.2	0.0	90	0.02	0.03	1.0	0.5	0.02	0.04	14.46	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.39	14.39	30	7.6	1.6	13	30	0.0003	0.01	0	0.00	0.01	4.8	5.1	0.0	1.3	0.0	51.7	0.01	0.03	1.0	0.5	0.02	0.02	14.42	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	14.36	14.36	30	8.0	1.6	0	25	0.0003	0.01	0	0.00	0.01	11.9	0.0	0.0	1.6	0.0	13	0.01	0.03	1.0	1.0	0.03	0.04	14.39	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.31	14.31	30	8.4	1.7	6	69	0.0004	0.02	0	0.00	0.01	13.0	0.0	0.0	1.6	0.0	0	0.00	0.03	1.0	1.0	0.03	0.05	14.36	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	14.25	14.25	30	8.7	1.8	13	52	0.0004	0.02	0	0.00	0.01	14.4	0.0	0.0	1.7	0.0	6	0.00	0.03	1.0	1.0	0.03	0.05	14.31	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	14.20	14.20	30	11.6	2.4	83	42	0.0007	0.03	0	0.00	0.02	15.6	6.3	0.0	1.8	0.0	13	0.01	0.05	1.0	0.5	0.02	0.05	14.25	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	14.09	14.09	36	11.9	1.7	90	23	0.0003	0.01	0	0.00	0.01	27.2	0.0	0.0	2.4	0.0	83	0.06	0.10	1.0	1.0	0.10	0.11	14.20	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	14.02	14.02	36	16.5	2.3	82	75	0.0005	0.04	0	0.00	0.02	19.9	8.4	0.0	1.7	0.0	90	0.03	0.07	1.0	0.5	0.03	0.07	14.09	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	13.93	13.93	36	16.2	2.3	7	76	0.0005	0.04	0	0.00	0.02	38.5	0.0	0.0	2.3	0.0	82	0.06	0.11	1.0	0.5	0.05	0.09	14.02	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	13.85	13.85	36	16.2	2.3	89	50	0.0005	0.03	0	0.00	0.02	37.3	0.0	0.0	2.3	0.0	7	0.01	0.06	1.0	1.0	0.06	0.08	13.93	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	13.72	13.72	36	19.1	2.7	92	25	0.0007	0.02	0	0.00	0.03	37.2	6.3	0.0	2.3	0.0	89	0.06	0.11	1.0	1.0	0.11	0.13	13.85	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	13.57	13.57	48	23.3	1.9	91	50	0.0002	0.01	0	0.00	0.01	51.7	12.9	0.0	2.7	0.0	92	0.08	0.13	1.0	1.0	0.13	0.14	13.72	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	13.40	13.40	60	41.4	2.1	17	186	0.0002	0.04	0	0.00	0.02	43.3	0.6	48.1	2.6	0.0	90	0.07	0.13	1.0	1.0	0.13	0.17	13.57	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	13.37	13.37	60	43.1	2.2	0	45	0.0002	0.01	0	0.00	0.02	87.4	10.4	0.0	2.1	0.0	17	0.01	0.06	1.0	0.5	0.03	0.04	13.40	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**13.34**	**13.34**	**60**	**45.7**	**2.3**	**0**	**9**	**0.0003**	**0.00**	**0**	**0.00**	**0.02**	**94.6**	**6.5**	**0.0**	**2.2**	**0.0**	**0**	**0.00**	**0.05**	**1.0**	**0.5**	**0.02**	**0.03**	**13.37**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.42	14.42	24	4.0	1.3	51.7	64	0.0003	0.02	0	0.00	0.01	3.1	0.9	0.0	1.0	0.0	51	0.01	0.02	1.0	0.5	0.01	0.03	14.45	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	14.25	14.25	18	3.3	1.9	83	16	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.03	14.28	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	13.90	13.90	18	3.4	1.9	75	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.92	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	13.85	13.85	18	3.3	1.9	74	20	0.0009	0.02	0	0.00	0.01	6.4	0.0	0.0	1.9	0.0	75	0.04	0.07	1.0	0.5	0.03	0.05	13.90	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	14.25	14.25	15	0.3	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.25	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	14.24	14.24	15	0.8	0.7	7	69	0.0001	0.01	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.01	14.25	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.21	14.21	15	1.3	1.0	13	51	0.0003	0.02	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	7	0.00	0.01	1.3	1.0	0.01	0.03	14.24	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	14.16	14.16	24	4.6	1.5	83	41	0.0004	0.01	0	0.00	0.01	1.3	6.9	0.0	2.0	0.0	83	0.04	0.07	1.0	0.5	0.04	0.05	14.21	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	14.09	14.09	24	5.1	1.6	90	23	0.0004	0.01	0	0.00	0.01	6.7	0.0	0.0	1.5	0.0	83	0.02	0.04	1.3	1.0	0.06	0.07	14.16	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.21	14.21	18	3.5	2.0	83	17	0.0009	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.02	14.24	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	14.12	14.12	15	0.4	0.3	89	84	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.13	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	14.12	14.12	18	0.7	0.4	82	29	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	89	0.00	0.00	1.3	1.0	0.00	0.00	14.12	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	14.11	14.11	18	1.5	0.8	2	42	0.0002	0.01	0	0.00	0.00	0.3	0.1	0.0	0.4	0.0	82	0.00	0.01	1.3	1.0	0.01	0.01	14.12	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	14.09	14.09	18	1.7	1.0	8	29	0.0002	0.01	0	0.00	0.00	1.3	0.0	0.0	0.8	0.0	2	0.00	0.01	1.3	1.0	0.01	0.02	14.11	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	14.08	14.08	18	1.8	1.0	8	17	0.0002	0.00	0	0.00	0.00	1.6	0.0	0.0	1.0	0.0	8	0.00	0.01	1.0	1.0	0.01	0.01	14.09	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	14.02	14.02	18	4.4	2.5	5	17	0.0015	0.03	0	0.00	0.02	1.8	4.1	0.0	1.5	0.0	82	0.02	0.06	1.0	0.5	0.03	0.06	14.08	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	13.88	13.88	18	4.6	2.6	9	43	0.0016	0.07	0	0.00	0.03	10.9	0.0	0.0	2.5	0.0	5	0.01	0.07	1.0	1.0	0.07	0.14	14.02	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	13.72	13.72	18	4.8	2.7	2	51	0.0018	0.09	0	0.00	0.03	11.9	0.0	0.0	2.6	0.0	9	0.01	0.08	1.0	1.0	0.08	0.16	13.88	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	14.12	14.12	15	0.4	0.3	7	86	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.12	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	14.08	14.08	18	2.7	1.5	82	24	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.10	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	13.48	13.48	15	0.7	0.5	0	79	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.49	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	13.37	13.37	18	3.4	1.9	86	81	0.0009	0.07	0	0.00	0.01	0.4	2.3	0.0	1.2	0.0	90	0.01	0.04	1.3	1.0	0.05	0.12	13.48	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	13.48	13.48	18	2.0	1.2	90	63	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.51	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	13.40	13.40	12	2.9	3.6	90	16	0.0046	0.07	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.03	0.10	13.50	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	13.59	13.59	15	0.2	0.1	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.59	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	13.58	13.58	15	0.5	0.4	89	70	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	13.59	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	13.57	13.57	18	1.0	0.6	0	26	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.01	0.01	13.58	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	13.82	13.82	36	18.3	2.6	2	94	0.0006	0.06	0	0.00	0.03	0.0	21.4	23.6	3.7	0.1	78	0.14	0.24	1.0	0.5	0.12	0.18	14.00	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	13.69	13.69	36	18.3	2.6	3	98	0.0006	0.06	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	2	0.00	0.06	1.0	1.0	0.06	0.13	13.82	10.67	HGL Too High!

Delaware Department of Transportation
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Segment:	Central Green Outfall	Design Freq.:	2	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	13.57	13.57	36	18.4	2.6	90	70	0.0007	0.05	0	0.00	0.03	47.5	0.0	0.0	2.6	0.0	3	0.01	0.07	1.0	1.0	0.07	0.12	13.69	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	14.00	14.00	18	0.1	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.00	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.32	14.32	15	0.5	0.4	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.32	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	14.29	14.29	15	1.0	0.9	6	92	0.0002	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	5	0.00	0.00	1.3	1.0	0.01	0.03	14.32	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	14.25	14.25	15	1.5	1.3	14	54	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	6	0.00	0.01	1.3	1.0	0.01	0.04	14.29	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	14.20	14.20	24	4.7	1.5	9	38	0.0004	0.01	0	0.00	0.01	2.0	6.2	0.0	1.9	0.0	82	0.04	0.06	1.0	0.5	0.03	0.05	14.25	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	14.14	14.14	24	5.1	1.6	91	73	0.0004	0.03	0	0.00	0.01	7.2	0.0	0.0	1.5	0.0	9	0.00	0.03	1.0	1.0	0.03	0.06	14.20	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	14.07	14.07	24	5.6	1.8	90	31	0.0005	0.02	0	0.00	0.01	8.4	0.0	0.0	1.6	0.0	91	0.03	0.06	1.0	1.0	0.06	0.07	14.14	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	14.25	14.25	18	3.3	1.9	82	17	0.0009	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	14.27	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.31	14.31	15	0.8	0.7	4	77	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.32	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.30	14.30	15	1.0	0.8	11	38	0.0002	0.01	0	0.00	0.00	0.5	0.0	0.0	0.7	0.0	4	0.00	0.01	1.3	1.0	0.01	0.02	14.31	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	14.26	14.26	15	1.5	1.3	14	46	0.0005	0.02	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	11	0.00	0.01	1.3	1.0	0.01	0.04	14.30	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	14.19	14.19	18	3.6	2.0	7	46	0.0010	0.05	0	0.00	0.02	1.9	2.6	0.0	1.2	0.0	83	0.02	0.04	1.0	0.5	0.02	0.07	14.26	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	14.14	14.14	24	4.0	1.3	90	73	0.0003	0.02	0	0.00	0.01	7.3	0.0	0.0	2.0	0.0	7	0.01	0.04	1.0	1.0	0.04	0.05	14.19	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	14.07	14.07	24	6.8	2.2	90	30	0.0008	0.02	0	0.00	0.02	5.1	3.3	0.0	1.3	0.0	90	0.02	0.04	1.0	1.0	0.04	0.07	14.14	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	14.00	14.00	36	12.3	1.7	102	115	0.0003	0.03	0	0.00	0.01	14.6	9.9	0.0	2.2	0.0	90	0.05	0.09	1.0	0.5	0.04	0.08	14.07	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	14.16	14.16	15	0.2	0.1	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.16	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	14.14	14.14	18	2.4	1.4	67	14	0.0005	0.01	0	0.00	0.01	0.0	2.9	0.0	1.3	0.0	67	0.02	0.03	1.0	0.5	0.02	0.02	14.16	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	14.26	14.26	18	2.1	1.2	83	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	14.27	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	14.16	14.16	18	2.3	1.3	67	17	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	14.17	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.51	14.51	8	0.6	1.6	47	39	0.0015	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.07	14.58	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.45	14.45	15	1.3	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.9	0.0	0.0	1.6	0.0	47	0.02	0.04	1.3	1.0	0.05	0.06	14.51	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	14.42	14.42	18	2.0	1.1	0	42	0.0003	0.01	0	0.00	0.01	1.3	0.5	0.0	1.0	0.0	90	0.01	0.02	1.0	0.5	0.01	0.02	14.45	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.23	14.23	18	5.7	3.2	0	66	0.0025	0.16	0	0.00	0.04	2.3	1.6	2.3	1.1	0.0	90	0.01	0.06	1.0	0.5	0.03	0.19	14.42	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	14.00	14.00	18	6.5	3.7	78	56	0.0032	0.18	0	0.00	0.05	18.2	0.1	0.1	3.2	0.1	0	0.00	0.11	1.0	0.5	0.05	0.23	14.23	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.45	14.45	15	0.8	0.6	90	31	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.45	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	14.42	14.42	18	1.7	1.0	90	56	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	0.5	0.00	0.01	14.44	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	14.42	14.42	18	2.0	1.1	90	56	0.0003	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	14.45	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.23	14.23	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.23	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.23	14.23	18	0.4	0.2	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.23	10.95	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) Storm Frequency: 2 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
RELOCATED INLET IN SMR																										
P4	**DI19**	**MH1**	CP-1	2405	0	2405	0.06	0.95	0.05	0.05	6.0	0.00	4.77	0.3	15	27.3	0.012	0.000013	0.005	4.1	5.0	2.0	0.23	6.23	4.49	4.35	Q ok
P5	MH1	MH2	CP-1	1	0	1	0.00	0.95	0.00	0.05	6.0	6.23	4.73	0.2	18	82.7	0.012	0.000005	0.005	4.5	8.0	2.2	0.62	6.85	4.25	3.84	Q ok
P7	MH2	MH3	CP-1	1	0	1	0.00	0.95	0.00	0.05	6.0	6.85	4.61	0.2	18	73.8	0.012	0.000005	0.005	4.6	8.1	2.2	0.55	7.40	3.81	3.44	Q ok
P10	MH3	MH4	CP-2	1	0	1	0.00	0.95	0.00	0.25	6.0	7.40	4.49	1.1	18	53.7	0.012	0.000096	0.005	4.6	8.1	3.2	0.28	7.68	3.34	3.07	Q ok
P13	MH4	MH5	CP-2	1	0	1	0.00	0.95	0.00	0.56	6.0	7.68	4.43	2.5	18	59.3	0.012	0.000482	0.005	4.3	7.7	3.9	0.25	7.93	2.97	2.70	Q ok
P15	MH5	MH41	CP-2	1	0	1	0.00	0.95	0.00	0.89	6.0	7.93	4.39	3.9	*24*	**50.0**	0.012	0.000255	0.020	11.0	34.7	6.6	0.13	8.06	2.60	1.60	Q ok
P9	DI3	MH3	CP-1	4110	3259	7369	0.17	0.61	0.10	0.10	6.0	0.00	4.77	0.5	15	18.3	0.012	0.000049	0.005	4.0	4.9	2.4	0.13	6.13	3.68	3.59	Q ok
P8	DI17	MH3	CP-1	3878	2100	5978	0.14	0.68	0.09	0.09	6.0	0.00	4.77	0.4	15	31.3	0.012	0.000040	0.005	4.2	5.2	2.5	0.21	6.21	3.71	3.54	Q ok
P12	DI4	MH4	CP-1	7109	2561	9670	0.22	0.75	0.17	0.17	6.0	0.00	6.73	1.1	15	20.1	0.012	0.000254	0.005	4.0	4.9	3.3	0.10	6.10	3.48	3.38	Q ok
P11	DI18	MH4	CP-1	6435	2210	8645	0.20	0.75	0.15	0.15	6.0	0.00	6.70	1.0	15	28.4	0.012	0.000205	0.005	4.1	5.1	3.1	0.15	6.15	3.48	3.33	Q ok
P14	DI5	MH5	CP-1	4974	2549	7523	0.17	0.69	0.12	0.12	6.0	0.00	4.77	0.6	15	22.6	0.012	0.000066	0.005	4.0	4.9	2.4	0.16	6.16	3.68	3.57	Q ok
P18	DI6	MH6	CP-1	6937	1863	8800	0.20	0.79	0.16	0.16	6.0	0.00	4.77	0.8	15	38.0	0.012	0.000117	0.005	4.0	4.9	2.8	0.22	6.22	4.57	4.38	Q ok
P16	MH6	MH5	CP-2	1	0	1	0.00	0.95	0.00	0.21	6.0	6.22	4.73	1.0	18	40.0	0.012	0.000075	0.011	6.8	12.1	4.1	0.16	6.39	3.77	3.32	Q ok
RELOCATED INLET IN SMR																											
P17	**DI49**	**MH6**	CP-2	2236	105	2341	0.05	0.92	0.05	0.05	6.0	0.00	4.77	0.2	15	33.0	0.012	0.000011	0.005	4.0	4.9	2.0	0.28	6.28	4.19	4.02	Q ok
P32	DI23	MH12	CP-2	5495	1914	7409	0.17	0.75	0.13	0.13	6.0	0.00	4.77	0.6	15	33.31	0.012	0.0001	0.005	4.1	5.0	2.4	0.23	6.23	3.98	3.81	Q ok
P31	DI9	MH12	CP-2	4483	551	5034	0.12	0.87	0.10	0.10	6.0	0.00	4.77	0.5	15	18.3	0.012	0.0000	0.005	4.0	4.9	2.4	0.13	6.13	3.86	3.77	Q ok
P30	MH12	MH11	CP-2	1	0	1	0.00	0.95	0.00	0.23	6.0	6.23	4.73	1.1	18	50.1	0.012	0.0001	0.005	4.5	8.0	3.2	0.26	6.49	3.67	3.42	Q ok
P27	MH11	MH10	CP-2	1	0	1	0.00	0.95	0.00	0.47	6.0	6.49	4.67	2.2	18	73.2	0.012	0.0004	0.005	4.6	8.1	3.8	0.32	6.81	3.39	3.02	Q ok
P25	MH10	MH9	CP-2	1	0	1	0.00	0.95	0.00	0.54	6.0	6.81	4.61	2.5	24	69.68	0.012	0.0001	0.006	6.3	19.7	4.4	0.26	7.08	2.92	2.47	Q ok
P22	MH9	MH8	CP-2	1	0	1	0.00	0.95	0.00	0.68	6.0	7.08	4.55	3.1	24	108.3	0.012	0.0002	0.005	5.5	17.3	4.1	0.44	7.52	2.47	1.93	Q ok
P-80	DI-80	MH-08		9967	0	9967	0.23	0.95	0.22	0.22	6.0	0.00	4.77	1.0	15	49	0.012	0.0002	0.009	5.5	6.8	3.9	0.21	6.21	4.53	4.07	Q ok
P28	DI22	MH11	CP-1	5555	1955	7510	0.17	0.75	0.13	0.13	6.0	0.00	4.77	0.6	15	30.3	0.012	0.0001	0.005	4.0	4.9	2.8	0.18	6.18	3.64	3.49	Q ok
P29	DI8	MH11	CP-1	5120	570	5690	0.13	0.87	0.11	0.11	6.0	0.00	4.77	0.5	15	18.3	0.012	0.0001	0.005	4.0	4.9	2.4	0.13	6.13	3.64	3.55	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____

County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077

Segment: Market Street (to Central Green Outfall) Storm Frequency: 2 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P26	DI21	MH10	CP-1	2755	930	3685	0.08	0.76	0.06	0.06	6.0	0.00	4.77	0.3	15	18.3	0.012	0.0000	0.005	4.0	4.9	2.0	0.16	6.16	4.02	3.93	Q ok
P23	DI20	MH9	CP-2	3213	1102	4315	0.10	0.75	0.07	0.07	6.0	0.00	4.77	0.4	15	29.3	0.012	0.0000	0.005	4.0	4.9	2.0	0.25	6.25	4.53	4.38	Q ok
P24	DI7	MH9	CP-2	3164	527	3691	0.08	0.84	0.07	0.07	6.0	0.00	4.77	0.3	15	28.02	0.012	0.0000	0.005	4.0	4.9	2.0	0.24	6.24	4.38	4.24	Q ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	5.04	5.35	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	7.41	
P5	MH1	MH2	1.20	4.64	5.04	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	5.04	7.93	HGL ok
P7	MH2	MH3	1.20	4.40	4.64	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.64	7.65	HGL ok
P10	MH3	MH4	1.20	4.39	4.39	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	4.40	7.28	HGL ok
P13	MH4	MH5	1.20	4.35	4.35	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	4.39	7.09	HGL ok
P15	MH5	MH41	1.60	4.32	4.32	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	4.35	7.40	HGL ok
P9	DI3	MH3	1.00	4.40	4.59	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.59	6.62	HGL ok
P8	DI17	MH3	1.00	4.40	4.54	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.54	6.96	HGL ok
P12	DI4	MH4	1.00	4.39	4.39	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.40	6.48	HGL ok
P11	DI18	MH4	1.00	4.39	4.39	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.40	6.56	HGL ok
P14	DI5	MH5	1.00	4.35	4.57	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.57	6.61	HGL ok
P18	DI6	MH6	1.00	4.53	5.38	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.39	7.13	HGL ok
P16	MH6	MH5	1.20	4.35	4.52	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	4.53	7.55	HGL ok
P17	DI49	MH6	1.00	4.53	5.02	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.08	HGL ok
P32	DI23	MH12	1.00	5.03	5.03	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.11	HGL ok
P31	DI9	MH12	1.00	5.03	5.03	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.13	HGL ok
P30	MH12	MH11	1.60	4.65	5.02	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	5.03	7.48	HGL ok
P27	MH11	MH10	1.60	4.34	4.62	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	4.65	7.21	HGL ok
P25	MH10	MH9	1.60	4.33	4.33	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	4.34	7.54	HGL ok
P22	MH9	MH8	1.60	4.31	4.31	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	4.33	7.85	HGL ok
P-80	DI-80	MH-08	1.00	4.31	5.07	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	5.08	7.34	HGL ok
P28	DI22	MH11	1.00	4.65	4.65	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.65	6.74	HGL ok
P29	DI8	MH11	1.00	4.65	4.65	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.65	6.92	HGL ok
P26	DI21	MH10	1.00	4.34	4.93	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.93	7.23	HGL ok
P23	DI20	MH9	1.00	4.33	5.38	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	5.38	7.38	HGL ok
P24	DI7	MH9	1.00	4.33	5.24	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.24	7.48	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	5.04	5.35	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	7.41	
P5	MH1	MH2	1.20	4.64	5.04	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	5.04	7.93	HGL ok
P7	MH2	MH3	1.20	4.60	4.64	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	4.64	7.65	HGL ok
P10	MH3	MH4	1.20	4.59	4.59	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	4.60	7.28	HGL ok
P13	MH4	MH5	1.20	4.55	4.55	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	4.59	7.09	HGL ok
P15	MH5	MH41	1.60	4.52	4.52	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	4.55	7.40	HGL ok
P9	DI3	MH3	1.00	4.60	4.60	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.60	6.62	HGL ok
P8	DI17	MH3	1.00	4.60	4.60	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.60	6.96	HGL ok
P12	DI4	MH4	1.00	4.59	4.59	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.60	6.48	HGL ok
P11	DI18	MH4	1.00	4.59	4.59	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	4.60	6.56	HGL ok
P14	DI5	MH5	1.00	4.55	4.57	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.57	6.61	HGL ok
P18	DI6	MH6	1.00	4.56	5.38	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.39	7.13	HGL ok
P16	MH6	MH5	1.20	4.55	4.55	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	4.56	7.55	HGL ok
P17	DI49	MH6	1.00	4.56	5.02	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.08	HGL ok
P32	DI23	MH12	1.00	5.03	5.03	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.11	HGL ok
P31	DI9	MH12	1.00	5.03	5.03	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.03	7.13	HGL ok
P30	MH12	MH11	1.60	4.65	5.02	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	5.03	7.48	HGL ok
P27	MH11	MH10	1.60	4.54	4.62	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	4.65	7.21	HGL ok
P25	MH10	MH9	1.60	4.53	4.53	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	4.54	7.54	HGL ok
P22	MH9	MH8	1.60	4.51	4.51	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	4.53	7.85	HGL ok
P-80	DI-80	MH-08	1.00	4.51	5.07	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	5.08	7.34	HGL ok
P28	DI22	MH11	1.00	4.65	4.65	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.65	6.74	HGL ok
P29	DI8	MH11	1.00	4.65	4.65	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.65	6.92	HGL ok
P26	DI21	MH10	1.00	4.54	4.93	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.93	7.23	HGL ok
P23	DI20	MH9	1.00	4.53	5.38	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	5.38	7.38	HGL ok
P24	DI7	MH9	1.00	4.53	5.24	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.24	7.48	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	8.10	8.10	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.10	7.41	
P5	MH1	MH2	1.20	8.10	8.10	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	8.10	7.93	HGL Too High!
P7	MH2	MH3	1.20	8.10	8.10	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.10	7.65	HGL Too High!
P10	MH3	MH4	1.20	8.09	8.09	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	8.10	7.28	HGL Too High!
P13	MH4	MH5	1.20	8.05	8.05	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	8.09	7.09	HGL Too High!
P15	MH5	MH41	1.60	8.02	8.02	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	8.05	7.40	HGL Too High!
P9	DI3	MH3	1.00	8.10	8.10	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.10	6.62	HGL Too High!
P8	DI17	MH3	1.00	8.10	8.10	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.10	6.96	HGL Too High!
P12	DI4	MH4	1.00	8.09	8.09	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.10	6.48	HGL Too High!
P11	DI18	MH4	1.00	8.09	8.09	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.10	6.56	HGL Too High!
P14	DI5	MH5	1.00	8.05	8.05	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.05	6.61	HGL Too High!
P18	DI6	MH6	1.00	8.06	8.06	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.06	7.13	HGL Too High!
P16	MH6	MH5	1.20	8.05	8.05	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	8.06	7.55	HGL Too High!
P17	DI49	MH6	1.00	8.06	8.06	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.06	7.08	HGL Too High!
P32	DI23	MH12	1.00	8.07	8.07	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.08	7.11	HGL Too High!
P31	DI9	MH12	1.00	8.07	8.07	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.07	7.13	HGL Too High!
P30	MH12	MH11	1.60	8.07	8.07	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	8.07	7.48	HGL Too High!
P27	MH11	MH10	1.60	8.04	8.04	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	8.07	7.21	HGL Too High!
P25	MH10	MH9	1.60	8.03	8.03	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	8.04	7.54	HGL Too High!
P22	MH9	MH8	1.60	8.01	8.01	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	8.03	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	8.01	8.01	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	8.02	7.34	HGL Too High!
P28	DI22	MH11	1.00	8.07	8.07	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.07	6.74	HGL Too High!
P29	DI8	MH11	1.00	8.07	8.07	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.07	6.92	HGL Too High!
P26	DI21	MH10	1.00	8.04	8.04	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.04	7.23	HGL Too High!
P23	DI20	MH9	1.00	8.03	8.03	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	8.03	7.38	HGL Too High!
P24	DI7	MH9	1.00	8.03	8.03	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.03	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	8.60	8.60	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.60	7.41	
P5	MH1	MH2	1.20	8.60	8.60	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	8.60	7.93	HGL Too High!
P7	MH2	MH3	1.20	8.60	8.60	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.60	7.65	HGL Too High!
P10	MH3	MH4	1.20	8.59	8.59	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	8.60	7.28	HGL Too High!
P13	MH4	MH5	1.20	8.55	8.55	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	8.59	7.09	HGL Too High!
P15	MH5	MH41	1.60	8.52	8.52	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	8.55	7.40	HGL Too High!
P9	DI3	MH3	1.00	8.60	8.60	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.60	6.62	HGL Too High!
P8	DI17	MH3	1.00	8.60	8.60	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.60	6.96	HGL Too High!
P12	DI4	MH4	1.00	8.59	8.59	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.60	6.48	HGL Too High!
P11	DI18	MH4	1.00	8.59	8.59	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.60	6.56	HGL Too High!
P14	DI5	MH5	1.00	8.55	8.55	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.55	6.61	HGL Too High!
P18	DI6	MH6	1.00	8.56	8.56	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.56	7.13	HGL Too High!
P16	MH6	MH5	1.20	8.55	8.55	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	8.56	7.55	HGL Too High!
P17	DI49	MH6	1.00	8.56	8.56	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.56	7.08	HGL Too High!
P32	DI23	MH12	1.00	8.57	8.57	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.58	7.11	HGL Too High!
P31	DI9	MH12	1.00	8.57	8.57	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.57	7.13	HGL Too High!
P30	MH12	MH11	1.60	8.57	8.57	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	8.57	7.48	HGL Too High!
P27	MH11	MH10	1.60	8.54	8.54	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	8.57	7.21	HGL Too High!
P25	MH10	MH9	1.60	8.53	8.53	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	8.54	7.54	HGL Too High!
P22	MH9	MH8	1.60	8.51	8.51	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	8.53	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	8.51	8.51	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	8.52	7.34	HGL Too High!
P28	DI22	MH11	1.00	8.57	8.57	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.57	6.74	HGL Too High!
P29	DI8	MH11	1.00	8.57	8.57	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.57	6.92	HGL Too High!
P26	DI21	MH10	1.00	8.54	8.54	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.54	7.23	HGL Too High!
P23	DI20	MH9	1.00	8.53	8.53	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	8.53	7.38	HGL Too High!
P24	DI7	MH9	1.00	8.53	8.53	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.53	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.00	9.00	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.00	7.41	
P5	MH1	MH2	1.20	9.00	9.00	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.00	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.00	9.00	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.00	7.65	HGL Too High!
P10	MH3	MH4	1.20	8.99	8.99	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	9.00	7.28	HGL Too High!
P13	MH4	MH5	1.20	8.95	8.95	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	8.99	7.09	HGL Too High!
P15	MH5	MH41	1.60	8.92	8.92	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	8.95	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.00	9.00	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.00	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.00	9.00	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.00	6.96	HGL Too High!
P12	DI4	MH4	1.00	8.99	8.99	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.00	6.48	HGL Too High!
P11	DI18	MH4	1.00	8.99	8.99	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.00	6.56	HGL Too High!
P14	DI5	MH5	1.00	8.95	8.95	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.95	6.61	HGL Too High!
P18	DI6	MH6	1.00	8.96	8.96	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.96	7.13	HGL Too High!
P16	MH6	MH5	1.20	8.95	8.95	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	8.96	7.55	HGL Too High!
P17	DI49	MH6	1.00	8.96	8.96	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.96	7.08	HGL Too High!
P32	DI23	MH12	1.00	8.97	8.97	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.98	7.11	HGL Too High!
P31	DI9	MH12	1.00	8.97	8.97	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.97	7.13	HGL Too High!
P30	MH12	MH11	1.60	8.97	8.97	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	8.97	7.48	HGL Too High!
P27	MH11	MH10	1.60	8.94	8.94	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	8.97	7.21	HGL Too High!
P25	MH10	MH9	1.60	8.93	8.93	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	8.94	7.54	HGL Too High!
P22	MH9	MH8	1.60	8.91	8.91	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	8.93	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	8.91	8.91	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	8.92	7.34	HGL Too High!
P28	DI22	MH11	1.00	8.97	8.97	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.97	6.74	HGL Too High!
P29	DI8	MH11	1.00	8.97	8.97	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.97	6.92	HGL Too High!
P26	DI21	MH10	1.00	8.94	8.94	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.94	7.23	HGL Too High!
P23	DI20	MH9	1.00	8.93	8.93	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	8.93	7.38	HGL Too High!
P24	DI7	MH9	1.00	8.93	8.93	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.93	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.50	9.50	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.50	7.41	
P5	MH1	MH2	1.20	9.50	9.50	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.50	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.50	9.50	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.50	7.65	HGL Too High!
P10	MH3	MH4	1.20	9.49	9.49	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	9.50	7.28	HGL Too High!
P13	MH4	MH5	1.20	9.45	9.45	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	9.49	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.42	9.42	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	9.45	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.50	9.50	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.50	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.50	9.50	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.50	6.96	HGL Too High!
P12	DI4	MH4	1.00	9.49	9.49	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.50	6.48	HGL Too High!
P11	DI18	MH4	1.00	9.49	9.49	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.50	6.56	HGL Too High!
P14	DI5	MH5	1.00	9.45	9.45	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.45	6.61	HGL Too High!
P18	DI6	MH6	1.00	9.46	9.46	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.46	7.13	HGL Too High!
P16	MH6	MH5	1.20	9.45	9.45	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	9.46	7.55	HGL Too High!
P17	DI49	MH6	1.00	9.46	9.46	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.46	7.08	HGL Too High!
P32	DI23	MH12	1.00	9.47	9.47	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.48	7.11	HGL Too High!
P31	DI9	MH12	1.00	9.47	9.47	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.47	7.13	HGL Too High!
P30	MH12	MH11	1.60	9.47	9.47	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	9.47	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.44	9.44	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	9.47	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.43	9.43	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	9.44	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.41	9.41	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	9.43	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.41	9.41	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	9.42	7.34	HGL Too High!
P28	DI22	MH11	1.00	9.47	9.47	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.47	6.74	HGL Too High!
P29	DI8	MH11	1.00	9.47	9.47	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.47	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.44	9.44	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.44	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.43	9.43	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.43	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.43	9.43	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.43	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.20	10.20	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.20	7.41	
P5	MH1	MH2	1.20	10.20	10.20	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.20	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.20	10.20	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.20	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.19	10.19	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	10.20	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.15	10.15	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	10.19	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.12	10.12	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	10.15	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.20	10.20	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.20	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.20	10.20	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.20	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.19	10.19	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.20	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.19	10.19	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.20	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.15	10.15	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.15	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.16	10.16	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.16	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.15	10.15	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	10.16	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.16	10.16	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.16	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.17	10.17	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.18	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.17	10.17	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.17	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.17	10.17	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	10.17	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.14	10.14	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	10.17	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.13	10.13	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	10.14	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.11	10.11	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	10.13	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.11	10.11	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	10.12	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.17	10.17	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.17	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.17	10.17	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.17	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.14	10.14	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.14	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.13	10.13	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.13	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.13	10.13	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.13	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.70	10.70	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.70	7.41	
P5	MH1	MH2	1.20	10.70	10.70	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.70	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.70	10.70	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.70	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.69	10.69	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	10.70	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.65	10.65	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	10.69	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.62	10.62	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	10.65	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.70	10.70	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.70	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.70	10.70	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.70	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.69	10.69	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.70	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.69	10.69	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.70	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.65	10.65	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.65	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.66	10.66	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.66	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.65	10.65	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	10.66	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.66	10.66	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.66	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.67	10.67	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.68	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.67	10.67	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.67	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.67	10.67	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	10.67	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.64	10.64	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	10.67	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.63	10.63	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	10.64	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.61	10.61	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	10.63	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.61	10.61	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	10.62	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.67	10.67	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.67	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.67	10.67	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.67	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.64	10.64	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.64	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.63	10.63	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.63	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.63	10.63	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.63	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.00	12.00	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.00	7.41	
P5	MH1	MH2	1.20	12.00	12.00	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.00	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.00	12.00	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.00	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.99	11.99	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	12.00	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.95	11.95	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	11.99	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.92	11.92	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	11.95	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.00	12.00	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.00	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.00	12.00	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.00	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.99	11.99	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.00	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.99	11.99	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.00	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.95	11.95	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.95	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.96	11.96	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.96	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.95	11.95	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	11.96	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.96	11.96	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.96	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.97	11.97	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.98	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.97	11.97	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.97	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.97	11.97	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	11.97	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.94	11.94	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	11.97	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.93	11.93	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	11.94	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.91	11.91	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	11.93	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.91	11.91	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	11.92	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.97	11.97	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.97	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.97	11.97	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.97	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.94	11.94	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.94	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.93	11.93	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.93	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.93	11.93	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.93	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	6.94	6.94	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.94	7.41	
P5	MH1	MH2	1.20	6.94	6.94	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	6.94	7.93	HGL Too High!
P7	MH2	MH3	1.20	6.94	6.94	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.94	7.65	HGL Too High!
P10	MH3	MH4	1.20	6.93	6.93	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	6.94	7.28	HGL Too High!
P13	MH4	MH5	1.20	6.89	6.89	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	6.93	7.09	HGL Too High!
P15	MH5	MH41	1.60	6.86	6.86	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	6.89	7.40	HGL Too High!
P9	DI3	MH3	1.00	6.94	6.94	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.94	6.62	HGL Too High!
P8	DI17	MH3	1.00	6.94	6.94	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.94	6.96	HGL Too High!
P12	DI4	MH4	1.00	6.93	6.93	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.94	6.48	HGL Too High!
P11	DI18	MH4	1.00	6.93	6.93	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.94	6.56	HGL Too High!
P14	DI5	MH5	1.00	6.89	6.89	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.89	6.61	HGL Too High!
P18	DI6	MH6	1.00	6.90	6.90	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.90	7.13	HGL Too High!
P16	MH6	MH5	1.20	6.89	6.89	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	6.90	7.55	HGL Too High!
P17	DI49	MH6	1.00	6.90	6.90	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.90	7.08	HGL Too High!
P32	DI23	MH12	1.00	6.91	6.91	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.92	7.11	HGL Too High!
P31	DI9	MH12	1.00	6.91	6.91	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.91	7.13	HGL Too High!
P30	MH12	MH11	1.60	6.91	6.91	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	6.91	7.48	HGL Too High!
P27	MH11	MH10	1.60	6.88	6.88	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	6.91	7.21	HGL Too High!
P25	MH10	MH9	1.60	6.87	6.87	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	6.88	7.54	HGL Too High!
P22	MH9	MH8	1.60	6.85	6.85	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	6.87	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	6.85	6.85	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	6.86	7.34	HGL Too High!
P28	DI22	MH11	1.00	6.91	6.91	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.91	6.74	HGL Too High!
P29	DI8	MH11	1.00	6.91	6.91	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.91	6.92	HGL Too High!
P26	DI21	MH10	1.00	6.88	6.88	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.88	7.23	HGL Too High!
P23	DI20	MH9	1.00	6.87	6.87	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	6.87	7.38	HGL Too High!
P24	DI7	MH9	1.00	6.87	6.87	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.87	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	7.14	7.14	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.14	7.41	
P5	MH1	MH2	1.20	7.14	7.14	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	7.14	7.93	HGL Too High!
P7	MH2	MH3	1.20	7.14	7.14	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.14	7.65	HGL Too High!
P10	MH3	MH4	1.20	7.13	7.13	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	7.14	7.28	HGL Too High!
P13	MH4	MH5	1.20	7.09	7.09	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	7.13	7.09	HGL Too High!
P15	MH5	MH41	1.60	7.06	7.06	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	7.09	7.40	HGL Too High!
P9	DI3	MH3	1.00	7.14	7.14	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.14	6.62	HGL Too High!
P8	DI17	MH3	1.00	7.14	7.14	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.14	6.96	HGL Too High!
P12	DI4	MH4	1.00	7.13	7.13	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.14	6.48	HGL Too High!
P11	DI18	MH4	1.00	7.13	7.13	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.14	6.56	HGL Too High!
P14	DI5	MH5	1.00	7.09	7.09	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.09	6.61	HGL Too High!
P18	DI6	MH6	1.00	7.10	7.10	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.10	7.13	HGL Too High!
P16	MH6	MH5	1.20	7.09	7.09	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	7.10	7.55	HGL Too High!
P17	DI49	MH6	1.00	7.10	7.10	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.10	7.08	HGL Too High!
P32	DI23	MH12	1.00	7.11	7.11	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.12	7.11	HGL Too High!
P31	DI9	MH12	1.00	7.11	7.11	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.11	7.13	HGL Too High!
P30	MH12	MH11	1.60	7.11	7.11	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	7.11	7.48	HGL Too High!
P27	MH11	MH10	1.60	7.08	7.08	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	7.11	7.21	HGL Too High!
P25	MH10	MH9	1.60	7.07	7.07	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	7.08	7.54	HGL Too High!
P22	MH9	MH8	1.60	7.05	7.05	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	7.07	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	7.05	7.05	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	7.06	7.34	HGL Too High!
P28	DI22	MH11	1.00	7.11	7.11	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.11	6.74	HGL Too High!
P29	DI8	MH11	1.00	7.11	7.11	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.11	6.92	HGL Too High!
P26	DI21	MH10	1.00	7.08	7.08	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.08	7.23	HGL Too High!
P23	DI20	MH9	1.00	7.07	7.07	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	7.07	7.38	HGL Too High!
P24	DI7	MH9	1.00	7.07	7.07	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.07	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.64	10.64	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.64	7.41	
P5	MH1	MH2	1.20	10.64	10.64	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.64	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.64	10.64	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.64	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.63	10.63	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	10.64	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.59	10.59	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	10.63	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.56	10.56	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	10.59	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.64	10.64	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.64	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.64	10.64	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.64	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.63	10.63	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.64	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.63	10.63	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.64	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.59	10.59	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.59	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.60	10.60	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.60	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.59	10.59	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	10.60	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.60	10.60	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.60	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.61	10.61	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.62	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.61	10.61	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.61	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.61	10.61	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	10.61	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.58	10.58	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	10.61	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.57	10.57	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	10.58	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.55	10.55	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	10.57	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.55	10.55	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	10.56	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.61	10.61	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.61	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.61	10.61	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.61	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.58	10.58	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.58	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.57	10.57	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.57	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.57	10.57	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.57	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.14	11.14	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.14	7.41	
P5	MH1	MH2	1.20	11.14	11.14	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.14	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.14	11.14	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.14	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.13	11.13	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	11.14	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.09	11.09	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	11.13	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.06	11.06	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	11.09	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.14	11.14	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.14	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.14	11.14	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.14	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.13	11.13	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.14	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.13	11.13	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.14	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.09	11.09	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.09	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.10	11.10	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.10	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.09	11.09	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	11.10	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.10	11.10	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.10	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.11	11.11	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.12	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.11	11.11	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.11	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.11	11.11	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	11.11	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.08	11.08	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	11.11	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.07	11.07	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	11.08	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.05	11.05	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	11.07	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.05	11.05	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	11.06	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.11	11.11	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.11	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.11	11.11	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.11	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.08	11.08	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.08	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.07	11.07	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.07	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.07	11.07	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.07	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., V_o=Q_o/A	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, H_t= H_o +H_i +H_Δ	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, H = H_f + $H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.54	11.54	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.54	7.41	
P5	MH1	MH2	1.20	11.54	11.54	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.54	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.54	11.54	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.54	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.53	11.53	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	11.54	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.49	11.49	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	11.53	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.46	11.46	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	11.49	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.54	11.54	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.54	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.54	11.54	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.54	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.53	11.53	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.54	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.53	11.53	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.54	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.49	11.49	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.49	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.50	11.50	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.50	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.49	11.49	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	11.50	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.50	11.50	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.50	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.51	11.51	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.52	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.51	11.51	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.51	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.51	11.51	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	11.51	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.48	11.48	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	11.51	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.47	11.47	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	11.48	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.45	11.45	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	11.47	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.45	11.45	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	11.46	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.51	11.51	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.51	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.51	11.51	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.51	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.48	11.48	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.48	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.47	11.47	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.47	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.47	11.47	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.47	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.04	12.04	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.04	7.41	
P5	MH1	MH2	1.20	12.04	12.04	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.04	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.04	12.04	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.04	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.03	12.03	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	12.04	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.99	11.99	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	12.03	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.96	11.96	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	11.99	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.04	12.04	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.04	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.04	12.04	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.04	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.03	12.03	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.04	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.03	12.03	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.04	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.99	11.99	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.99	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.00	12.00	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.00	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.99	11.99	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	12.00	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.00	12.00	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.00	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.01	12.01	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.02	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.01	12.01	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.01	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.01	12.01	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	12.01	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.98	11.98	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	12.01	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.97	11.97	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	11.98	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.95	11.95	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	11.97	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.95	11.95	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	11.96	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.01	12.01	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.01	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.01	12.01	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.01	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.98	11.98	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.98	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.97	11.97	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.97	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.97	11.97	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.97	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.74	12.74	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.74	7.41	
P5	MH1	MH2	1.20	12.74	12.74	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.74	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.74	12.74	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.74	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.73	12.73	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	12.74	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.69	12.69	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	12.73	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.66	12.66	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	12.69	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.74	12.74	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.74	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.74	12.74	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.74	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.73	12.73	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.74	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.73	12.73	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.74	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.69	12.69	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.69	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.70	12.70	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.70	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.69	12.69	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	12.70	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.70	12.70	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.70	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.71	12.71	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.72	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.71	12.71	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.71	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.71	12.71	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	12.71	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.68	12.68	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	12.71	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.67	12.67	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	12.68	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.65	12.65	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	12.67	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.65	12.65	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	12.66	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.71	12.71	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.71	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.71	12.71	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.71	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.68	12.68	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.68	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.67	12.67	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.67	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.67	12.67	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.67	7.48	HGL Too High!

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Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.24	13.24	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.24	7.41	
P5	MH1	MH2	1.20	13.24	13.24	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.24	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.24	13.24	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.24	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.23	13.23	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	13.24	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.19	13.19	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	13.23	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.16	13.16	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	13.19	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.24	13.24	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.24	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.24	13.24	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.24	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.23	13.23	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.24	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.23	13.23	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.24	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.19	13.19	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.19	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.20	13.20	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.20	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.19	13.19	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	13.20	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.20	13.20	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.20	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.21	13.21	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.22	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.21	13.21	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.21	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.21	13.21	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	13.21	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.18	13.18	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	13.21	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.17	13.17	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	13.18	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.15	13.15	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	13.17	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.15	13.15	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	13.16	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.21	13.21	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.21	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.21	13.21	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.21	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.18	13.18	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.18	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.17	13.17	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.17	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.17	13.17	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.17	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 2 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	14.54	14.54	15	0.3	0.2	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.54	7.41	
P5	MH1	MH2	1.20	14.54	14.54	18	0.2	0.1	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	14.54	7.93	HGL Too High!
P7	MH2	MH3	1.20	14.54	14.54	18	0.2	0.1	1	73.8	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.1	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	14.54	7.65	HGL Too High!
P10	MH3	MH4	1.20	14.53	14.53	18	1.1	0.6	8	53.7	0.0001	0.01	0	0.00	0.00	0.0	0.2	0.2	0.4	0.0	87	0.00	0.00	1.0	0.5	0.00	0.01	14.54	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.49	14.49	18	2.5	1.4	84	59.3	0.0005	0.03	0	0.00	0.01	0.7	1.0	0.8	0.9	0.0	99	0.01	0.02	1.0	0.5	0.01	0.04	14.53	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.46	14.46	24	3.9	1.2	90	50	0.0003	0.01	0	0.00	0.01	3.5	0.3	0.5	1.4	0.0	84	0.02	0.04	1.0	0.5	0.02	0.03	14.49	7.40	HGL Too High!
P9	DI3	MH3	1.00	14.54	14.54	15	0.5	0.4	87	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.54	6.62	HGL Too High!
P8	DI17	MH3	1.00	14.54	14.54	15	0.4	0.4	81	31.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.54	6.96	HGL Too High!
P12	DI4	MH4	1.00	14.53	14.53	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.54	6.48	HGL Too High!
P11	DI18	MH4	1.00	14.53	14.53	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.54	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.49	14.49	15	0.6	0.5	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.49	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.50	14.50	15	0.8	0.6	23	38	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.50	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.49	14.49	18	1.0	0.6	86	40	0.0001	0.00	0	0.00	0.00	0.5	0.0	0.0	0.6	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	14.50	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.50	14.50	15	0.2	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.50	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.51	14.51	15	0.6	0.5	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.52	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.51	14.51	15	0.5	0.4	90	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.51	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.51	14.51	24	1.1	0.3	1	50.1	0.0001	0.00	0	0.00	0.00	0.2	0.3	0.0	0.5	0.0	64	0.00	0.00	1.0	0.5	0.00	0.01	14.51	7.48	HGL Too High!
P27	MH11	MH10	1.60	14.48	14.48	24	2.2	0.7	5	73.2	0.0004	0.03	0	0.00	0.00	0.4	0.3	0.2	0.3	0.0	1	0.00	0.00	1.0	0.5	0.00	0.03	14.51	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.47	14.47	24	2.5	0.8	5	69.7	0.0001	0.01	0	0.00	0.00	1.5	0.1	0.0	0.7	0.0	5	0.00	0.01	1.0	0.5	0.00	0.01	14.48	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.45	14.45	24	3.1	1.0	51	108	0.0002	0.02	0	0.00	0.00	1.9	0.1	0.1	0.8	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	14.47	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.45	14.45	15	1.0	0.8	35	49	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.01	14.46	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.51	14.51	15	0.6	0.5	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.51	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.51	14.51	15	0.5	0.4	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.51	6.92	HGL Too High!
P26	DI21	MH10	1.00	14.48	14.48	15	0.3	0.2	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.48	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.47	14.47	15	0.4	0.3	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.47	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.47	14.47	15	0.3	0.3	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.47	7.48	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 10 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-41	MH-41	MH-42	1	0	1	0.00	0.95	0.00	0.89	6.0	8.01	5.65	5.03	24	92	0.012	0.000422	0.0033	4.5	14.0	4.0	0.38	8.40	1.50	1.20	Q ok
P-42	MH-42	DI-43	1	0	1	0.00	0.95	0.00	1.79	6.0	8.40	5.54	9.92	30	30	0.012	0.000498	0.0030	5.0	24.3	4.6	0.11	8.51	1.10	1.01	Q ok
P-43	DI-43	DI-44	4208	31	4239	0.10	0.94	0.09	1.88	6.0	8.51	5.52	10.38	30	25	0.012	0.000546	0.0032	5.1	25.1	4.7	0.09	8.60	0.91	0.83	Q ok
P-44	DI-44	DI-45	4675	523	5198	0.12	0.87	0.10	1.99	6.0	8.60	5.49	10.90	30	69	0.012	0.000602	0.0030	5.0	24.5	4.8	0.24	8.83	0.73	0.52	Q ok
P-45	DI-45	MH-46	4490	535	5025	0.12	0.87	0.10	2.09	6.0	8.83	5.44	11.34	30	52	0.012	0.000652	0.0031	5.0	24.6	4.9	0.18	9.01	0.42	0.26	Q ok
P-46	MH-46	DI-47	1	0	1	0.00	0.95	0.00	2.78	6.0	9.01	5.39	15.00	30	42	0.012	0.001140	0.0031	5.0	24.7	5.3	0.13	9.14	0.16	0.03	Q ok
P-47	DI-47	MH-60	4551	287	4838	0.11	0.90	0.10	2.88	6.0	9.14	5.36	15.47	36	23	0.012	0.000458	0.0030	5.6	39.9	5.2	0.07	9.22	-0.07	-0.14	Q ok
P-60	MH-60	MH-61	1	0	1	0.00	0.95	0.00	4.01	6.0	9.22	5.34	21.41	36	75	0.012	0.000878	0.0039	6.4	44.9	6.3	0.20	9.42	-0.24	-0.53	Q ok
P-61	MH-61	DI-62	1	0	1	0.00	0.95	0.00	4.01	6.0	9.42	5.28	21.20	36	76	0.012	0.000861	0.0039	6.4	45.4	6.2	0.20	9.62	-0.63	-0.93	Q ok
P-62	DI-62	DI-63	1435	40	1475	0.03	0.93	0.03	4.04	6.0	9.62	5.23	21.16	36	50	0.012	0.000857	0.0040	6.5	45.7	6.3	0.13	9.75	-1.03	-1.23	Q ok
P-63	DI-63	DI-77	1999	107	2106	0.05	0.91	0.04	4.79	6.0	9.75	5.18	24.82	36	25	0.012	0.001180	0.0036	6.1	43.4	6.3	0.07	9.82	-1.33	-1.42	Q ok
P-77	DI-77	DI-85	2311	122	2433	0.06	0.91	0.05	5.88	6.0	9.82	5.18	30.46	48	50	0.012	0.000383	0.0030	6.8	85.2	6.1	0.14	9.95	-1.52	-1.67	Q ok
P-85	DI-85	MH-86	5006	304	5310	0.12	0.91	0.11	10.47	6.0	9.95	5.13	53.71	60	186	0.012	0.000362	0.0030	7.9	154.8	7.1	0.44	10.39	-1.77	-2.33	Q ok
P-86	MH-86	MH-87	1	0	1	0.00	0.95	0.00	11.07	6.0	10.39	5.07	56.07	60	45	0.012	0.000395	0.0031	8.0	157.4	7.2	0.10	10.50	-2.43	-2.57	Q ok
P-87	**MH-87**	**OUTFALL**	**1**	**0**	**1**	**0.00**	**0.95**	**0.00**	**11.79**	**6.0**	**10.50**	**5.05**	**59.52**	**60**	**9**	**0.012**	**0.000445**	**0.0033**	**8.3**	**162.9**	**7.5**	**0.02**	**10.52**	**-2.67**	**-2.70**	**Q ok**
P-48	MSS MH-08	MH-49	1	0	1	0.00	0.95	0.00	0.90	6.0	7.42	5.80	5.21	24	64	0.012	0.000452	0.0070	6.5	20.6	5.4	0.20	7.62	1.65	1.20	Q ok
P-50	B7 North	1.00	32048	0	32048	0.74	0.95	0.70	0.70	6.0	0.00	6.16	4.31	18	16	0.012	0.001432	0.0050	4.6	8.0	4.6	0.06	6.06	0.35	0.27	Q ok
P-65	B7 West	MH-64	32234	0	32234	0.74	0.95	0.70	0.70	6.0	0.00	6.16	4.33	18	17	0.012	0.001449	0.0047	4.4	7.8	4.5	0.06	6.06	-0.95	-1.03	Q ok
P-64	MH-64	DI-63	1	0	1	0.00	0.95	0.00	0.70	6.0	6.06	6.14	4.31	18	20	0.012	0.001437	0.0050	4.6	8.0	4.6	0.07	6.13	-1.13	-1.23	Q ok
P-51	DI-51	DI-52	3030	31	3061	0.07	0.94	0.07	0.07	6.0	0.00	6.16	0.41	15	26	0.012	0.000034	0.0050	4.0	4.9	2.4	0.18	6.18	3.70	3.57	Q ok
P-52	DI-52	DI-53	4699	521	5220	0.12	0.87	0.10	0.17	6.0	6.18	6.11	1.04	15	69	0.012	0.000223	0.0049	4.0	4.9	3.0	0.38	6.56	3.37	3.03	Q ok
P-53	DI-53	MH-54	4484	537	5021	0.12	0.87	0.10	0.27	6.0	6.56	6.01	1.63	15	51	0.012	0.000541	0.0051	4.1	5.0	3.7	0.23	6.79	2.83	2.57	Q ok
P-54	MH-54	DI-55	1	0	1	0.00	0.95	0.00	1.00	6.0	6.79	5.96	5.96	24	41	0.012	0.000592	0.0049	5.4	17.1	4.9	0.14	6.93	2.37	2.17	Q ok
P-55	DI-55	MH-60	5685	291	5976	0.14	0.91	0.13	1.13	6.0	6.93	5.93	6.68	24	23	0.012	0.000743	0.0052	5.6	17.7	5.2	0.07	7.01	1.97	1.85	Q ok
P-56	B5 South	MH-54	33482	0	33482	0.77	0.95	0.73	0.73	6.0	0.00	6.16	4.50	18	17	0.012	0.001563	0.0053	4.7	8.3	4.8	0.06	6.06	2.56	2.47	Q ok
P-78	DI-78	DI-79	3667	223	3890	0.09	0.91	0.08	0.08	6.0	0.00	6.16	0.50	15	84	0.012	0.000051	0.0200	8.1	9.9	4.0	0.35	6.35	7.12	5.44	Q ok
P-79	DI-79	DI-71	3253	204	3457	0.08	0.90	0.07	0.15	6.0	6.35	6.06	0.93	18	29	0.012	0.000066	0.0200	9.1	16.1	4.5	0.11	6.46	5.24	4.66	Q ok
P-71	DI-71	DI-72	3698	198	3896	0.09	0.91	0.08	0.32	6.0	6.46	6.03	1.92	18	42	0.012	0.000285	0.0200	9.1	16.1	5.5	0.13	6.59	4.46	3.62	Q ok
P-72	DI-72	DI-73	2021	16	2037	0.05	0.94	0.04	0.36	6.0	6.59	6.01	2.18	18	29	0.012	0.000366	0.0200	9.1	16.1	6.4	0.08	6.67	3.42	2.84	Q ok
P-73	DI-73	MH-74	1071	0	1071	0.02	0.95	0.02	0.39	6.0	6.67	5.98	2.31	18	17	0.012	0.000411	0.0200	9.1	16.1	6.4	0.04	6.71	2.64	2.30	Q ok
P-74	MH-74	DI-75	1	0	1	0.00	0.95	0.00	0.95	6.0	6.71	5.98	5.67	18	17	0.012	0.002483	0.0200	9.1	16.1	8.2	0.03	6.75	2.10	1.76	Q ok
P-75	DI-75	DI-76	2135	0	2135	0.05	0.95	0.05	0.99	6.0	6.75	5.98	5.95	18	43	0.012	0.002733	0.0200	9.1	16.1	8.2	0.09	6.83	1.56	0.70	Q ok
P-76	DI-76	DI-77	1993	48	2041	0.05	0.93	0.04	1.04	6.0	6.83	5.96	6.18	18	51	0.012	0.002953	0.0200	9.1	16.1	8.4	0.10	6.93	0.50	-0.52	Q ok
P-70	DI-70	DI-71	3812	274	4086	0.09	0.90	0.08	0.08	6.0	0.00	6.16	0.52	15	86	0.012	0.000055	0.0200	8.1	9.9	4.0	0.36	6.36	6.38	4.66	Q ok
P-80	DI-80	MH-74	22886	15258	38144	0.88	0.64	0.56	0.56	6.0	0.00	6.16	3.46	18	24	0.012	0.000927	0.0050	4.6	8.0	4.4	0.09	6.09	2.42	2.30	Q ok
P-90	DI-90	DI-91	6026	1962	7988	0.18	0.76	0.14	0.14	6.0	0.00	6.16	0.86	15	79	0.012	0.000151	0.0200	8.1	9.9	4.8	0.27	6.27	2.54	0.96	Q ok
P-91	DI-91	MH-87	6475	2667	9142	0.21	0.73	0.15	0.72	6.0	6.27	6.08	4.37	18	81	0.012	0.001476	0.0200	9.1	16.1	7.5	0.18	6.45	-0.04	-1.66	Q ok
P-92	B6 North	DI-91	19569	0	19569	0.45	0.95	0.43	0.43	6.0	0.00	6.16	2.63	18	63	0.012	0.000534	0.0049	4.5	8.0	4.1	0.26	6.26	0.47	0.16	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 10 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-95	TD-04	MH-86	21353	32030	53383	1.23	0.49	0.60	0.60	6.0	0.00	6.16	3.69	12	16	0.011	0.007660	0.0506	12.1	9.5	11.1	0.02	6.02	8.01	7.20	Q ok
P-38	DI-38	DI-39	1483	0	1483	0.03	0.95	0.03	0.03	6.0	0.00	6.16	0.20	15	99	0.012	0.000008	0.0200	8.1	9.9	4.0	0.42	6.42	2.75	0.77	Q ok
P-39	DI-39	DI-40	3833	220	4053	0.09	0.91	0.08	0.12	6.0	6.42	6.06	0.71	15	70	0.012	0.000102	0.0200	8.1	9.9	4.0	0.30	6.71	0.57	-0.83	Q ok
P-40	DI-40	DI-85	4668	293	4961	0.11	0.90	0.10	0.22	6.0	6.71	5.98	1.32	18	26	0.012	0.000134	0.0208	9.3	16.4	5.6	0.08	6.79	-1.03	-1.57	Q ok
P-35	MH-35	DI-36	1	0	1	0.00	0.95	0.00	4.13	6.0	7.56	5.75	23.77	**36**	94	0.012	0.001082	0.0050	7.2	51.1	7.0	0.22	7.78	-0.16	-0.63	Q ok
P-36	DI-36	DI-37	1851	0	1851	0.04	0.95	0.04	4.17	6.0	7.78	5.70	23.79	**36**	98	0.012	0.001084	0.0050	7.2	51.1	7.0	0.23	8.02	-0.73	-1.22	Q ok
P-37	DI-37	DI-85	3893	195	4088	0.09	0.91	0.09	4.26	6.0	8.02	5.65	24.05	36	70	0.012	0.001108	0.0050	7.2	51.1	7.0	0.17	8.18	-1.32	-1.67	Q ok
P-30	DI-30	MH-35	1403	0	1403	0.03	0.95	0.03	0.03	6.0	0.00	6.16	0.19	18	47	0.012	0.000003	0.0200	9.1	16.1	4.5	0.18	6.18	0.98	0.04	Q ok
P-11	DI-11	DI-12	4746	684	5430	0.12	0.85	0.11	0.11	6.0	0.00	6.16	0.66	15	20	0.012	0.000088	0.0065	4.6	5.6	2.8	0.12	6.12	2.91	2.78	Q ok
P-12	DI-12	DI-13	4957	1287	6244	0.14	0.79	0.11	0.22	6.0	6.12	6.14	1.35	15	92	0.012	0.000371	0.0065	4.6	5.7	3.8	0.41	6.53	2.68	2.08	Q ok
P-13	DI-13	MH-14	4947	1296	6243	0.14	0.79	0.11	0.33	6.0	6.53	6.03	2.01	15	54	0.012	0.000824	0.0065	4.6	5.6	4.1	0.22	6.74	1.98	1.63	Q ok
P-14	MH-14	DI-15	1	0	1	0.00	0.95	0.00	1.03	6.0	6.74	5.98	6.16	24	38	0.012	0.000631	0.0066	6.3	19.9	5.4	0.12	6.86	1.53	1.28	Q ok
P-15	DI-15	DI-16	3998	870	4868	0.11	0.81	0.09	1.12	6.0	6.86	5.93	6.64	24	73	0.012	0.000735	0.0064	6.3	19.7	5.6	0.22	7.08	1.18	0.71	Q ok
P-16	DI-16	MH-17	5113	501	5614	0.13	0.88	0.11	1.23	6.0	7.08	5.88	7.25	24	31	0.012	0.000876	0.0071	6.6	20.6	5.9	0.09	7.17	0.61	0.39	Q ok
P-18	B7 South	MH-14	31929	0	31929	0.73	0.95	0.70	0.70	6.0	0.00	6.16	4.29	18	17	0.012	0.001422	0.0053	4.7	8.3	4.6	0.06	6.06	1.72	1.63	Q ok
P-01	DI-01	DI-02	7520	1261	8781	0.20	0.84	0.17	0.17	6.0	0.00	6.16	1.04	15	77	0.012	0.000222	0.0065	4.6	5.6	3.4	0.37	6.37	2.91	2.41	Q ok
P-02	DI-02	DI-03	2113	487	2600	0.06	0.81	0.05	0.22	6.0	6.37	6.06	1.32	15	38	0.012	0.000354	0.0066	4.6	5.7	3.8	0.17	6.54	2.31	2.06	Q ok
P-03	DI-03	MH-04	4989	1312	6301	0.14	0.79	0.11	0.33	6.0	6.54	6.03	2.00	15	46	0.012	0.000817	0.0065	4.6	5.7	4.1	0.18	6.72	1.96	1.66	Q ok
P-04	MH-04	DI-05	1	0	1	0.00	0.95	0.00	0.78	6.0	6.72	5.98	4.67	18	46	0.012	0.001683	0.0065	5.2	9.2	5.1	0.15	6.87	1.56	1.26	Q ok
P-05	DI-05	DI-06	3831	995	4826	0.11	0.79	0.09	0.87	6.0	6.87	5.93	5.15	24	73	0.012	0.000441	0.0064	6.3	19.7	5.1	0.24	7.11	1.16	0.69	Q ok
P-06	DI-06	MH-17	5161	592	5753	0.13	0.87	0.12	1.49	6.0	7.11	5.88	8.78	24	30	0.012	0.001282	0.0067	6.4	20.0	6.2	0.08	7.19	0.59	0.39	Q ok
P-17	MH-17	MH-35	1	0	1	0.00	0.95	0.00	2.73	6.0	7.19	5.85	15.96	*36*	115	0.012	0.000488	0.0030	5.6	39.9	5.2	0.37	7.56	0.29	-0.06	Q ok
Check P-17 for Sanitary Crossing for Conflict																										Check P-1
P-08	DI-08	MH-07	1526	0	1526	0.04	0.95	0.03	0.03	6.0	0.00	6.16	0.21	15	58	0.012	0.000009	0.0066	4.6	5.7	2.3	0.43	6.43	1.36	0.98	Q ok
P-07	MH-07	DI-06	1	0	1	0.00	0.95	0.00	0.51	6.0	0.00	6.16	3.14	18	14	0.012	0.000762	0.0064	5.2	9.1	4.6	0.05	6.05	0.88	0.79	Q ok
P-09	B9/J	MH-04	20585	0	20585	0.47	0.95	0.45	0.45	6.0	0.00	6.16	2.77	18	17	0.012	0.000591	0.0053	4.7	8.3	4.2	0.07	6.07	1.75	1.66	Q ok
P-10	B9/J	MH-07	21845	0	21845	0.50	0.95	0.48	0.48	6.0	0.00	6.16	2.94	18	17	0.012	0.000666	0.0053	4.7	8.3	4.2	0.07	6.07	1.07	0.98	Q ok
P-20	TD-05	DI-21	5394	0	5394	0.12	0.95	0.12	0.12	6.0	0.00	6.16	0.72	8	39	0.011	0.002576	0.0500	9.1	3.2	7.5	0.09	6.09	8.50	6.55	Q ok
P-21	DI-21	MH-22	6185	3410	9595	0.22	0.68	0.15	0.27	6.0	6.09	6.14	1.64	15	31	0.012	0.000547	0.0200	8.1	9.9	5.6	0.09	6.18	4.54	3.92	Q ok
P-22	MH-22	MH-23	1	0	1	0.00	0.95	0.00	0.42	6.0	6.18	6.11	2.59	18	42	0.012	0.000520	0.0200	9.1	16.1	6.4	0.11	6.29	3.72	2.88	Q ok
P-23	MH-23	MH-24	1	0	1	0.00	0.95	0.00	1.20	6.0	6.29	6.08	7.33	18	66	0.012	0.004149	0.0200	9.1	16.1	8.8	0.12	6.41	2.68	1.36	Q ok
P-24	MH-24	MH-35	1	0	1	0.00	0.95	0.00	1.38	6.0	6.41	6.06	8.34	18	56	0.012	0.005376	0.0200	9.1	16.1	9.0	0.10	6.52	1.16	0.04	Q ok
P-25	DI-25	MH-22	6504	3883	10387	0.24	0.66	0.16	0.16	6.0	0.00	6.16	0.97	15	31	0.012	0.000193	0.0200	8.1	9.9	4.8	0.11	6.11	4.54	3.92	Q ok
P-26	B8/K	MH-23	16317	0	16317	0.37	0.95	0.36	0.36	6.0	0.00	6.16	2.19	18	56	0.012	0.000371	0.0050	4.6	8.0	3.7	0.25	6.25	3.06	2.78	Q ok
P-27	B6 South	MH-23	19451	0	19451	0.45	0.95	0.42	0.42	6.0	0.00	6.16	2.61	18	56	0.012	0.000528	0.0050	4.6	8.0	3.9	0.24	6.24	3.06	2.78	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/2023 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/2023 | Cm. No.: 20077.000
Segment: Central Green Outfall | Storm Frequency: 10 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-28	DI-28	MH-24	3596	533	4129	0.09	0.85	0.08	0.08	6.0	0.00	6.16	0.50	18	34	0.012	0.000019	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok
P-29	DI-29	MH-24	4110	551	4661	0.11	0.86	0.09	0.09	6.0	0.00	6.16	0.57	18	34	0.012	0.000025	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok

KEY

	Upsized from Semi-Final Design to have capacity for 50-yr design storm
	Optional Upsize-50-yr design storm results in >85% Full
	No Change from Semi-Final Design

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR Date: 2/23/23 Sheet No.: 2 of 5
Checked by: TMC Date: 3/23/23 Cm. No.: 20077
Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	5.03	5.03	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	5.09	7.00	HGL ok
P-42	MH-42	DI-43	2.00	4.98	4.98	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	5.03	7.86	HGL ok
P-43	DI-43	DI-44	2.00	4.92	4.92	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	4.98	7.11	HGL ok
P-44	DI-44	DI-45	2.00	4.83	4.83	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	4.92	7.03	HGL ok
P-45	DI-45	MH-46	2.00	4.75	4.75	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	4.83	7.59	HGL ok
P-46	MH-46	DI-47	2.00	4.66	4.66	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	4.75	8.54	HGL ok
P-47	DI-47	MH-60	2.40	4.48	4.48	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	4.66	9.09	HGL ok
P-60	MH-60	MH-61	2.40	4.36	4.36	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	4.48	9.84	HGL ok
P-61	MH-61	DI-62	2.40	4.20	4.20	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	4.36	11.03	HGL ok
P-62	DI-62	DI-63	2.40	4.06	4.06	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	4.20	10.34	HGL ok
P-63	DI-63	DI-77	1.93	3.84	3.84	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	4.06	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.59	3.59	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	3.84	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.31	3.31	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	3.59	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.24	3.24	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	3.31	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.20**	**3.20**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	0.5	**0.04**	**0.04**	**3.24**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	5.03	5.03	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	5.07	8.07	HGL ok
P-50	B7 North	1.00	1.20	4.75	4.75	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	4.79	10.00	HGL ok
P-65	B7 West	MH-64	1.20	4.15	4.15	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	4.18	10.00	HGL ok
P-64	MH-64	DI-63	1.20	4.06	4.06	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	4.15	10.14	HGL ok
P-51	DI-51	DI-52	1.00	4.74	4.74	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.74	7.11	HGL ok
P-52	DI-52	DI-53	1.00	4.72	4.72	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	4.74	7.03	HGL ok
P-53	DI-53	MH-54	1.00	4.68	4.68	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	4.72	7.59	HGL ok
P-54	MH-54	DI-55	1.60	4.59	4.59	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	4.68	8.54	HGL ok
P-55	DI-55	MH-60	1.60	4.48	4.48	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	4.59	9.09	HGL ok
P-56	B5 South	MH-54	1.20	4.68	4.68	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	4.72	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.87	6.44	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.44	11.60	HGL ok
P-79	DI-79	DI-71	1.20	4.84	5.86	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	5.87	11.15	HGL ok
P-71	DI-71	DI-72	1.20	4.49	4.82	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	4.84	11.15	HGL ok
P-72	DI-72	DI-73	1.20	4.46	4.46	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	4.49	10.99	HGL ok
P-73	DI-73	MH-74	1.20	4.44	4.44	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	4.46	10.84	HGL ok
P-74	MH-74	DI-75	1.20	4.35	4.35	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	4.44	11.24	HGL ok
P-75	DI-75	DI-76	1.20	4.11	4.11	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	4.35	10.63	HGL ok
P-76	DI-76	DI-77	1.20	3.84	3.84	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	4.11	10.34	HGL ok
P-70	DI-70	DI-71	1.00	4.84	5.66	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.67	11.60	HGL ok
P-80	DI-80	MH-74	1.20	4.44	4.44	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	4.48	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.44	3.44	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.46	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.24	3.24	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	3.44	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.44	3.44	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	3.48	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.31	8.00	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	8.17	10.50	HGL ok
P-38	DI-38	DI-39	1.00	3.62	3.62	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.62	10.67	HGL ok
P-39	DI-39	DI-40	1.00	3.61	3.61	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	3.62	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.59	3.59	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	3.61	9.98	HGL ok
P-35	MH-35	DI-36	2.40	4.01	4.01	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	4.31	11.72	HGL ok
P-36	DI-36	DI-37	2.40	3.80	3.80	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	4.01	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*Q*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.59	3.59	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	3.80	10.16	HGL ok
P-30	DI-30	MH-35	1.20	4.31	4.31	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.31	11.24	HGL ok
P-11	DI-11	DI-12	1.00	4.84	4.84	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.85	6.84	HGL ok
P-12	DI-12	DI-13	1.00	4.80	4.80	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	4.84	6.99	HGL ok
P-13	DI-13	MH-14	1.00	4.73	4.73	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	4.80	7.91	HGL ok
P-14	MH-14	DI-15	1.60	4.65	4.65	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	4.73	8.68	HGL ok
P-15	DI-15	DI-16	1.60	4.56	4.56	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	4.65	9.01	HGL ok
P-16	DI-16	MH-17	1.60	4.44	4.44	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	4.56	9.77	HGL ok
P-18	B7 South	MH-14	1.20	4.73	4.73	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	4.77	10.00	HGL ok
P-01	DI-01	DI-02	1.00	4.84	4.84	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	4.86	6.84	HGL ok
P-02	DI-02	DI-03	1.00	4.81	4.81	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	4.84	7.35	HGL ok
P-03	DI-03	MH-04	1.00	4.75	4.75	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	4.81	7.91	HGL ok
P-04	MH-04	DI-05	1.20	4.64	4.64	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	4.75	8.60	HGL ok
P-05	DI-05	DI-06	1.60	4.55	4.55	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	4.64	9.01	HGL ok
P-06	DI-06	MH-17	1.60	4.44	4.44	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	4.55	9.87	HGL ok
P-17	MH-17	MH-35	1.60	4.31	4.31	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	4.44	10.61	HGL ok
P-08	DI-08	MH-07	1.00	4.59	4.59	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.59	11.39	HGL ok
P-07	MH-07	DI-06	1.20	4.55	4.55	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	4.59	10.19	HGL ok
P-09	B9/J	MH-04	1.20	4.75	4.75	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.76	10.00	HGL ok
P-10	B9/J	MH-07	1.20	4.59	4.59	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	4.60	10.00	HGL ok
P-20	TD-05	DI-21	0.53	5.16	7.08	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	7.20	10.50	HGL ok
P-21	DI-21	MH-22	1.00	5.06	5.06	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	5.16	9.46	HGL ok
P-22	MH-22	MH-23	1.20	5.02	5.02	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	5.06	9.72	HGL ok
P-23	MH-23	MH-24	1.20	4.70	4.70	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	5.02	10.97	HGL ok
P-24	MH-24	MH-35	1.20	4.31	4.31	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	4.70	11.20	HGL ok
P-25	DI-25	MH-22	1.00	5.06	5.06	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.07	9.46	HGL ok
P-26	B8/K	MH-23	1.20	5.02	5.02	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	5.05	10.00	HGL ok
P-27	B6 South	MH-23	1.20	5.02	5.02	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	5.06	10.00	HGL ok
P-28	DI-28	MH-24	1.20	4.70	4.70	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.70	10.95	HGL ok
P-29	DI-29	MH-24	1.20	4.70	4.70	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.70	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	5.23	5.23	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	5.29	7.00	HGL ok
P-42	MH-42	DI-43	2.00	5.18	5.18	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	5.23	7.86	HGL ok
P-43	DI-43	DI-44	2.00	5.12	5.12	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	5.18	7.11	HGL ok
P-44	DI-44	DI-45	2.00	5.03	5.03	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	5.12	7.03	HGL ok
P-45	DI-45	MH-46	2.00	4.95	4.95	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	5.03	7.59	HGL ok
P-46	MH-46	DI-47	2.00	4.86	4.86	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	4.95	8.54	HGL ok
P-47	DI-47	MH-60	2.40	4.68	4.68	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	4.86	9.09	HGL ok
P-60	MH-60	MH-61	2.40	4.56	4.56	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	4.68	9.84	HGL ok
P-61	MH-61	DI-62	2.40	4.40	4.40	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	4.56	11.03	HGL ok
P-62	DI-62	DI-63	2.40	4.26	4.26	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	4.40	10.34	HGL ok
P-63	DI-63	DI-77	1.93	4.04	4.04	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	4.26	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.79	3.79	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	4.04	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.51	3.51	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	3.79	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.44	3.44	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	3.51	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.40**	**3.40**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	*0.5*	**0.04**	**0.04**	**3.44**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	5.23	5.23	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	5.27	8.07	HGL ok
P-50	B7 North	1.00	1.20	4.95	4.95	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	4.99	10.00	HGL ok
P-65	B7 West	MH-64	1.20	4.35	4.35	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	4.38	10.00	HGL ok
P-64	MH-64	DI-63	1.20	4.26	4.26	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	4.35	10.14	HGL ok
P-51	DI-51	DI-52	1.00	4.94	4.94	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.94	7.11	HGL ok
P-52	DI-52	DI-53	1.00	4.92	4.92	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	4.94	7.03	HGL ok
P-53	DI-53	MH-54	1.00	4.88	4.88	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	4.92	7.59	HGL ok
P-54	MH-54	DI-55	1.60	4.79	4.79	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	4.88	8.54	HGL ok
P-55	DI-55	MH-60	1.60	4.68	4.68	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	4.79	9.09	HGL ok
P-56	B5 South	MH-54	1.20	4.88	4.88	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	4.92	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.87	6.44	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.44	11.60	HGL ok
P-79	DI-79	DI-71	1.20	4.84	5.86	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	5.87	11.15	HGL ok
P-71	DI-71	DI-72	1.20	4.69	4.82	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	4.84	11.15	HGL ok
P-72	DI-72	DI-73	1.20	4.66	4.66	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	4.69	10.99	HGL ok
P-73	DI-73	MH-74	1.20	4.64	4.64	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	4.66	10.84	HGL ok
P-74	MH-74	DI-75	1.20	4.55	4.55	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	4.64	11.24	HGL ok
P-75	DI-75	DI-76	1.20	4.31	4.31	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	4.55	10.63	HGL ok
P-76	DI-76	DI-77	1.20	4.04	4.04	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	4.31	10.34	HGL ok
P-70	DI-70	DI-71	1.00	4.84	5.66	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.67	11.60	HGL ok
P-80	DI-80	MH-74	1.20	4.64	4.64	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	4.68	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.64	3.64	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	3.66	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.44	3.44	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	3.64	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.64	3.64	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	3.68	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.51	8.00	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	8.17	10.50	HGL ok
P-38	DI-38	DI-39	1.00	3.82	3.82	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.82	10.67	HGL ok
P-39	DI-39	DI-40	1.00	3.81	3.81	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	3.82	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.79	3.79	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	3.81	9.98	HGL ok
P-35	MH-35	DI-36	2.40	4.21	4.21	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	4.51	11.72	HGL ok
P-36	DI-36	DI-37	2.40	4.00	4.00	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	4.21	10.67	HGL ok

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.79	3.79	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	4.00	10.16	HGL ok
P-30	DI-30	MH-35	1.20	4.51	4.51	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.51	11.24	HGL ok
P-11	DI-11	DI-12	1.00	5.04	5.04	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.05	6.84	HGL ok
P-12	DI-12	DI-13	1.00	5.00	5.00	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	5.04	6.99	HGL ok
P-13	DI-13	MH-14	1.00	4.93	4.93	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	5.00	7.91	HGL ok
P-14	MH-14	DI-15	1.60	4.85	4.85	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	4.93	8.68	HGL ok
P-15	DI-15	DI-16	1.60	4.76	4.76	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	4.85	9.01	HGL ok
P-16	DI-16	MH-17	1.60	4.64	4.64	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	4.76	9.77	HGL ok
P-18	B7 South	MH-14	1.20	4.93	4.93	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	4.97	10.00	HGL ok
P-01	DI-01	DI-02	1.00	5.04	5.04	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	5.06	6.84	HGL ok
P-02	DI-02	DI-03	1.00	5.01	5.01	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	5.04	7.35	HGL ok
P-03	DI-03	MH-04	1.00	4.95	4.95	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	5.01	7.91	HGL ok
P-04	MH-04	DI-05	1.20	4.84	4.84	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	4.95	8.60	HGL ok
P-05	DI-05	DI-06	1.60	4.75	4.75	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	4.84	9.01	HGL ok
P-06	DI-06	MH-17	1.60	4.64	4.64	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	4.75	9.87	HGL ok
P-17	MH-17	MH-35	1.60	4.51	4.51	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	4.64	10.61	HGL ok
P-08	DI-08	MH-07	1.00	4.79	4.79	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.79	11.39	HGL ok
P-07	MH-07	DI-06	1.20	4.75	4.75	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	4.79	10.19	HGL ok
P-09	B9/J	MH-04	1.20	4.95	4.95	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	4.96	10.00	HGL ok
P-10	B9/J	MH-07	1.20	4.79	4.79	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	4.80	10.00	HGL ok
P-20	TD-05	DI-21	0.53	5.36	7.08	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	7.20	10.50	HGL ok
P-21	DI-21	MH-22	1.00	5.26	5.26	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	5.36	9.46	HGL ok
P-22	MH-22	MH-23	1.20	5.22	5.22	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	5.26	9.72	HGL ok
P-23	MH-23	MH-24	1.20	4.90	4.90	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	5.22	10.97	HGL ok
P-24	MH-24	MH-35	1.20	4.51	4.51	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	4.90	11.20	HGL ok
P-25	DI-25	MH-22	1.00	5.26	5.26	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.27	9.46	HGL ok
P-26	B8/K	MH-23	1.20	5.22	5.22	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	5.25	10.00	HGL ok
P-27	B6 South	MH-23	1.20	5.22	5.22	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	5.26	10.00	HGL ok
P-28	DI-28	MH-24	1.20	4.90	4.90	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.90	10.95	HGL ok
P-29	DI-29	MH-24	1.20	4.90	4.90	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.90	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	8.73	8.73	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	8.79	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	8.68	8.68	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	8.73	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	8.62	8.62	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	8.68	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	8.53	8.53	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	8.62	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	8.45	8.45	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	8.53	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	8.36	8.36	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	8.45	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.18	8.18	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	8.36	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.06	8.06	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	8.18	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.90	7.90	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	8.06	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.76	7.76	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	7.90	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.54	7.54	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	7.76	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.29	7.29	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	7.54	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.01	7.01	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	7.29	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.94	6.94	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	7.01	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**6.90**	**6.90**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**6.94**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	8.73	8.73	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	8.77	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	8.45	8.45	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	8.49	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.85	7.85	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	7.88	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.76	7.76	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	7.85	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.44	8.44	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.44	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	8.42	8.42	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	8.44	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.38	8.38	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	8.42	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.29	8.29	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	8.38	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.18	8.18	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	8.29	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	8.38	8.38	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	8.42	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.22	8.22	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.23	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.21	8.21	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	8.22	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.19	8.19	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	8.21	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.16	8.16	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	8.19	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.14	8.14	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	8.16	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.05	8.05	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	8.14	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.81	7.81	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	8.05	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.54	7.54	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	7.81	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.21	8.21	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.22	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.14	8.14	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	8.18	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.14	7.14	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.16	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.94	6.94	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	7.14	8.33	HGL ok
P-92	B6 North	DI-91	1.20	7.14	7.14	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	7.18	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.01	8.00	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	8.17	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.32	7.32	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.32	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.31	7.31	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	7.32	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.29	7.29	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	7.31	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.71	7.71	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	8.01	11.72	HGL ok
P-36	DI-36	DI-37	2.40	7.50	7.50	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	7.71	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.29	7.29	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	7.50	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.01	8.01	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.01	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.54	8.54	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.55	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	8.50	8.50	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	8.54	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	8.43	8.43	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	8.50	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.35	8.35	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	8.43	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.26	8.26	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	8.35	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.14	8.14	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	8.26	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.43	8.43	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	8.47	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.54	8.54	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.56	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	8.51	8.51	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	8.54	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	8.45	8.45	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	8.51	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.34	8.34	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	8.45	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.25	8.25	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	8.34	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.14	8.14	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	8.25	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.01	8.01	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	8.14	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.29	8.29	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.29	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.25	8.25	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	8.29	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.45	8.45	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.46	10.00	HGL ok
P-10	B9/J	MH-07	1.20	8.29	8.29	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.30	10.00	HGL ok
P-20	TD-05	DI-21	0.53	8.86	8.86	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	8.98	10.50	HGL ok
P-21	DI-21	MH-22	1.00	8.76	8.76	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	8.86	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	8.72	8.72	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	8.76	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	8.40	8.40	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	8.72	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.01	8.01	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	8.40	11.20	HGL ok
P-25	DI-25	MH-22	1.00	8.76	8.76	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.77	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	8.72	8.72	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	8.75	10.00	HGL ok
P-27	B6 South	MH-23	1.20	8.72	8.72	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.76	10.00	HGL ok
P-28	DI-28	MH-24	1.20	8.40	8.40	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.40	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.40	8.40	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.40	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inle WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvatu O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	**HGL Check**
P-41	MH-41	MH-42	1.60	9.23	9.23	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	9.29	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	9.18	9.18	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	9.23	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.12	9.12	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	9.18	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.03	9.03	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	9.12	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	8.95	8.95	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	9.03	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	8.86	8.86	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	8.95	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.68	8.68	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	8.86	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.56	8.56	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	8.68	9.84	HGL ok
P-61	MH-61	DI-62	2.40	8.40	8.40	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	8.56	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.26	8.26	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	8.40	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.04	8.04	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	8.26	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.79	7.79	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	8.04	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.51	7.51	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	7.79	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.44	7.44	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	7.51	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.40**	**7.40**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**7.44**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.23	9.23	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	9.27	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	8.95	8.95	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	8.99	10.00	HGL ok
P-65	B7 West	MH-64	1.20	8.35	8.35	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	8.38	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.26	8.26	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	8.35	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.94	8.94	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.94	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	8.92	8.92	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	8.94	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.88	8.88	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	8.92	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.79	8.79	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	8.88	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.68	8.68	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	8.79	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	8.88	8.88	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	8.92	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.72	8.72	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.73	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.71	8.71	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	8.72	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.69	8.69	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	8.71	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.66	8.66	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	8.69	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.64	8.64	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	8.66	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.55	8.55	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	8.64	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.31	8.31	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	8.55	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.04	8.04	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	8.31	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.71	8.71	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.72	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.64	8.64	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	8.68	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.64	7.64	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.66	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.44	7.44	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	7.64	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	7.64	7.64	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	7.68	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.51	8.00	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	8.17	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.82	7.82	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.82	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.81	7.81	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	7.82	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.79	7.79	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	7.81	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.21	8.21	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	8.51	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.00	8.00	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	8.21	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.79	7.79	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	8.00	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.51	8.51	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.51	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.04	9.04	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.05	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.00	9.00	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	9.04	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	8.93	8.93	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	9.00	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.85	8.85	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	8.93	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.76	8.76	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	8.85	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.64	8.64	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	8.76	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.93	8.93	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	8.97	10.00	HGL ok
P-01	DI-01	DI-02	1.00	9.04	9.04	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.06	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.01	9.01	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	9.04	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	8.95	8.95	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	9.01	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.84	8.84	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	8.95	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.75	8.75	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	8.84	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.64	8.64	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	8.75	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.51	8.51	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	8.64	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.79	8.79	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.79	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.75	8.75	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	8.79	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.95	8.95	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	8.96	10.00	HGL ok
P-10	B9/J	MH-07	1.20	8.79	8.79	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.80	10.00	HGL ok
P-20	TD-05	DI-21	0.53	9.36	9.36	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	9.48	10.50	HGL ok
P-21	DI-21	MH-22	1.00	9.26	9.26	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	9.36	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.22	9.22	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	9.26	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	8.90	8.90	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	9.22	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.51	8.51	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	8.90	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.26	9.26	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.27	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.22	9.22	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.25	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.22	9.22	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.26	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	8.90	8.90	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.90	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.90	8.90	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.90	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	**HGL Check**
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	9.63	9.63	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	9.69	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	9.58	9.58	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	9.63	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.52	9.52	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	9.58	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.43	9.43	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	9.52	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.35	9.35	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	9.43	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.26	9.26	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	9.35	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.08	9.08	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	9.26	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.96	8.96	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	9.08	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	8.80	8.80	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	8.96	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.66	8.66	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	8.80	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.44	8.44	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	8.66	10.08	HGL ok
P-77	DI-77	DI-85	3.20	8.19	8.19	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	8.44	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.91	7.91	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	8.19	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.84	7.84	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	7.91	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.80**	**7.80**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	*0.5*	**0.04**	**0.04**	**7.84**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.63	9.63	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	9.67	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.35	9.35	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	9.39	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	8.75	8.75	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	8.78	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.66	8.66	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	8.75	10.14	HGL ok
P-51	DI-51	DI-52	1.00	9.34	9.34	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.34	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.32	9.32	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	9.34	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.28	9.28	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	9.32	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.19	9.19	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	9.28	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.08	9.08	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	9.19	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.28	9.28	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	9.32	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.12	9.12	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.13	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.11	9.11	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	9.12	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.09	9.09	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	9.11	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.06	9.06	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	9.09	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.04	9.04	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	9.06	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.95	8.95	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	9.04	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.71	8.71	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	8.95	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.44	8.44	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	8.71	10.34	HGL ok
P-70	DI-70	DI-71	1.00	9.11	9.11	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.12	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.04	9.04	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	9.08	11.00	HGL ok
P-90	DI-90	DI-91	1.00	8.04	8.04	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.06	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.84	7.84	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	8.04	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.04	8.04	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	8.08	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.91	8.00	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	8.17	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.22	8.22	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.22	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.21	8.21	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.22	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.19	8.19	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	8.21	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.61	8.61	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	8.91	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.40	8.40	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	8.61	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.19	8.19	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	8.40	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.91	8.91	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.91	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.44	9.44	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.45	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.40	9.40	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	9.44	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.33	9.33	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	9.40	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.25	9.25	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	9.33	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.16	9.16	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	9.25	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.04	9.04	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	9.16	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.33	9.33	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	9.37	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.44	9.44	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.46	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.41	9.41	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	9.44	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.35	9.35	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	9.41	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.24	9.24	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	9.35	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.15	9.15	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	9.24	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.04	9.04	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	9.15	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	8.91	8.91	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	9.04	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.19	9.19	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.19	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.15	9.15	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	9.19	10.19	HGL ok
P-09	B9/J	MH-04	1.20	9.35	9.35	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.36	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.19	9.19	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.20	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	9.76	9.76	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	9.88	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	9.66	9.66	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	9.76	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.62	9.62	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	9.66	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.30	9.30	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	9.62	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.91	8.91	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	9.30	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.66	9.66	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.67	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.62	9.62	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	9.65	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.62	9.62	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.66	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.30	9.30	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.30	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.30	9.30	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.30	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)			

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvatu O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	10.13	10.13	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	10.19	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.08	10.08	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	10.13	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.02	10.02	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	10.08	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.93	9.93	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	10.02	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.85	9.85	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	9.93	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.76	9.76	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	9.85	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.58	9.58	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	9.76	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.46	9.46	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	9.58	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.30	9.30	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	9.46	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.16	9.16	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	9.30	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.94	8.94	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	9.16	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	8.69	8.69	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	8.94	10.08	HGL ok
P-85	DI-85	MH-86	4.00	8.41	8.41	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	8.69	9.98	HGL ok
P-86	MH-86	MH-87	4.00	8.34	8.34	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	8.41	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**8.30**	**8.30**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**8.34**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.13	10.13	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	10.17	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.85	9.85	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	9.89	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.25	9.25	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	9.28	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.16	9.16	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	9.25	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	9.84	9.84	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.84	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.82	9.82	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	9.84	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.78	9.78	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	9.82	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.69	9.69	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	9.78	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.58	9.58	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	9.69	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.78	9.78	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	9.82	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.62	9.62	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.63	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.61	9.61	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	9.62	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.59	9.59	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	9.61	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.56	9.56	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	9.59	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.54	9.54	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	9.56	10.84	HGL ok
P-74	MH-74	DI-75	1.20	9.45	9.45	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	9.54	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.21	9.21	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	9.45	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.94	8.94	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	9.21	10.34	HGL ok
P-70	DI-70	DI-71	1.00	9.61	9.61	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.62	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.54	9.54	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	9.58	11.00	HGL ok
P-90	DI-90	DI-91	1.00	8.54	8.54	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.56	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	8.34	8.34	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	8.54	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.54	8.54	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	8.58	10.00	HGL ok
P-95	TD-04	MH-86	0.80	8.41	8.41	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	8.57	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.72	8.72	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.72	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.71	8.71	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.72	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.69	8.69	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	8.71	9.98	HGL ok
P-35	MH-35	DI-36	2.40	9.11	9.11	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	9.41	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.90	8.90	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	9.11	10.67	HGL ok

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*Q*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.69	8.69	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	8.90	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.41	9.41	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.41	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.94	9.94	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.95	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.90	9.90	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	9.94	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.83	9.83	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	9.90	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.75	9.75	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	9.83	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.66	9.66	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	9.75	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.54	9.54	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	9.66	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.83	9.83	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	9.87	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.94	9.94	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.96	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.91	9.91	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	9.94	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.85	9.85	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	9.91	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.74	9.74	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	9.85	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.65	9.65	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	9.74	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.54	9.54	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	9.65	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.41	9.41	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	9.54	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.69	9.69	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.69	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.65	9.65	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	9.69	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	9.85	9.85	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	9.86	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.69	9.69	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.70	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.26	10.26	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	10.38	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.16	10.16	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	10.26	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.12	10.12	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	10.16	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.80	9.80	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	10.12	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.41	9.41	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	9.80	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.16	10.16	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.17	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.12	10.12	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.15	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.12	10.12	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.16	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.80	9.80	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.80	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.80	9.80	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.80	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR Date: 2/23/23 Sheet No.: 2 of 5
Checked by: TMC Date: 3/23/23 Cm. No.: 20077
Design Freq.: 10 -year (50-year for sumps)

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	10.83	10.83	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	10.89	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.78	10.78	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	10.83	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.72	10.72	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	10.78	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.63	10.63	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	10.72	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.55	10.55	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	10.63	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.46	10.46	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	10.55	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.28	10.28	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	10.46	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.16	10.16	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	10.28	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.00	10.00	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	10.16	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	9.86	9.86	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	10.00	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.64	9.64	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	9.86	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.39	9.39	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	9.64	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.11	9.11	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	9.39	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.04	9.04	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	9.11	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.00**	**9.00**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**9.04**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.83	10.83	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	10.87	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.55	10.55	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	10.59	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.95	9.95	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	9.98	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.86	9.86	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	9.95	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.54	10.54	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.54	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.52	10.52	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	10.54	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.48	10.48	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	10.52	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.39	10.39	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	10.48	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.28	10.28	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	10.39	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.48	10.48	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	10.52	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.32	10.32	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.33	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.31	10.31	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	10.32	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.29	10.29	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	10.31	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.26	10.26	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	10.29	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.24	10.24	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	10.26	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.15	10.15	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	10.24	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	9.91	9.91	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	10.15	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.64	9.64	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	9.91	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.31	10.31	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.32	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.24	10.24	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.28	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.24	9.24	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.26	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.04	9.04	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	9.24	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.24	9.24	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.28	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.11	9.11	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	9.27	10.50	HGL ok
P-38	DI-38	DI-39	1.00	9.42	9.42	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.42	10.67	HGL ok
P-39	DI-39	DI-40	1.00	9.41	9.41	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.42	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.39	9.39	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	9.41	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	9.81	9.81	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	10.11	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.60	9.60	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	9.81	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.39	9.39	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	9.60	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.11	10.11	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.11	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.64	10.64	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.65	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.60	10.60	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	10.64	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.53	10.53	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	10.60	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.45	10.45	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	10.53	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.36	10.36	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	10.45	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.24	10.24	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	10.36	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.53	10.53	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	10.57	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.64	10.64	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.66	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.61	10.61	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	10.64	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.55	10.55	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	10.61	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.44	10.44	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	10.55	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.35	10.35	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	10.44	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.24	10.24	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	10.35	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.11	10.11	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	10.24	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.39	10.39	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.39	11.39	HGL ok
P-07	MH-07	DI-06	1.20	10.35	10.35	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	10.39	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.55	10.55	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	10.56	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.39	10.39	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.40	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.96	10.96	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	11.08	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.86	10.86	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	10.96	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.82	10.82	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	10.86	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.50	10.50	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	10.82	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.11	10.11	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	10.50	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	10.86	10.86	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.87	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.82	10.82	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	10.85	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.82	10.82	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.86	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.50	10.50	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.50	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.50	10.50	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.50	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.33	11.33	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	11.39	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.28	11.28	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	11.33	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.22	11.22	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	11.28	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.13	11.13	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	11.22	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.05	11.05	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	11.13	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.96	10.96	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	11.05	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.78	10.78	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	10.96	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.66	10.66	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	10.78	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.50	10.50	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	10.66	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.36	10.36	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	10.50	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.14	10.14	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	10.36	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.89	9.89	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	10.14	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.61	9.61	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	9.89	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.54	9.54	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	9.61	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.50**	**9.50**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**9.54**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	11.33	11.33	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	11.37	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.05	11.05	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	11.09	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.45	10.45	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	10.48	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.36	10.36	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	10.45	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.04	11.04	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.04	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.02	11.02	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	11.04	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.98	10.98	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	11.02	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.89	10.89	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	10.98	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.78	10.78	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	10.89	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.98	10.98	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	11.02	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.82	10.82	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.83	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	10.81	10.81	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	10.82	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.79	10.79	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	10.81	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.76	10.76	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	10.79	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.74	10.74	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	10.76	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.65	10.65	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	10.74	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.41	10.41	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	10.65	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.14	10.14	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	10.41	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.81	10.81	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.82	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	10.74	10.74	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.78	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.74	9.74	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.76	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.54	9.54	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	9.74	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.74	9.74	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.78	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.61	9.61	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	9.77	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	9.92	9.92	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.92	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	9.91	9.91	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.92	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.89	9.89	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	9.91	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.31	10.31	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	10.61	11.72	HGL ok
P-36	DI-36	DI-37	2.40	10.10	10.10	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	10.31	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 10 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.89	9.89	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	10.10	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.61	10.61	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.61	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.14	11.14	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.15	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.10	11.10	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	*1.3*	1.0	0.01	0.04	11.14	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.03	11.03	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	*1.3*	1.0	0.02	0.07	11.10	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.95	10.95	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	*0.5*	0.05	0.08	11.03	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.86	10.86	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	10.95	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.74	10.74	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	10.86	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.03	11.03	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.04	11.07	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.14	11.14	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.16	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.11	11.11	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	*1.3*	1.0	0.01	0.03	11.14	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.05	11.05	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	*1.3*	1.0	0.02	0.06	11.11	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.94	10.94	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	*0.5*	0.03	0.11	11.05	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.85	10.85	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	10.94	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.74	10.74	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	10.85	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.61	10.61	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	*0.5*	0.07	0.13	10.74	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.89	10.89	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.89	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	10.85	10.85	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	*0.5*	0.03	0.04	10.89	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.05	11.05	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.01	11.06	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.89	10.89	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.01	0.02	10.90	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.46	11.46	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	11.58	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.36	11.36	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	*1.3*	1.0	0.08	0.10	11.46	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.32	11.32	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	*0.5*	0.02	0.04	11.36	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.00	11.00	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	*0.5*	0.05	0.33	11.32	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.61	10.61	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	*0.5*	0.09	0.39	11.00	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.36	11.36	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.37	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.32	11.32	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.02	11.35	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.32	11.32	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.00	0.03	11.36	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.00	11.00	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.00	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.00	11.00	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.00	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	12.63	12.63	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	12.69	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.58	12.58	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	12.63	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.52	12.52	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	12.58	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.43	12.43	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	12.52	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.35	12.35	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	12.43	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.26	12.26	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	12.35	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.08	12.08	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	12.26	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.96	11.96	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	12.08	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.80	11.80	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	11.96	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.66	11.66	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	11.80	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.44	11.44	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	11.66	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.19	11.19	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	11.44	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.91	10.91	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	11.19	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.84	10.84	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	10.91	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.80**	**10.80**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**10.84**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.63	12.63	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	12.67	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.35	12.35	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	12.39	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.75	11.75	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	11.78	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.66	11.66	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	11.75	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.34	12.34	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.34	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.32	12.32	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	12.34	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.28	12.28	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	12.32	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.19	12.19	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	12.28	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.08	12.08	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	12.19	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.28	12.28	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	12.32	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.12	12.12	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.13	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.11	12.11	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	12.12	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.09	12.09	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	12.11	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.06	12.06	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	12.09	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.04	12.04	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	12.06	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.95	11.95	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	12.04	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.71	11.71	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	11.95	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.44	11.44	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	11.71	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.11	12.11	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.12	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.04	12.04	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.08	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.04	11.04	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.06	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.84	10.84	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	11.04	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.04	11.04	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.08	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.91	10.91	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	11.07	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.22	11.22	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.22	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.21	11.21	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.22	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.19	11.19	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.21	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.61	11.61	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	11.91	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.40	11.40	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	11.61	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.19	11.19	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	11.40	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.91	11.91	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.91	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.44	12.44	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.45	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.40	12.40	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	12.44	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.33	12.33	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	12.40	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.25	12.25	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	12.33	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.16	12.16	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	12.25	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.04	12.04	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	12.16	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.33	12.33	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	12.37	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.44	12.44	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.46	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.41	12.41	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	12.44	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.35	12.35	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	12.41	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.24	12.24	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	12.35	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.15	12.15	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	12.24	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.04	12.04	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	12.15	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.91	11.91	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	12.04	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.19	12.19	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.19	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.15	12.15	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	12.19	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.35	12.35	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.36	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.19	12.19	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.20	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.76	12.76	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	12.88	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.66	12.66	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	12.76	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.62	12.62	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	12.66	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.30	12.30	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	12.62	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.91	11.91	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	12.30	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.66	12.66	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.67	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.62	12.62	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.65	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.62	12.62	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.66	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.30	12.30	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.30	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.30	12.30	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.30	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	7.57	7.57	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	7.63	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	7.52	7.52	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	7.57	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	7.46	7.46	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	7.52	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	7.37	7.37	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	7.46	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	7.29	7.29	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	7.37	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	7.20	7.20	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	7.29	8.54	HGL ok
P-47	DI-47	MH-60	2.40	7.02	7.02	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	7.20	9.09	HGL ok
P-60	MH-60	MH-61	2.40	6.90	6.90	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	7.02	9.84	HGL ok
P-61	MH-61	DI-62	2.40	6.74	6.74	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	6.90	11.03	HGL ok
P-62	DI-62	DI-63	2.40	6.60	6.60	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	6.74	10.34	HGL ok
P-63	DI-63	DI-77	1.93	6.38	6.38	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	6.60	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.13	6.13	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	6.38	10.08	HGL ok
P-85	DI-85	MH-86	4.00	5.85	5.85	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	6.13	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.78	5.78	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	5.85	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.74**	**5.74**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**5.78**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	7.57	7.57	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	7.61	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	7.29	7.29	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	7.33	10.00	HGL ok
P-65	B7 West	MH-64	1.20	6.69	6.69	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	6.72	10.00	HGL ok
P-64	MH-64	DI-63	1.20	6.60	6.60	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	6.69	10.14	HGL ok
P-51	DI-51	DI-52	1.00	7.28	7.28	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.28	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	7.26	7.26	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	7.28	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	7.22	7.22	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	7.26	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	7.13	7.13	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	7.22	8.54	HGL ok
P-55	DI-55	MH-60	1.60	7.02	7.02	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	7.13	9.09	HGL ok
P-56	B5 South	MH-54	1.20	7.22	7.22	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	7.26	10.00	HGL ok
P-78	DI-78	DI-79	1.00	7.06	7.06	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.07	11.60	HGL ok
P-79	DI-79	DI-71	1.20	7.05	7.05	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	7.06	11.15	HGL ok
P-71	DI-71	DI-72	1.20	7.03	7.03	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	7.05	11.15	HGL ok
P-72	DI-72	DI-73	1.20	7.00	7.00	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	7.03	10.99	HGL ok
P-73	DI-73	MH-74	1.20	6.98	6.98	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	7.00	10.84	HGL ok
P-74	MH-74	DI-75	1.20	6.89	6.89	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	6.98	11.24	HGL ok
P-75	DI-75	DI-76	1.20	6.65	6.65	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	6.89	10.63	HGL ok
P-76	DI-76	DI-77	1.20	6.38	6.38	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	6.65	10.34	HGL ok
P-70	DI-70	DI-71	1.00	7.05	7.05	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.06	11.60	HGL ok
P-80	DI-80	MH-74	1.20	6.98	6.98	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	7.02	11.00	HGL ok
P-90	DI-90	DI-91	1.00	5.98	5.98	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.00	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.78	5.78	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	5.98	8.33	HGL ok
P-92	B6 North	DI-91	1.20	5.98	5.98	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	6.02	10.00	HGL ok
P-95	TD-04	MH-86	0.80	5.85	8.00	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	8.17	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.16	6.16	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.16	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.15	6.15	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.16	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.13	6.13	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	6.15	9.98	HGL ok
P-35	MH-35	DI-36	2.40	6.55	6.55	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	6.85	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.34	6.34	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	6.55	10.67	HGL ok

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*Q*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.13	6.13	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	6.34	10.16	HGL ok
P-30	DI-30	MH-35	1.20	6.85	6.85	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.85	11.24	HGL ok
P-11	DI-11	DI-12	1.00	7.38	7.38	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.39	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	7.34	7.34	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	7.38	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	7.27	7.27	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	7.34	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	7.19	7.19	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	7.27	8.68	HGL ok
P-15	DI-15	DI-16	1.60	7.10	7.10	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	7.19	9.01	HGL ok
P-16	DI-16	MH-17	1.60	6.98	6.98	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	7.10	9.77	HGL ok
P-18	B7 South	MH-14	1.20	7.27	7.27	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	7.31	10.00	HGL ok
P-01	DI-01	DI-02	1.00	7.38	7.38	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.40	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	7.35	7.35	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	7.38	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	7.29	7.29	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	7.35	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	7.18	7.18	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	7.29	8.60	HGL ok
P-05	DI-05	DI-06	1.60	7.09	7.09	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	7.18	9.01	HGL ok
P-06	DI-06	MH-17	1.60	6.98	6.98	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	7.09	9.87	HGL ok
P-17	MH-17	MH-35	1.60	6.85	6.85	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	6.98	10.61	HGL ok
P-08	DI-08	MH-07	1.00	7.13	7.13	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.13	11.39	HGL ok
P-07	MH-07	DI-06	1.20	7.09	7.09	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	7.13	10.19	HGL ok
P-09	B9/J	MH-04	1.20	7.29	7.29	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.30	10.00	HGL ok
P-10	B9/J	MH-07	1.20	7.13	7.13	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.14	10.00	HGL ok
P-20	TD-05	DI-21	0.53	7.70	7.70	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	7.82	10.50	HGL ok
P-21	DI-21	MH-22	1.00	7.60	7.60	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	7.70	9.46	HGL ok
P-22	MH-22	MH-23	1.20	7.56	7.56	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	7.60	9.72	HGL ok
P-23	MH-23	MH-24	1.20	7.24	7.24	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	7.56	10.97	HGL ok
P-24	MH-24	MH-35	1.20	6.85	6.85	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	7.24	11.20	HGL ok
P-25	DI-25	MH-22	1.00	7.60	7.60	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.61	9.46	HGL ok
P-26	B8/K	MH-23	1.20	7.56	7.56	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.59	10.00	HGL ok
P-27	B6 South	MH-23	1.20	7.56	7.56	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.60	10.00	HGL ok
P-28	DI-28	MH-24	1.20	7.24	7.24	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.24	10.95	HGL ok
P-29	DI-29	MH-24	1.20	7.24	7.24	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.24	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	7.77	7.77	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	7.83	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	7.72	7.72	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	7.77	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	7.66	7.66	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	7.72	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	7.57	7.57	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	7.66	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	7.49	7.49	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	7.57	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	7.40	7.40	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	7.49	8.54	HGL ok
P-47	DI-47	MH-60	2.40	7.22	7.22	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	7.40	9.09	HGL ok
P-60	MH-60	MH-61	2.40	7.10	7.10	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	7.22	9.84	HGL ok
P-61	MH-61	DI-62	2.40	6.94	6.94	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	7.10	11.03	HGL ok
P-62	DI-62	DI-63	2.40	6.80	6.80	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	6.94	10.34	HGL ok
P-63	DI-63	DI-77	1.93	6.58	6.58	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	6.80	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.33	6.33	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	6.58	10.08	HGL ok
P-85	DI-85	MH-86	4.00	6.05	6.05	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	6.33	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.98	5.98	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	6.05	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.94**	**5.94**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**5.98**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	7.77	7.77	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	7.81	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	7.49	7.49	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	7.53	10.00	HGL ok
P-65	B7 West	MH-64	1.20	6.89	6.89	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	6.92	10.00	HGL ok
P-64	MH-64	DI-63	1.20	6.80	6.80	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	6.89	10.14	HGL ok
P-51	DI-51	DI-52	1.00	7.48	7.48	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.48	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	7.46	7.46	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	7.48	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	7.42	7.42	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	7.46	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	7.33	7.33	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	7.42	8.54	HGL ok
P-55	DI-55	MH-60	1.60	7.22	7.22	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	7.33	9.09	HGL ok
P-56	B5 South	MH-54	1.20	7.42	7.42	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	7.46	10.00	HGL ok
P-78	DI-78	DI-79	1.00	7.26	7.26	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.27	11.60	HGL ok
P-79	DI-79	DI-71	1.20	7.25	7.25	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	7.26	11.15	HGL ok
P-71	DI-71	DI-72	1.20	7.23	7.23	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	7.25	11.15	HGL ok
P-72	DI-72	DI-73	1.20	7.20	7.20	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	7.23	10.99	HGL ok
P-73	DI-73	MH-74	1.20	7.18	7.18	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	7.20	10.84	HGL ok
P-74	MH-74	DI-75	1.20	7.09	7.09	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	7.18	11.24	HGL ok
P-75	DI-75	DI-76	1.20	6.85	6.85	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	7.09	10.63	HGL ok
P-76	DI-76	DI-77	1.20	6.58	6.58	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	6.85	10.34	HGL ok
P-70	DI-70	DI-71	1.00	7.25	7.25	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.26	11.60	HGL ok
P-80	DI-80	MH-74	1.20	7.18	7.18	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	7.22	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.18	6.18	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.20	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.98	5.98	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	6.18	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.18	6.18	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	6.22	10.00	HGL ok
P-95	TD-04	MH-86	0.80	6.05	8.00	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	8.17	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.36	6.36	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.36	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.35	6.35	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.36	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.33	6.33	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	6.35	9.98	HGL ok
P-35	MH-35	DI-36	2.40	6.75	6.75	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	7.05	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.54	6.54	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	6.75	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*Q*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.33	6.33	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	6.54	10.16	HGL ok
P-30	DI-30	MH-35	1.20	7.05	7.05	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.05	11.24	HGL ok
P-11	DI-11	DI-12	1.00	7.58	7.58	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.59	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	7.54	7.54	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	7.58	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	7.47	7.47	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	7.54	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	7.39	7.39	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	7.47	8.68	HGL ok
P-15	DI-15	DI-16	1.60	7.30	7.30	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	7.39	9.01	HGL ok
P-16	DI-16	MH-17	1.60	7.18	7.18	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	7.30	9.77	HGL ok
P-18	B7 South	MH-14	1.20	7.47	7.47	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	7.51	10.00	HGL ok
P-01	DI-01	DI-02	1.00	7.58	7.58	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.60	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	7.55	7.55	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	7.58	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	7.49	7.49	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	7.55	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	7.38	7.38	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	7.49	8.60	HGL ok
P-05	DI-05	DI-06	1.60	7.29	7.29	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	7.38	9.01	HGL ok
P-06	DI-06	MH-17	1.60	7.18	7.18	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	7.29	9.87	HGL ok
P-17	MH-17	MH-35	1.60	7.05	7.05	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	7.18	10.61	HGL ok
P-08	DI-08	MH-07	1.00	7.33	7.33	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.33	11.39	HGL ok
P-07	MH-07	DI-06	1.20	7.29	7.29	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	7.33	10.19	HGL ok
P-09	B9/J	MH-04	1.20	7.49	7.49	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	7.50	10.00	HGL ok
P-10	B9/J	MH-07	1.20	7.33	7.33	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.34	10.00	HGL ok
P-20	TD-05	DI-21	0.53	7.90	7.90	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	8.02	10.50	HGL ok
P-21	DI-21	MH-22	1.00	7.80	7.80	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	7.90	9.46	HGL ok
P-22	MH-22	MH-23	1.20	7.76	7.76	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	7.80	9.72	HGL ok
P-23	MH-23	MH-24	1.20	7.44	7.44	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	7.76	10.97	HGL ok
P-24	MH-24	MH-35	1.20	7.05	7.05	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	7.44	11.20	HGL ok
P-25	DI-25	MH-22	1.00	7.80	7.80	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.81	9.46	HGL ok
P-26	B8/K	MH-23	1.20	7.76	7.76	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	7.79	10.00	HGL ok
P-27	B6 South	MH-23	1.20	7.76	7.76	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	7.80	10.00	HGL ok
P-28	DI-28	MH-24	1.20	7.44	7.44	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.44	10.95	HGL ok
P-29	DI-29	MH-24	1.20	7.44	7.44	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.44	10.95	HGL ok

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)			

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add $H_c = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	**HGL Check**
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.27	11.27	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	11.33	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.22	11.22	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	11.27	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.16	11.16	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	11.22	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.07	11.07	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	11.16	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.99	10.99	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	11.07	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.90	10.90	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	10.99	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.72	10.72	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	10.90	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.60	10.60	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	10.72	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.44	10.44	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	10.60	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.30	10.30	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	10.44	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.08	10.08	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	10.30	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.83	9.83	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	10.08	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.55	9.55	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	9.83	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.48	9.48	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	9.55	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.44**	**9.44**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**9.48**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	11.27	11.27	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	11.31	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.99	10.99	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	11.03	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.39	10.39	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	10.42	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.30	10.30	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	10.39	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.98	10.98	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.98	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.96	10.96	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	10.98	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.92	10.92	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	10.96	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.83	10.83	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	10.92	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.72	10.72	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	10.83	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.92	10.92	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	10.96	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.76	10.76	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.77	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	10.75	10.75	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	10.76	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.73	10.73	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	10.75	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.70	10.70	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	10.73	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.68	10.68	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	10.70	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.59	10.59	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	10.68	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.35	10.35	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	10.59	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.08	10.08	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	10.35	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.75	10.75	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.76	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	10.68	10.68	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.72	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.68	9.68	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.70	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.48	9.48	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	9.68	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.68	9.68	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.72	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.55	9.55	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	9.71	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	9.86	9.86	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.86	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	9.85	9.85	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.86	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.83	9.83	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	9.85	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.25	10.25	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	10.55	11.72	HGL ok
P-36	DI-36	DI-37	2.40	10.04	10.04	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	10.25	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.83	9.83	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	10.04	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.55	10.55	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.55	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.08	11.08	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.09	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.04	11.04	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	11.08	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.97	10.97	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	11.04	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.89	10.89	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	10.97	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.80	10.80	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	10.89	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.68	10.68	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	10.80	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.97	10.97	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	11.01	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.08	11.08	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.10	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.05	11.05	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	11.08	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.99	10.99	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	11.05	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.88	10.88	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	10.99	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.79	10.79	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	10.88	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.68	10.68	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	10.79	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.55	10.55	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	10.68	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.83	10.83	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.83	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	10.79	10.79	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	10.83	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.99	10.99	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.00	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.83	10.83	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.84	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.40	11.40	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	11.52	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.30	11.30	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	11.40	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.26	11.26	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	11.30	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.94	10.94	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	11.26	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.55	10.55	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	10.94	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.30	11.30	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.31	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.26	11.26	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.29	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.26	11.26	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.30	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.94	10.94	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.94	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.94	10.94	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.94	10.95	HGL Too High!

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)			

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvatu (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	11.77	11.77	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	11.83	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.72	11.72	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	11.77	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.66	11.66	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	11.72	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.57	11.57	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	11.66	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.49	11.49	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	11.57	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.40	11.40	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	11.49	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.22	11.22	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	11.40	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.10	11.10	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	11.22	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.94	10.94	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	11.10	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.80	10.80	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	10.94	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.58	10.58	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	10.80	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.33	10.33	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	10.58	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.05	10.05	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	10.33	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.98	9.98	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	10.05	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.94**	**9.94**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**9.98**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	11.77	11.77	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	11.81	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.49	11.49	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	11.53	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.89	10.89	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	10.92	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.80	10.80	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	10.89	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.48	11.48	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.48	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.46	11.46	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	11.48	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.42	11.42	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	11.46	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.33	11.33	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	11.42	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.22	11.22	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	11.33	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.42	11.42	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	11.46	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.26	11.26	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.27	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.25	11.25	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	11.26	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.23	11.23	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	11.25	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.20	11.20	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	11.23	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.18	11.18	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	11.20	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.09	11.09	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	11.18	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.85	10.85	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	11.09	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.58	10.58	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	10.85	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.25	11.25	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.26	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.18	11.18	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	11.22	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.18	10.18	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.20	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.98	9.98	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	10.18	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.18	10.18	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	10.22	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.05	10.05	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	10.21	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.36	10.36	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.36	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.35	10.35	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.36	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.33	10.33	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	10.35	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.75	10.75	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	11.05	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.54	10.54	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	10.75	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.33	10.33	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	10.54	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.05	11.05	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.05	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.58	11.58	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.59	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.54	11.54	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	11.58	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.47	11.47	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	11.54	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.39	11.39	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	11.47	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.30	11.30	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	11.39	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.18	11.18	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	11.30	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.47	11.47	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	11.51	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.58	11.58	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.60	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.55	11.55	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	11.58	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.49	11.49	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	11.55	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.38	11.38	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	11.49	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.29	11.29	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	11.38	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.18	11.18	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	11.29	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.05	11.05	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	11.18	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.33	11.33	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.33	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.29	11.29	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	11.33	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.49	11.49	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.50	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.33	11.33	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.34	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.90	11.90	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	12.02	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.80	11.80	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	11.90	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.76	11.76	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	11.80	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.44	11.44	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	11.76	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.05	11.05	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	11.44	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.80	11.80	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.81	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.76	11.76	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	11.79	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.76	11.76	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.80	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.44	11.44	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.44	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.44	11.44	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.44	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR — Date: 2/23/23 — Sheet No.: 2 of 5
Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Design Freq.: 10 -year (50-year for sumps)

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ ft	Tot. H Loss, $H=H_f+H_{t\,adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	12.17	12.17	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	12.23	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.12	12.12	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	12.17	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.06	12.06	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	12.12	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.97	11.97	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	12.06	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.89	11.89	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	11.97	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.80	11.80	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	11.89	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.62	11.62	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	11.80	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.50	11.50	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	11.62	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.34	11.34	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	11.50	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.20	11.20	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	11.34	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.98	10.98	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	11.20	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.73	10.73	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	10.98	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.45	10.45	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	10.73	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.38	10.38	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	10.45	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.34**	**10.34**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**10.38**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.17	12.17	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	12.21	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.89	11.89	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	11.93	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.29	11.29	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	11.32	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.20	11.20	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	11.29	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.88	11.88	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.88	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.86	11.86	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	11.88	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.82	11.82	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	11.86	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.73	11.73	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	11.82	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.62	11.62	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	11.73	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.82	11.82	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	11.86	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.66	11.66	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.67	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.65	11.65	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	11.66	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.63	11.63	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	11.65	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.60	11.60	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	11.63	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.58	11.58	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	11.60	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.49	11.49	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	11.58	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.25	11.25	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	11.49	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.98	10.98	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	11.25	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.65	11.65	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.66	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.58	11.58	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	11.62	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.58	10.58	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.60	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.38	10.38	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	10.58	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.58	10.58	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	10.62	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.45	10.45	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	10.61	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.76	10.76	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.76	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.75	10.75	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.76	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.73	10.73	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	10.75	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.15	11.15	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	11.45	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.94	10.94	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	11.15	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.73	10.73	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	10.94	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.45	11.45	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.45	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.98	11.98	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.99	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.94	11.94	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	11.98	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.87	11.87	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	11.94	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.79	11.79	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	11.87	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.70	11.70	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	11.79	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.58	11.58	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	11.70	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.87	11.87	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	11.91	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.98	11.98	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.00	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.95	11.95	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	11.98	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.89	11.89	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	11.95	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.78	11.78	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	11.89	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.69	11.69	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	11.78	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.58	11.58	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	11.69	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.45	11.45	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	11.58	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.73	11.73	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.73	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.69	11.69	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	11.73	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.89	11.89	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	11.90	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.73	11.73	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.74	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.30	12.30	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	12.42	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.20	12.20	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	12.30	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.16	12.16	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	12.20	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.84	11.84	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	12.16	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.45	11.45	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	11.84	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.20	12.20	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.21	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.16	12.16	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.19	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.16	12.16	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.20	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.84	11.84	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.84	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.84	11.84	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.84	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR Date: 2/23/23 Sheet No.: 2 of 5
Checked by: TMC Date: 3/23/23 Cm. No.: 20077
Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	12.67	12.67	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	12.73	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.62	12.62	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	12.67	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.56	12.56	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	12.62	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.47	12.47	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	12.56	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.39	12.39	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	12.47	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.30	12.30	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	12.39	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.12	12.12	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	12.30	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.00	12.00	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	12.12	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.84	11.84	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	12.00	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.70	11.70	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	11.84	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.48	11.48	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	11.70	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.23	11.23	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	11.48	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.95	10.95	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	11.23	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.88	10.88	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	10.95	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.84**	**10.84**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	***0.5***	**0.04**	**0.04**	**10.88**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.67	12.67	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	12.71	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.39	12.39	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	12.43	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.79	11.79	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	11.82	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.70	11.70	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	11.79	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.38	12.38	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.38	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.36	12.36	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	12.38	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.32	12.32	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	12.36	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.23	12.23	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	12.32	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.12	12.12	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	12.23	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.32	12.32	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	12.36	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.16	12.16	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.17	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.15	12.15	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	12.16	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.13	12.13	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	12.15	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.10	12.10	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	12.13	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.08	12.08	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	12.10	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.99	11.99	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	12.08	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.75	11.75	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	11.99	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.48	11.48	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	11.75	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.15	12.15	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.16	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.08	12.08	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.12	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.08	11.08	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.10	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.88	10.88	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	11.08	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.08	11.08	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.12	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.95	10.95	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	11.11	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.26	11.26	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.26	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.25	11.25	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.26	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.23	11.23	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.25	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.65	11.65	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	11.95	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.44	11.44	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	11.65	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.23	11.23	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	11.44	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.95	11.95	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.95	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.48	12.48	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.49	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.44	12.44	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	12.48	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.37	12.37	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	12.44	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.29	12.29	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	12.37	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.20	12.20	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	12.29	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.08	12.08	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	12.20	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.37	12.37	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	12.41	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.48	12.48	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.50	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.45	12.45	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	12.48	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.39	12.39	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	12.45	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.28	12.28	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	12.39	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.19	12.19	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	12.28	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.08	12.08	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	12.19	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.95	11.95	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	12.08	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.23	12.23	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.23	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.19	12.19	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	12.23	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.39	12.39	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	12.40	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.23	12.23	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.24	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.80	12.80	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	12.92	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.70	12.70	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	12.80	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.66	12.66	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	12.70	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.34	12.34	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	12.66	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.95	11.95	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	12.34	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.70	12.70	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.71	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.66	12.66	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	12.69	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.66	12.66	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.70	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.34	12.34	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.34	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.34	12.34	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.34	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvatu O deg	Curved align; add $Hc = 0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	13.37	13.37	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	13.43	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.32	13.32	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	13.37	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.26	13.26	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	13.32	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.17	13.17	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	13.26	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.09	13.09	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	13.17	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.00	13.00	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	13.09	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.82	12.82	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	13.00	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.70	12.70	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	12.82	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.54	12.54	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	12.70	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.40	12.40	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	12.54	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.18	12.18	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	12.40	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.93	11.93	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	12.18	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.65	11.65	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	11.93	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	11.58	11.58	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	11.65	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**11.54**	**11.54**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**11.58**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.37	13.37	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	13.41	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.09	13.09	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	13.13	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.49	12.49	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	12.52	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.40	12.40	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	12.49	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.08	13.08	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.08	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.06	13.06	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	13.08	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.02	13.02	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	13.06	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.93	12.93	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	13.02	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.82	12.82	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	12.93	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.02	13.02	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	13.06	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.86	12.86	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.87	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.85	12.85	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	12.86	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.83	12.83	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	12.85	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.80	12.80	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	12.83	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.78	12.78	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	12.80	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.69	12.69	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	12.78	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.45	12.45	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	12.69	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.18	12.18	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	12.45	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.85	12.85	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.86	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.78	12.78	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.82	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.78	11.78	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.80	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	11.58	11.58	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	11.78	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.78	11.78	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.82	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.65	11.65	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	11.81	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.96	11.96	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.96	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.95	11.95	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.96	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.93	11.93	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.95	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.35	12.35	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	12.65	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.14	12.14	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	12.35	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.93	11.93	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	12.14	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.65	12.65	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.65	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.18	13.18	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.19	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.14	13.14	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	13.18	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.07	13.07	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	13.14	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.99	12.99	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	13.07	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.90	12.90	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	12.99	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.78	12.78	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	12.90	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.07	13.07	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	13.11	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.18	13.18	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.20	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.15	13.15	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	13.18	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.09	13.09	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	13.15	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.98	12.98	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	13.09	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.89	12.89	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	12.98	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.78	12.78	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	12.89	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.65	12.65	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	12.78	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.93	12.93	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.93	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.89	12.89	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	12.93	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.09	13.09	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.10	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.93	12.93	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.94	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.50	13.50	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	13.62	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.40	13.40	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	13.50	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.36	13.36	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	13.40	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.04	13.04	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	13.36	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.65	12.65	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	13.04	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.40	13.40	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.41	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.36	13.36	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.39	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.36	13.36	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	13.40	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.04	13.04	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.04	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.04	13.04	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.04	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o + H_i + H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ ft	Tot. H Loss, $H = H_f + H_{t\,adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	**HGL Check**
P-41	MH-41	MH-42	1.60	13.87	13.87	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	13.93	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.82	13.82	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	13.87	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.76	13.76	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	13.82	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.67	13.67	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	13.76	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.59	13.59	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	13.67	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.50	13.50	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	13.59	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.32	13.32	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	13.50	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	13.20	13.20	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	13.32	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	13.04	13.04	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	13.20	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.90	12.90	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	13.04	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.68	12.68	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	12.90	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.43	12.43	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	12.68	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	12.15	12.15	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	12.43	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	12.08	12.08	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	12.15	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**12.04**	**12.04**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**12.08**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.87	13.87	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	13.91	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.59	13.59	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	13.63	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.99	12.99	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	13.02	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.90	12.90	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	12.99	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.58	13.58	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.58	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.56	13.56	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	13.58	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.52	13.52	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	13.56	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.43	13.43	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	13.52	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.32	13.32	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	13.43	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.52	13.52	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	13.56	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.36	13.36	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.37	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.35	13.35	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	13.36	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.33	13.33	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	13.35	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.30	13.30	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	13.33	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.28	13.28	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	13.30	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	13.19	13.19	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	13.28	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.95	12.95	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	13.19	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.68	12.68	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	12.95	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.35	13.35	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.36	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.28	13.28	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	13.32	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	12.28	12.28	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.30	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	12.08	12.08	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	12.28	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	12.28	12.28	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	12.32	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	12.15	12.15	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	12.31	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.46	12.46	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.46	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.45	12.45	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.46	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.43	12.43	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.45	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.85	12.85	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	13.15	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.64	12.64	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	12.85	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.43	12.43	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	12.64	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.15	13.15	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.15	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.68	13.68	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.69	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.64	13.64	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	13.68	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.57	13.57	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	13.64	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.49	13.49	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	13.57	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.40	13.40	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	13.49	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.28	13.28	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	13.40	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.57	13.57	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	13.61	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.68	13.68	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.70	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.65	13.65	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	13.68	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.59	13.59	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	13.65	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.48	13.48	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	13.59	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.39	13.39	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	13.48	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.28	13.28	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	13.39	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.15	13.15	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	13.28	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.43	13.43	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.43	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.39	13.39	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	13.43	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.59	13.59	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	13.60	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.43	13.43	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.44	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.00	14.00	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	14.12	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.90	13.90	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	14.00	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.86	13.86	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	13.90	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.54	13.54	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	13.86	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.15	13.15	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	13.54	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.90	13.90	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.91	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.86	13.86	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	13.89	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.86	13.86	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	13.90	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.54	13.54	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.54	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.54	13.54	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.54	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	15.17	15.17	24	5.0	1.6	69	92	0.0004	0.04	0	0.00	0.01	8.1	0.0	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	15.23	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	15.12	15.12	30	9.9	2.0	13	30	0.0005	0.01	0	0.00	0.02	8.1	8.6	0.0	1.7	0.0	51.7	0.02	0.05	1.0	0.5	0.03	0.04	15.17	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	15.06	15.06	30	10.4	2.1	0	25	0.0005	0.01	0	0.00	0.02	20.0	0.0	0.0	2.0	0.0	13	0.01	0.05	1.0	1.0	0.05	0.07	15.12	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.97	14.97	30	10.9	2.2	6	69	0.0006	0.04	0	0.00	0.02	21.9	0.0	0.0	2.1	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	15.06	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	14.89	14.89	30	11.3	2.3	13	52	0.0007	0.03	0	0.00	0.02	24.2	0.0	0.0	2.2	0.0	6	0.01	0.06	1.0	1.0	0.06	0.09	14.97	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	14.80	14.80	30	15.0	3.1	83	42	0.0011	0.05	0	0.00	0.04	26.2	10.5	0.0	2.3	0.0	13	0.02	0.08	1.0	0.5	0.04	0.09	14.89	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	14.62	14.62	36	15.5	2.2	90	23	0.0005	0.01	0	0.00	0.02	45.9	0.0	0.0	3.1	0.1	83	0.10	0.17	1.0	1.0	0.17	0.18	14.80	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	14.50	14.50	36	21.4	3.0	82	75	0.0009	0.07	0	0.00	0.04	33.9	14.2	0.0	2.2	0.0	90	0.05	0.11	1.0	0.5	0.06	0.12	14.62	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	14.34	14.34	36	21.2	3.0	7	76	0.0009	0.07	0	0.00	0.03	64.8	0.0	0.0	3.0	0.0	82	0.09	0.18	1.0	0.5	0.09	0.15	14.50	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	14.20	14.20	36	21.2	3.0	89	50	0.0009	0.04	0	0.00	0.03	63.6	0.0	0.0	3.0	0.0	7	0.01	0.10	1.0	1.0	0.10	0.14	14.34	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	13.98	13.98	36	24.8	3.5	92	25	0.0012	0.03	0	0.00	0.05	63.3	10.5	0.0	3.0	0.0	89	0.10	0.19	1.0	1.0	0.19	0.22	14.20	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	13.73	13.73	48	30.5	2.4	91	50	0.0004	0.02	0	0.00	0.02	87.1	21.6	0.0	3.5	0.1	92	0.13	0.22	1.0	1.0	0.22	0.24	13.98	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	13.45	13.45	60	53.7	2.7	17	186	0.0004	0.07	0	0.00	0.03	73.8	1.0	81.9	3.4	0.1	90	0.13	0.22	1.0	1.0	0.22	0.29	13.73	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	13.38	13.38	60	56.1	2.9	0	45	0.0004	0.02	0	0.00	0.03	146.9	17.3	0.0	2.7	0.0	17	0.02	0.09	1.0	0.5	0.05	0.06	13.45	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**13.34**	**13.34**	**60**	**59.5**	**3.0**	**0**	**9**	**0.0004**	**0.00**	**0**	**0.00**	**0.04**	**160.1**	**10.8**	**0.0**	**2.9**	**0.0**	**0**	**0.00**	**0.08**	**1.0**	**0.5**	**0.04**	**0.04**	**13.38**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	15.17	15.17	24	5.2	1.7	51.7	64	0.0005	0.03	0	0.00	0.01	5.1	1.5	0.0	1.3	0.0	51	0.01	0.03	1.0	0.5	0.02	0.05	15.21	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	14.89	14.89	18	4.3	2.4	83	16	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.05	14.93	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	14.29	14.29	18	4.3	2.5	75	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	14.32	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	14.20	14.20	18	4.3	2.4	74	20	0.0014	0.03	0	0.00	0.02	10.6	0.0	0.0	2.5	0.0	75	0.06	0.12	1.0	0.5	0.06	0.09	14.29	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	14.88	14.88	15	0.4	0.3	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.88	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	14.86	14.86	15	1.0	0.9	7	69	0.0002	0.02	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	1	0.00	0.00	1.3	1.0	0.00	0.02	14.88	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.82	14.82	15	1.6	1.3	13	51	0.0005	0.03	0	0.00	0.01	0.9	0.0	0.0	0.9	0.0	7	0.00	0.01	1.3	1.0	0.02	0.04	14.86	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	14.73	14.73	24	6.0	1.9	83	41	0.0006	0.02	0	0.00	0.01	2.2	11.5	0.0	2.5	0.0	83	0.07	0.12	1.0	0.5	0.06	0.08	14.82	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	14.62	14.62	24	6.7	2.1	90	23	0.0007	0.02	0	0.00	0.02	11.3	0.0	0.0	1.9	0.0	83	0.04	0.08	1.3	1.0	0.10	0.11	14.73	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.82	14.82	18	4.5	2.5	83	17	0.0016	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.01	0.04	14.86	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	14.66	14.66	15	0.5	0.4	89	84	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.67	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	14.65	14.65	18	0.9	0.5	82	29	0.0001	0.00	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	89	0.00	0.00	1.3	1.0	0.00	0.01	14.66	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	14.63	14.63	18	1.9	1.1	2	42	0.0003	0.01	0	0.00	0.00	0.5	0.2	0.0	0.5	0.0	82	0.00	0.01	1.3	1.0	0.01	0.02	14.65	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	14.60	14.60	18	2.2	1.2	8	29	0.0004	0.01	0	0.00	0.01	2.1	0.0	0.0	1.1	0.0	2	0.00	0.01	1.3	1.0	0.02	0.03	14.63	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	14.58	14.58	18	2.3	1.3	8	17	0.0004	0.01	0	0.00	0.01	2.7	0.0	0.0	1.2	0.0	8	0.00	0.02	1.0	1.0	0.02	0.02	14.60	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	14.49	14.49	18	5.7	3.2	5	17	0.0025	0.04	0	0.00	0.04	3.0	6.8	0.0	2.0	0.0	82	0.04	0.10	1.0	0.5	0.05	0.09	14.58	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	14.25	14.25	18	5.9	3.4	9	43	0.0027	0.12	0	0.00	0.04	18.2	0.0	0.0	3.2	0.1	5	0.02	0.12	1.0	1.0	0.12	0.23	14.49	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	13.98	13.98	18	6.2	3.5	2	51	0.0030	0.15	0	0.00	0.05	20.0	0.0	0.0	3.4	0.1	9	0.02	0.13	1.0	1.0	0.13	0.28	14.25	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	14.65	14.65	15	0.5	0.4	7	86	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.66	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	14.58	14.58	18	3.5	2.0	82	24	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	14.62	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	13.58	13.58	15	0.9	0.7	0	79	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.60	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	13.38	13.38	18	4.4	2.5	86	81	0.0015	0.12	0	0.00	0.02	0.6	3.9	0.0	1.5	0.0	90	0.02	0.06	1.3	1.0	0.08	0.20	13.58	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	13.58	13.58	18	2.6	1.5	90	63	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	13.62	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	13.45	13.45	12	3.7	4.7	90	16	0.0077	0.12	0	0.00	0.09	0.0	0.0	0.0	0.0	0.0	0	0.00	0.09	1.0	0.5	0.04	0.17	13.61	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	13.76	13.76	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.76	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	13.75	13.75	15	0.7	0.6	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	13.76	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	13.73	13.73	18	1.3	0.7	0	26	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.75	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	14.15	14.15	36	23.8	3.4	2	94	0.0011	0.10	0	0.00	0.04	0.0	36.0	39.4	4.7	0.1	78	0.23	0.39	1.0	0.5	0.20	0.30	14.45	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	13.94	13.94	36	23.8	3.4	3	98	0.0011	0.11	0	0.00	0.04	79.9	0.0	0.0	3.4	0.1	2	0.00	0.11	1.0	1.0	0.11	0.21	14.15	10.67	HGL Too High!

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	10	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	13.73	13.73	36	24.1	3.4	90	70	0.0011	0.08	0	0.00	0.04	80.0	0.0	0.0	3.4	0.1	3	0.02	0.12	1.0	1.0	0.12	0.20	13.94	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	14.45	14.45	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.45	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.98	14.98	15	0.7	0.5	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.99	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	14.94	14.94	15	1.3	1.1	6	92	0.0004	0.03	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	5	0.00	0.01	1.3	1.0	0.01	0.04	14.98	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	14.87	14.87	15	2.0	1.6	14	54	0.0008	0.04	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	6	0.00	0.02	1.3	1.0	0.02	0.07	14.94	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	14.79	14.79	24	6.2	2.0	9	38	0.0006	0.02	0	0.00	0.01	3.3	10.4	0.0	2.4	0.0	82	0.06	0.11	1.0	0.5	0.05	0.08	14.87	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	14.70	14.70	24	6.6	2.1	91	73	0.0007	0.05	0	0.00	0.02	12.1	0.0	0.0	2.0	0.0	9	0.01	0.04	1.0	1.0	0.04	0.10	14.79	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	14.58	14.58	24	7.3	2.3	90	31	0.0009	0.03	0	0.00	0.02	14.0	0.0	0.0	2.1	0.0	91	0.05	0.09	1.0	1.0	0.09	0.12	14.70	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	14.87	14.87	18	4.3	2.4	82	17	0.0014	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.04	14.91	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.98	14.98	15	1.0	0.8	4	77	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	15.00	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.95	14.95	15	1.3	1.1	11	38	0.0004	0.01	0	0.00	0.00	0.9	0.0	0.0	0.8	0.0	4	0.00	0.01	1.3	1.0	0.01	0.03	14.98	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	14.89	14.89	15	2.0	1.6	14	46	0.0008	0.04	0	0.00	0.01	1.4	0.0	0.0	1.1	0.0	11	0.00	0.02	1.3	1.0	0.02	0.06	14.95	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	14.78	14.78	18	4.7	2.6	7	46	0.0017	0.08	0	0.00	0.03	3.3	4.3	0.0	1.6	0.0	83	0.03	0.07	1.0	0.5	0.03	0.11	14.89	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	14.69	14.69	24	5.1	1.6	90	73	0.0004	0.03	0	0.00	0.01	12.3	0.0	0.0	2.6	0.0	7	0.01	0.06	1.0	1.0	0.06	0.09	14.78	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	14.58	14.58	24	8.8	2.8	90	30	0.0013	0.04	0	0.00	0.03	8.4	5.6	0.0	1.6	0.0	90	0.03	0.07	1.0	1.0	0.07	0.11	14.69	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	14.45	14.45	36	16.0	2.3	102	115	0.0005	0.06	0	0.00	0.02	24.5	16.7	0.0	2.8	0.0	90	0.08	0.15	1.0	0.5	0.07	0.13	14.58	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	14.73	14.73	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.73	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	14.69	14.69	18	3.1	1.8	67	14	0.0008	0.01	0	0.00	0.01	0.0	4.9	0.0	1.7	0.0	67	0.03	0.05	1.0	0.5	0.03	0.04	14.73	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	14.89	14.89	18	2.8	1.6	83	17	0.0006	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.01	14.90	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	14.73	14.73	18	2.9	1.7	67	17	0.0007	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	14.74	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	15.30	15.30	8	0.7	2.1	47	39	0.0026	0.10	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.12	15.42	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	15.20	15.20	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	1.5	0.0	0.0	2.1	0.0	47	0.03	0.06	1.3	1.0	0.08	0.10	15.30	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	15.16	15.16	18	2.6	1.5	0	42	0.0005	0.02	0	0.00	0.01	2.2	0.8	0.0	1.3	0.0	90	0.02	0.04	1.0	0.5	0.02	0.04	15.20	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.84	14.84	18	7.3	4.1	0	66	0.0041	0.27	0	0.00	0.07	3.8	2.7	3.9	1.5	0.0	90	0.02	0.10	1.0	0.5	0.05	0.33	15.16	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	14.45	14.45	18	8.3	4.7	78	56	0.0054	0.30	0	0.00	0.09	30.4	0.1	0.2	4.1	0.1	0	0.00	0.18	1.0	0.5	0.09	0.39	14.84	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	15.20	15.20	15	1.0	0.8	90	31	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.21	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	15.16	15.16	18	2.2	1.2	90	56	0.0004	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.02	15.19	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	15.16	15.16	18	2.6	1.5	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	15.20	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.84	14.84	18	0.5	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.84	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.84	14.84	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.84	10.95	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) Storm Frequency: 10 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
RELOCATED INLET IN SMR																										
P4	**DI19**	**MH1**	CP-1	2405	0	2405	0.06	0.95	0.05	0.05	6.0	0.00	6.16	0.3	15	27.3	0.012	0.000021	0.005	4.1	5.0	2.0	0.23	6.23	4.49	4.35	Q ok
P5	MH1	MH2	CP-1	1	0	1	0.00	0.95	0.00	0.05	6.0	6.23	6.11	0.3	18	82.7	0.012	0.000008	0.005	4.5	8.0	2.2	0.62	6.85	4.25	3.84	Q ok
P7	MH2	MH3	CP-1	1	0	1	0.00	0.95	0.00	0.05	6.0	6.85	5.96	0.3	18	73.8	0.012	0.000008	0.005	4.6	8.1	2.2	0.55	7.40	3.81	3.44	Q ok
P10	MH3	MH4	CP-2	1	0	1	0.00	0.95	0.00	0.25	6.0	7.40	5.80	1.4	18	53.7	0.012	0.000161	0.005	4.6	8.1	3.4	0.26	7.66	3.34	3.07	Q ok
P13	MH4	MH5	CP-2	1	0	1	0.00	0.95	0.00	0.56	6.0	7.66	5.72	3.2	18	59.3	0.012	0.000805	0.005	4.3	7.7	4.0	0.25	7.91	2.97	2.70	Q ok
P15	MH5	MH41	CP-2	1	0	1	0.00	0.95	0.00	0.89	6.0	7.91	5.67	5.1	*24*	**50.0**	0.012	0.000425	0.020	11.0	34.7	7.7	0.11	8.01	2.60	1.60	Q ok
P9	DI3	MH3	CP-1	4110	3259	7369	0.17	0.61	0.10	0.10	6.0	0.00	6.16	0.6	15	18.3	0.012	0.000082	0.005	4.0	4.9	2.8	0.11	6.11	3.68	3.59	Q ok
P8	DI17	MH3	CP-1	3878	2100	5978	0.14	0.68	0.09	0.09	6.0	0.00	6.16	0.6	15	31.3	0.012	0.000067	0.005	4.2	5.2	2.5	0.21	6.21	3.71	3.54	Q ok
P12	DI4	MH4	CP-1	7109	2561	9670	0.22	0.75	0.17	0.17	6.0	0.00	6.73	1.1	15	20.1	0.012	0.000254	0.005	4.0	4.9	3.3	0.10	6.10	3.48	3.38	Q ok
P11	DI18	MH4	CP-1	6435	2210	8645	0.20	0.75	0.15	0.15	6.0	0.00	6.70	1.0	15	28.4	0.012	0.000205	0.005	4.1	5.1	3.1	0.15	6.15	3.48	3.33	Q ok
P14	DI5	MH5	CP-1	4974	2549	7523	0.17	0.69	0.12	0.12	6.0	0.00	6.16	0.7	15	22.6	0.012	0.000110	0.005	4.0	4.9	2.8	0.13	6.13	3.68	3.57	Q ok
P18	DI6	MH6	CP-1	6937	1863	8800	0.20	0.79	0.16	0.16	6.0	0.00	6.16	1.0	15	38.0	0.012	0.000196	0.005	4.0	4.9	3.0	0.21	6.21	4.57	4.38	Q ok
P16	MH6	MH5	CP-2	1	0	1	0.00	0.95	0.00	0.21	6.0	6.21	6.11	1.3	18	40.0	0.012	0.000125	0.011	6.8	12.1	4.1	0.16	6.37	3.77	3.32	Q ok
RELOCATED INLET IN SMR																											
P17	**DI49**	**MH6**	CP-2	2236	105	2341	0.05	0.92	0.05	0.05	6.0	0.00	6.16	0.3	15	33.0	0.012	0.000019	0.005	4.0	4.9	2.0	0.28	6.28	4.19	4.02	Q ok
P32	DI23	MH12	CP-2	5495	1914	7409	0.17	0.75	0.13	0.13	6.0	0.00	6.16	0.8	15	33.31	0.012	0.0001	0.005	4.1	5.0	2.9	0.19	6.19	3.98	3.81	Q ok
P31	DI9	MH12	CP-2	4483	551	5034	0.12	0.87	0.10	0.10	6.0	0.00	6.16	0.6	15	18.3	0.012	0.0001	0.005	4.0	4.9	2.8	0.11	6.11	3.86	3.77	Q ok
P30	MH12	MH11	CP-2	1	0	1	0.00	0.95	0.00	0.23	6.0	6.19	6.11	1.4	18	50.1	0.012	0.0001	0.005	4.5	8.0	3.2	0.26	6.46	3.67	3.42	Q ok
P27	MH11	MH10	CP-2	1	0	1	0.00	0.95	0.00	0.47	6.0	6.46	6.03	2.8	18	73.2	0.012	0.0006	0.005	4.6	8.1	4.1	0.30	6.75	3.39	3.02	Q ok
P25	MH10	MH9	CP-2	1	0	1	0.00	0.95	0.00	0.54	6.0	6.75	5.96	3.2	24	69.68	0.012	0.0002	0.006	6.3	19.7	4.4	0.26	7.02	2.92	2.47	Q ok
P22	MH9	MH8	CP-2	1	0	1	0.00	0.95	0.00	0.68	6.0	7.02	5.90	4.0	24	108.3	0.012	0.0003	0.005	5.5	17.3	4.5	0.40	7.42	2.47	1.93	Q ok
P-80	DI-80	MH-08		9967	0	9967	0.23	0.95	0.22	0.22	6.0	0.00	6.16	1.3	15	49	0.012	0.0004	0.009	5.5	6.8	4.1	0.20	6.20	4.53	4.07	Q ok
P28	DI22	MH11	CP-1	5555	1955	7510	0.17	0.75	0.13	0.13	6.0	0.00	6.16	0.8	15	30.3	0.012	0.0001	0.005	4.0	4.9	2.8	0.18	6.18	3.64	3.49	Q ok
P29	DI8	MH11	CP-1	5120	570	5690	0.13	0.87	0.11	0.11	6.0	0.00	6.16	0.7	15	18.3	0.012	0.0001	0.005	4.0	4.9	2.8	0.11	6.11	3.64	3.55	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) Storm Frequency: 10 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P26	DI21	MH10	CP-1	2755	930	3685	0.08	0.76	0.06	0.06	6.0	0.00	6.16	0.4	15	18.3	0.012	0.0000	0.005	4.0	4.9	2.4	0.13	6.13	4.02	3.93	Q ok
P23	DI20	MH9	CP-2	3213	1102	4315	0.10	0.75	0.07	0.07	6.0	0.00	6.16	0.5	15	29.3	0.012	0.0000	0.005	4.0	4.9	2.4	0.20	6.20	4.53	4.38	Q ok
P24	DI7	MH9	CP-2	3164	527	3691	0.08	0.84	0.07	0.07	6.0	0.00	6.16	0.4	15	28.02	0.012	0.0000	0.005	4.0	4.9	2.4	0.19	6.19	4.38	4.24	Q ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	5.21	5.35	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	7.41	
P5	MH1	MH2	1.20	5.21	5.21	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	5.21	7.93	HGL ok
P7	MH2	MH3	1.20	5.21	5.21	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.21	7.65	HGL ok
P10	MH3	MH4	1.20	5.20	5.20	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	5.21	7.28	HGL ok
P13	MH4	MH5	1.20	5.14	5.14	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	5.20	7.09	HGL ok
P15	MH5	MH41	1.60	5.09	5.09	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	5.14	7.40	HGL ok
P9	DI3	MH3	1.00	5.21	5.21	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.21	6.62	HGL ok
P8	DI17	MH3	1.00	5.21	5.21	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.22	6.96	HGL ok
P12	DI4	MH4	1.00	5.20	5.20	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.21	6.48	HGL ok
P11	DI18	MH4	1.00	5.20	5.20	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.21	6.56	HGL ok
P14	DI5	MH5	1.00	5.14	5.14	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.15	6.61	HGL ok
P18	DI6	MH6	1.00	5.15	5.38	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.39	7.13	HGL ok
P16	MH6	MH5	1.20	5.14	5.14	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	5.15	7.55	HGL ok
P17	DI49	MH6	1.00	5.15	5.15	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.15	7.08	HGL ok
P32	DI23	MH12	1.00	5.18	5.18	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.19	7.11	HGL ok
P31	DI9	MH12	1.00	5.18	5.18	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.18	7.13	HGL ok
P30	MH12	MH11	1.60	5.17	5.17	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	5.18	7.48	HGL ok
P27	MH11	MH10	1.60	5.12	5.12	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	5.17	7.21	HGL ok
P25	MH10	MH9	1.60	5.11	5.11	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	5.12	7.54	HGL ok
P22	MH9	MH8	1.60	5.07	5.07	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	5.11	7.85	HGL ok
P-80	DI-80	MH-08	1.00	5.07	5.07	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	5.09	7.34	HGL ok
P28	DI22	MH11	1.00	5.17	5.17	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.18	6.74	HGL ok
P29	DI8	MH11	1.00	5.17	5.17	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.17	6.92	HGL ok
P26	DI21	MH10	1.00	5.12	5.12	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.12	7.23	HGL ok
P23	DI20	MH9	1.00	5.11	5.38	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	5.39	7.38	HGL ok
P24	DI7	MH9	1.00	5.11	5.24	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.24	7.48	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	5.41	5.41	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.42	7.41	
P5	MH1	MH2	1.20	5.41	5.41	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	5.41	7.93	HGL ok
P7	MH2	MH3	1.20	5.41	5.41	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	5.41	7.65	HGL ok
P10	MH3	MH4	1.20	5.40	5.40	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	5.41	7.28	HGL ok
P13	MH4	MH5	1.20	5.34	5.34	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	5.40	7.09	HGL ok
P15	MH5	MH41	1.60	5.29	5.29	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	5.34	7.40	HGL ok
P9	DI3	MH3	1.00	5.41	5.41	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.41	6.62	HGL ok
P8	DI17	MH3	1.00	5.41	5.41	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.42	6.96	HGL ok
P12	DI4	MH4	1.00	5.40	5.40	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.41	6.48	HGL ok
P11	DI18	MH4	1.00	5.40	5.40	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.41	6.56	HGL ok
P14	DI5	MH5	1.00	5.34	5.34	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	6.61	HGL ok
P18	DI6	MH6	1.00	5.35	5.38	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.39	7.13	HGL ok
P16	MH6	MH5	1.20	5.34	5.34	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	5.35	7.55	HGL ok
P17	DI49	MH6	1.00	5.35	5.35	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.35	7.08	HGL ok
P32	DI23	MH12	1.00	5.38	5.38	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.39	7.11	HGL ok
P31	DI9	MH12	1.00	5.38	5.38	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.38	7.13	HGL ok
P30	MH12	MH11	1.60	5.37	5.37	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	5.38	7.48	HGL ok
P27	MH11	MH10	1.60	5.32	5.32	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	5.37	7.21	HGL ok
P25	MH10	MH9	1.60	5.31	5.31	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	5.32	7.54	HGL ok
P22	MH9	MH8	1.60	5.27	5.27	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	5.31	7.85	HGL ok
P-80	DI-80	MH-08	1.00	5.27	5.27	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	5.29	7.34	HGL ok
P28	DI22	MH11	1.00	5.37	5.37	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.38	6.74	HGL ok
P29	DI8	MH11	1.00	5.37	5.37	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.37	6.92	HGL ok
P26	DI21	MH10	1.00	5.32	5.32	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.32	7.23	HGL ok
P23	DI20	MH9	1.00	5.31	5.38	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	5.39	7.38	HGL ok
P24	DI7	MH9	1.00	5.31	5.31	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.31	7.48	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	8.91	8.91	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.92	7.41	
P5	MH1	MH2	1.20	8.91	8.91	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	8.91	7.93	HGL Too High!
P7	MH2	MH3	1.20	8.91	8.91	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.91	7.65	HGL Too High!
P10	MH3	MH4	1.20	8.90	8.90	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	8.91	7.28	HGL Too High!
P13	MH4	MH5	1.20	8.84	8.84	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	8.90	7.09	HGL Too High!
P15	MH5	MH41	1.60	8.79	8.79	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	8.84	7.40	HGL Too High!
P9	DI3	MH3	1.00	8.91	8.91	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.91	6.62	HGL Too High!
P8	DI17	MH3	1.00	8.91	8.91	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.92	6.96	HGL Too High!
P12	DI4	MH4	1.00	8.90	8.90	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.91	6.48	HGL Too High!
P11	DI18	MH4	1.00	8.90	8.90	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.91	6.56	HGL Too High!
P14	DI5	MH5	1.00	8.84	8.84	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.85	6.61	HGL Too High!
P18	DI6	MH6	1.00	8.85	8.85	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.86	7.13	HGL Too High!
P16	MH6	MH5	1.20	8.84	8.84	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	8.85	7.55	HGL Too High!
P17	DI49	MH6	1.00	8.85	8.85	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.85	7.08	HGL Too High!
P32	DI23	MH12	1.00	8.88	8.88	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.89	7.11	HGL Too High!
P31	DI9	MH12	1.00	8.88	8.88	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.88	7.13	HGL Too High!
P30	MH12	MH11	1.60	8.87	8.87	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	8.88	7.48	HGL Too High!
P27	MH11	MH10	1.60	8.82	8.82	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	8.87	7.21	HGL Too High!
P25	MH10	MH9	1.60	8.81	8.81	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	8.82	7.54	HGL Too High!
P22	MH9	MH8	1.60	8.77	8.77	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	8.81	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	8.77	8.77	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	8.79	7.34	HGL Too High!
P28	DI22	MH11	1.00	8.87	8.87	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.88	6.74	HGL Too High!
P29	DI8	MH11	1.00	8.87	8.87	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.87	6.92	HGL Too High!
P26	DI21	MH10	1.00	8.82	8.82	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.82	7.23	HGL Too High!
P23	DI20	MH9	1.00	8.81	8.81	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	8.81	7.38	HGL Too High!
P24	DI7	MH9	1.00	8.81	8.81	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.81	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.41	9.41	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.42	7.41	
P5	MH1	MH2	1.20	9.41	9.41	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.41	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.41	9.41	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.41	7.65	HGL Too High!
P10	MH3	MH4	1.20	9.40	9.40	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	9.41	7.28	HGL Too High!
P13	MH4	MH5	1.20	9.34	9.34	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	9.40	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.29	9.29	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	9.34	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.41	9.41	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.41	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.41	9.41	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.42	6.96	HGL Too High!
P12	DI4	MH4	1.00	9.40	9.40	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.41	6.48	HGL Too High!
P11	DI18	MH4	1.00	9.40	9.40	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.41	6.56	HGL Too High!
P14	DI5	MH5	1.00	9.34	9.34	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.35	6.61	HGL Too High!
P18	DI6	MH6	1.00	9.35	9.35	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.36	7.13	HGL Too High!
P16	MH6	MH5	1.20	9.34	9.34	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	9.35	7.55	HGL Too High!
P17	DI49	MH6	1.00	9.35	9.35	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.35	7.08	HGL Too High!
P32	DI23	MH12	1.00	9.38	9.38	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.39	7.11	HGL Too High!
P31	DI9	MH12	1.00	9.38	9.38	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.38	7.13	HGL Too High!
P30	MH12	MH11	1.60	9.37	9.37	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	9.38	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.32	9.32	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	9.37	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.31	9.31	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	9.32	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.27	9.27	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	9.31	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.27	9.27	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	9.29	7.34	HGL Too High!
P28	DI22	MH11	1.00	9.37	9.37	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.38	6.74	HGL Too High!
P29	DI8	MH11	1.00	9.37	9.37	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.37	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.32	9.32	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.32	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.31	9.31	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.31	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.31	9.31	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.31	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.81	9.81	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	7.41	
P5	MH1	MH2	1.20	9.81	9.81	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.81	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.81	9.81	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.81	7.65	HGL Too High!
P10	MH3	MH4	1.20	9.80	9.80	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	9.81	7.28	HGL Too High!
P13	MH4	MH5	1.20	9.74	9.74	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	9.80	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.69	9.69	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	9.74	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.81	9.81	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.81	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.81	9.81	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	6.96	HGL Too High!
P12	DI4	MH4	1.00	9.80	9.80	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.81	6.48	HGL Too High!
P11	DI18	MH4	1.00	9.80	9.80	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.81	6.56	HGL Too High!
P14	DI5	MH5	1.00	9.74	9.74	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.75	6.61	HGL Too High!
P18	DI6	MH6	1.00	9.75	9.75	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.76	7.13	HGL Too High!
P16	MH6	MH5	1.20	9.74	9.74	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	9.75	7.55	HGL Too High!
P17	DI49	MH6	1.00	9.75	9.75	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.75	7.08	HGL Too High!
P32	DI23	MH12	1.00	9.78	9.78	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.79	7.11	HGL Too High!
P31	DI9	MH12	1.00	9.78	9.78	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.78	7.13	HGL Too High!
P30	MH12	MH11	1.60	9.77	9.77	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	9.78	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.72	9.72	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	9.77	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.71	9.71	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	9.72	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.67	9.67	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	9.71	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.67	9.67	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	9.69	7.34	HGL Too High!
P28	DI22	MH11	1.00	9.77	9.77	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.78	6.74	HGL Too High!
P29	DI8	MH11	1.00	9.77	9.77	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.77	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.72	9.72	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.72	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.71	9.71	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.71	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.71	9.71	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.71	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.31	10.31	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	7.41	
P5	MH1	MH2	1.20	10.31	10.31	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.31	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.31	10.31	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.31	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.30	10.30	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	10.31	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.24	10.24	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	10.30	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.19	10.19	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	10.24	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.31	10.31	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.31	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.31	10.31	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.30	10.30	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.31	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.30	10.30	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.31	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.24	10.24	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.25	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.25	10.25	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.26	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.24	10.24	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	10.25	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.25	10.25	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.25	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.28	10.28	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.29	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.28	10.28	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.28	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.27	10.27	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	10.28	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.22	10.22	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	10.27	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.21	10.21	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	10.22	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.17	10.17	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	10.21	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.17	10.17	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	10.19	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.27	10.27	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.28	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.27	10.27	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.27	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.22	10.22	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.22	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.21	10.21	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.21	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.21	10.21	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.21	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.01	11.01	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.02	7.41	
P5	MH1	MH2	1.20	11.01	11.01	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.01	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.01	11.01	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.01	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.00	11.00	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	11.01	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.94	10.94	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	11.00	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.89	10.89	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	10.94	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.01	11.01	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.01	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.01	11.01	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.02	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.00	11.00	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.01	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.00	11.00	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.01	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.94	10.94	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.95	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.95	10.95	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.96	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.94	10.94	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	10.95	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.95	10.95	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.95	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.98	10.98	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.99	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.98	10.98	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.98	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.97	10.97	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	10.98	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.92	10.92	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	10.97	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.91	10.91	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	10.92	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.87	10.87	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	10.91	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.87	10.87	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	10.89	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.97	10.97	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.98	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.97	10.97	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.97	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.92	10.92	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.92	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.91	10.91	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.91	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.91	10.91	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.91	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.51	11.51	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.52	7.41	
P5	MH1	MH2	1.20	11.51	11.51	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.51	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.51	11.51	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.51	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.50	11.50	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	11.51	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.44	11.44	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	11.50	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.39	11.39	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	11.44	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.51	11.51	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.51	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.51	11.51	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.52	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.50	11.50	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.51	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.50	11.50	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.51	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.44	11.44	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.45	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.45	11.45	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.46	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.44	11.44	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	11.45	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.45	11.45	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.45	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.48	11.48	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.49	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.48	11.48	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.48	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.47	11.47	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	11.48	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.42	11.42	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	11.47	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.41	11.41	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	11.42	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.37	11.37	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	11.41	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.37	11.37	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	11.39	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.47	11.47	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.48	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.47	11.47	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.47	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.42	11.42	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.42	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.41	11.41	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.41	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.41	11.41	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.41	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.81	12.81	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.82	7.41	
P5	MH1	MH2	1.20	12.81	12.81	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.81	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.81	12.81	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.81	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.80	12.80	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	12.81	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.74	12.74	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	12.80	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.69	12.69	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	12.74	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.81	12.81	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.81	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.81	12.81	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.82	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.80	12.80	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.81	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.80	12.80	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.81	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.74	12.74	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.75	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.75	12.75	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.76	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.74	12.74	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	12.75	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.75	12.75	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.75	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.78	12.78	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.79	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.78	12.78	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.78	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.77	12.77	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	12.78	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.72	12.72	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	12.77	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.71	12.71	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	12.72	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.67	12.67	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	12.71	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.67	12.67	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	12.69	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.77	12.77	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.78	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.77	12.77	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.77	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.72	12.72	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.72	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.71	12.71	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.71	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.71	12.71	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.71	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	7.75	7.75	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.76	7.41	
P5	MH1	MH2	1.20	7.75	7.75	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	7.75	7.93	HGL Too High!
P7	MH2	MH3	1.20	7.75	7.75	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.75	7.65	HGL Too High!
P10	MH3	MH4	1.20	7.74	7.74	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	7.75	7.28	HGL Too High!
P13	MH4	MH5	1.20	7.68	7.68	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	7.74	7.09	HGL Too High!
P15	MH5	MH41	1.60	7.63	7.63	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	7.68	7.40	HGL Too High!
P9	DI3	MH3	1.00	7.75	7.75	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.75	6.62	HGL Too High!
P8	DI17	MH3	1.00	7.75	7.75	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.76	6.96	HGL Too High!
P12	DI4	MH4	1.00	7.74	7.74	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.75	6.48	HGL Too High!
P11	DI18	MH4	1.00	7.74	7.74	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.75	6.56	HGL Too High!
P14	DI5	MH5	1.00	7.68	7.68	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.69	6.61	HGL Too High!
P18	DI6	MH6	1.00	7.69	7.69	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.70	7.13	HGL Too High!
P16	MH6	MH5	1.20	7.68	7.68	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	7.69	7.55	HGL Too High!
P17	DI49	MH6	1.00	7.69	7.69	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.69	7.08	HGL Too High!
P32	DI23	MH12	1.00	7.72	7.72	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.73	7.11	HGL Too High!
P31	DI9	MH12	1.00	7.72	7.72	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.72	7.13	HGL Too High!
P30	MH12	MH11	1.60	7.71	7.71	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	7.72	7.48	HGL Too High!
P27	MH11	MH10	1.60	7.66	7.66	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	7.71	7.21	HGL Too High!
P25	MH10	MH9	1.60	7.65	7.65	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	7.66	7.54	HGL Too High!
P22	MH9	MH8	1.60	7.61	7.61	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	7.65	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	7.61	7.61	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	7.63	7.34	HGL Too High!
P28	DI22	MH11	1.00	7.71	7.71	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.72	6.74	HGL Too High!
P29	DI8	MH11	1.00	7.71	7.71	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.71	6.92	HGL Too High!
P26	DI21	MH10	1.00	7.66	7.66	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.66	7.23	HGL Too High!
P23	DI20	MH9	1.00	7.65	7.65	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	7.65	7.38	HGL Too High!
P24	DI7	MH9	1.00	7.65	7.65	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.65	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	7.95	7.95	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.96	7.41	
P5	MH1	MH2	1.20	7.95	7.95	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	7.95	7.93	HGL Too High!
P7	MH2	MH3	1.20	7.95	7.95	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.95	7.65	HGL Too High!
P10	MH3	MH4	1.20	7.94	7.94	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	7.95	7.28	HGL Too High!
P13	MH4	MH5	1.20	7.88	7.88	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	7.94	7.09	HGL Too High!
P15	MH5	MH41	1.60	7.83	7.83	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	7.88	7.40	HGL Too High!
P9	DI3	MH3	1.00	7.95	7.95	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.95	6.62	HGL Too High!
P8	DI17	MH3	1.00	7.95	7.95	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.96	6.96	HGL Too High!
P12	DI4	MH4	1.00	7.94	7.94	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.95	6.48	HGL Too High!
P11	DI18	MH4	1.00	7.94	7.94	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.95	6.56	HGL Too High!
P14	DI5	MH5	1.00	7.88	7.88	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.89	6.61	HGL Too High!
P18	DI6	MH6	1.00	7.89	7.89	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.90	7.13	HGL Too High!
P16	MH6	MH5	1.20	7.88	7.88	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	7.89	7.55	HGL Too High!
P17	DI49	MH6	1.00	7.89	7.89	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.89	7.08	HGL Too High!
P32	DI23	MH12	1.00	7.92	7.92	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.93	7.11	HGL Too High!
P31	DI9	MH12	1.00	7.92	7.92	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.92	7.13	HGL Too High!
P30	MH12	MH11	1.60	7.91	7.91	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	7.92	7.48	HGL Too High!
P27	MH11	MH10	1.60	7.86	7.86	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	7.91	7.21	HGL Too High!
P25	MH10	MH9	1.60	7.85	7.85	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	7.86	7.54	HGL Too High!
P22	MH9	MH8	1.60	7.81	7.81	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	7.85	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	7.81	7.81	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	7.83	7.34	HGL Too High!
P28	DI22	MH11	1.00	7.91	7.91	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.92	6.74	HGL Too High!
P29	DI8	MH11	1.00	7.91	7.91	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.91	6.92	HGL Too High!
P26	DI21	MH10	1.00	7.86	7.86	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.86	7.23	HGL Too High!
P23	DI20	MH9	1.00	7.85	7.85	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	7.85	7.38	HGL Too High!
P24	DI7	MH9	1.00	7.85	7.85	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.85	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.45	11.45	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.46	7.41	
P5	MH1	MH2	1.20	11.45	11.45	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.45	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.45	11.45	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.45	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.44	11.44	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	11.45	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.38	11.38	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	11.44	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.33	11.33	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	11.38	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.45	11.45	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.45	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.45	11.45	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.46	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.44	11.44	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.45	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.44	11.44	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.45	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.38	11.38	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.39	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.39	11.39	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.40	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.38	11.38	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	11.39	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.39	11.39	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.39	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.42	11.42	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.43	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.42	11.42	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.42	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.41	11.41	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	11.42	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.36	11.36	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	11.41	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.35	11.35	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	11.36	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.31	11.31	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	11.35	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.31	11.31	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	11.33	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.41	11.41	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.42	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.41	11.41	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.41	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.36	11.36	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.36	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.35	11.35	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.35	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.35	11.35	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.35	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.95	11.95	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.96	7.41	
P5	MH1	MH2	1.20	11.95	11.95	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.95	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.95	11.95	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.95	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.94	11.94	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	11.95	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.88	11.88	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	11.94	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.83	11.83	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	11.88	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.95	11.95	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.95	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.95	11.95	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.96	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.94	11.94	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.95	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.94	11.94	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.95	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.88	11.88	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.89	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.89	11.89	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.90	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.88	11.88	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	11.89	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.89	11.89	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.89	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.92	11.92	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.93	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.92	11.92	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.92	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.91	11.91	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	11.92	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.86	11.86	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	11.91	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.85	11.85	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	11.86	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.81	11.81	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	11.85	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.81	11.81	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	11.83	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.91	11.91	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.92	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.91	11.91	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.91	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.86	11.86	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.86	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.85	11.85	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.85	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.85	11.85	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.85	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.35	12.35	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	7.41	
P5	MH1	MH2	1.20	12.35	12.35	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.35	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.35	12.35	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.35	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.34	12.34	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	12.35	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.28	12.28	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	12.34	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.23	12.23	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	12.28	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.35	12.35	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.35	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.35	12.35	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.34	12.34	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.35	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.34	12.34	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.35	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.28	12.28	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.29	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.29	12.29	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.30	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.28	12.28	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	12.29	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.29	12.29	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.29	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.32	12.32	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.33	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.32	12.32	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.32	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.31	12.31	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	12.32	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.26	12.26	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	12.31	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.25	12.25	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	12.26	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.21	12.21	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	12.25	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.21	12.21	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	12.23	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.31	12.31	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.32	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.31	12.31	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.31	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.26	12.26	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.26	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.25	12.25	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.25	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.25	12.25	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.25	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.85	12.85	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.86	7.41	
P5	MH1	MH2	1.20	12.85	12.85	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.85	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.85	12.85	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.85	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.84	12.84	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	12.85	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.78	12.78	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	12.84	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.73	12.73	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	12.78	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.85	12.85	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.85	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.85	12.85	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.86	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.84	12.84	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.85	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.84	12.84	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.85	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.78	12.78	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.79	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.79	12.79	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.80	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.78	12.78	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	12.79	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.79	12.79	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.79	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.82	12.82	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.83	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.82	12.82	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.82	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.81	12.81	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	12.82	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.76	12.76	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	12.81	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.75	12.75	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	12.76	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.71	12.71	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	12.75	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.71	12.71	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	12.73	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.81	12.81	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.82	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.81	12.81	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.81	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.76	12.76	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.76	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.75	12.75	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.75	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.75	12.75	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.75	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.55	13.55	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.56	7.41	
P5	MH1	MH2	1.20	13.55	13.55	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.55	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.55	13.55	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.55	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.54	13.54	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	13.55	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.48	13.48	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	13.54	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.43	13.43	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	13.48	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.55	13.55	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.55	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.55	13.55	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.56	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.54	13.54	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.55	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.54	13.54	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.55	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.48	13.48	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.49	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.49	13.49	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.50	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.48	13.48	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	13.49	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.49	13.49	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.49	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.52	13.52	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.53	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.52	13.52	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.52	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.51	13.51	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	13.52	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.46	13.46	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	13.51	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.45	13.45	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	13.46	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.41	13.41	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	13.45	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.41	13.41	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	13.43	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.51	13.51	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.52	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.51	13.51	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.51	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.46	13.46	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.46	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.45	13.45	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.45	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.45	13.45	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.45	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	14.05	14.05	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.06	7.41	
P5	MH1	MH2	1.20	14.05	14.05	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	14.05	7.93	HGL Too High!
P7	MH2	MH3	1.20	14.05	14.05	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	14.05	7.65	HGL Too High!
P10	MH3	MH4	1.20	14.04	14.04	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	14.05	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.98	13.98	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	14.04	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.93	13.93	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	13.98	7.40	HGL Too High!
P9	DI3	MH3	1.00	14.05	14.05	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.05	6.62	HGL Too High!
P8	DI17	MH3	1.00	14.05	14.05	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.06	6.96	HGL Too High!
P12	DI4	MH4	1.00	14.04	14.04	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.05	6.48	HGL Too High!
P11	DI18	MH4	1.00	14.04	14.04	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.05	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.98	13.98	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.99	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.99	13.99	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.00	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.98	13.98	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	13.99	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.99	13.99	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.99	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.02	14.02	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.03	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.02	14.02	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.02	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.01	14.01	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	14.02	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.96	13.96	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	14.01	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.95	13.95	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	13.96	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.91	13.91	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	13.95	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.91	13.91	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	13.93	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.01	14.01	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.02	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.01	14.01	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.01	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.96	13.96	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.96	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.95	13.95	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.95	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.95	13.95	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.95	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 10 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	15.35	15.35	15	0.3	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.36	7.41	
P5	MH1	MH2	1.20	15.35	15.35	18	0.3	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	15.35	7.93	HGL Too High!
P7	MH2	MH3	1.20	15.35	15.35	18	0.3	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	15.35	7.65	HGL Too High!
P10	MH3	MH4	1.20	15.34	15.34	18	1.4	0.8	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.3	0.3	0.5	0.0	87	0.00	0.01	1.0	0.5	0.00	0.01	15.35	7.28	HGL Too High!
P13	MH4	MH5	1.20	15.28	15.28	18	3.2	1.8	84	59.3	0.0008	0.05	0	0.00	0.01	1.2	1.0	0.8	0.8	0.0	8	0.00	0.02	1.0	0.5	0.01	0.06	15.34	7.09	HGL Too High!
P15	MH5	MH41	1.60	15.23	15.23	24	5.1	1.6	90	50	0.0004	0.02	0	0.00	0.01	5.9	0.4	0.9	1.8	0.0	84	0.04	0.06	1.0	0.5	0.03	0.05	15.28	7.40	HGL Too High!
P9	DI3	MH3	1.00	15.35	15.35	15	0.6	0.5	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.35	6.62	HGL Too High!
P8	DI17	MH3	1.00	15.35	15.35	15	0.6	0.5	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.36	6.96	HGL Too High!
P12	DI4	MH4	1.00	15.34	15.34	15	1.1	0.9	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.35	6.48	HGL Too High!
P11	DI18	MH4	1.00	15.34	15.34	15	1.0	0.8	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.35	6.56	HGL Too High!
P14	DI5	MH5	1.00	15.28	15.28	15	0.7	0.6	21	22.6	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.29	6.61	HGL Too High!
P18	DI6	MH6	1.00	15.29	15.29	15	1.0	0.8	23	38	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.30	7.13	HGL Too High!
P16	MH6	MH5	1.20	15.28	15.28	18	1.3	0.7	86	40	0.0001	0.01	0	0.00	0.00	0.8	0.1	0.0	0.8	0.0	23	0.00	0.01	1.0	0.5	0.00	0.01	15.29	7.55	HGL Too High!
P17	DI49	MH6	1.00	15.29	15.29	15	0.3	0.2	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.29	7.08	HGL Too High!
P32	DI23	MH12	1.00	15.32	15.32	15	0.8	0.6	64	33.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.33	7.11	HGL Too High!
P31	DI9	MH12	1.00	15.32	15.32	15	0.6	0.5	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.32	7.13	HGL Too High!
P30	MH12	MH11	1.60	15.31	15.31	24	1.4	0.4	1	50.1	0.0001	0.01	0	0.00	0.00	0.3	0.5	0.0	0.6	0.0	64	0.00	0.01	1.0	0.5	0.00	0.01	15.32	7.48	HGL Too High!
P27	MH11	MH10	1.60	15.26	15.26	24	2.8	0.9	5	73.2	0.0006	0.05	0	0.00	0.00	0.6	0.5	0.4	0.4	0.0	1	0.00	0.00	1.0	0.5	0.00	0.05	15.31	7.21	HGL Too High!
P25	MH10	MH9	1.60	15.25	15.25	24	3.2	1.0	5	69.7	0.0002	0.01	0	0.00	0.00	2.6	0.1	0.0	0.9	0.0	5	0.00	0.01	1.0	0.5	0.00	0.02	15.26	7.54	HGL Too High!
P22	MH9	MH8	1.60	15.21	15.21	24	4.0	1.3	51	108	0.0003	0.03	0	0.00	0.01	3.2	0.2	0.2	1.0	0.0	5	0.00	0.01	1.0	0.5	0.01	0.04	15.25	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	15.21	15.21	15	1.3	1.1	35	49	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	26	0.00	0.00	1.0	1.0	0.00	0.02	15.23	7.34	HGL Too High!
P28	DI22	MH11	1.00	15.31	15.31	15	0.8	0.6	90	30.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.32	6.74	HGL Too High!
P29	DI8	MH11	1.00	15.31	15.31	15	0.7	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.31	6.92	HGL Too High!
P26	DI21	MH10	1.00	15.26	15.26	15	0.4	0.3	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.26	7.23	HGL Too High!
P23	DI20	MH9	1.00	15.25	15.25	15	0.5	0.4	85	29.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	15.25	7.38	HGL Too High!
P24	DI7	MH9	1.00	15.25	15.25	15	0.4	0.4	47	28	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.25	7.48	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 25 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-41	MH-41	MH-42	1	0	1	0.00	1.00	0.00	0.98	6.0	7.95	6.29	6.15	24	92	0.012	0.000629	0.0033	4.5	14.0	4.3	0.35	8.30	1.50	1.20	Q ok
P-42	MH-42	DI-43	1	0	1	0.00	1.00	0.00	1.96	6.0	8.30	6.17	12.07	30	30	0.012	0.000738	0.0030	5.0	24.3	4.9	0.10	8.41	1.10	1.01	Q ok
P-43	DI-43	DI-44	4208	31	4239	0.10	1.00	0.10	2.05	6.0	8.41	6.14	12.61	30	25	0.012	0.000805	0.0032	5.1	25.1	5.1	0.08	8.49	0.91	0.83	Q ok
P-44	DI-44	DI-45	4675	523	5198	0.12	0.96	0.11	2.17	6.0	8.49	6.12	13.25	30	69	0.012	0.000889	0.0030	5.0	24.5	5.1	0.23	8.71	0.73	0.52	Q ok
P-45	DI-45	MH-46	4490	535	5025	0.12	0.95	0.11	2.28	6.0	8.71	6.06	13.79	30	52	0.012	0.000964	0.0031	5.0	24.6	5.1	0.17	8.88	0.42	0.26	Q ok
P-46	MH-46	DI-47	1	0	1	0.00	1.00	0.00	3.01	6.0	8.88	6.00	18.07	30	42	0.012	0.001655	0.0031	5.0	24.7	5.6	0.13	9.01	0.16	0.03	Q ok
P-47	DI-47	MH-60	4551	287	4838	0.11	0.99	0.11	3.12	6.0	9.01	5.97	18.65	36	23	0.012	0.000666	0.0030	5.6	39.9	5.5	0.07	9.08	-0.07	-0.14	Q ok
P-60	MH-60	MH-61	1	0	1	0.00	1.00	0.00	4.32	6.0	9.08	5.94	25.69	36	75	0.012	0.001264	0.0039	6.4	44.9	6.5	0.19	9.27	-0.24	-0.53	Q ok
P-61	MH-61	DI-62	1	0	1	0.00	1.00	0.00	4.32	6.0	9.27	5.88	25.44	36	76	0.012	0.001240	0.0039	6.4	45.4	6.6	0.19	9.46	-0.63	-0.93	Q ok
P-62	DI-62	DI-63	1435	40	1475	0.03	1.00	0.03	4.36	6.0	9.46	5.83	25.39	36	50	0.012	0.001235	0.0040	6.5	45.7	6.6	0.13	9.59	-1.03	-1.23	Q ok
P-63	DI-63	DI-77	1999	107	2106	0.05	1.00	0.05	5.15	6.0	9.59	5.80	29.83	36	25	0.012	0.001705	0.0036	6.1	43.4	6.7	0.06	9.65	-1.33	-1.42	Q ok
P-77	DI-77	DI-85	2311	122	2433	0.06	1.00	0.06	6.34	6.0	9.65	5.77	36.55	48	50	0.012	0.000552	0.0030	6.8	85.2	6.6	0.13	9.78	-1.52	-1.67	Q ok
P-85	DI-85	MH-86	5006	304	5310	0.12	1.00	0.12	11.26	6.0	9.78	5.74	64.62	60	186	0.012	0.000525	0.0030	7.9	154.8	7.3	0.43	10.21	-1.77	-2.33	Q ok
P-86	MH-86	MH-87	1	0	1	0.00	1.00	0.00	11.92	6.0	10.21	5.64	67.29	60	45	0.012	0.000569	0.0031	8.0	157.4	7.8	0.10	10.30	-2.43	-2.57	Q ok
P-87	**MH-87**	**OUTFALL**	**1**	**0**	**1**	**0.00**	**1.00**	**0.00**	**12.69**	**6.0**	**10.30**	**5.63**	**71.41**	**60**	**9**	**0.012**	**0.000641**	**0.0033**	**8.3**	**162.9**	**8.0**	**0.02**	**10.32**	**-2.67**	**-2.70**	**Q ok**
P-48	MSS MH-08	MH-49	1	0	1	0.00	1.00	0.00	0.98	6.0	7.33	6.46	6.32	24	64	0.012	0.000665	0.0070	6.5	20.6	5.6	0.19	7.52	1.65	1.20	Q ok
P-50	B7 North	1.00	32048	0	32048	0.74	1.00	0.74	0.74	6.0	0.00	6.84	5.03	18	16	0.012	0.001956	0.0050	4.6	8.0	4.9	0.05	6.05	0.35	0.27	Q ok
P-65	B7 West	MH-64	32234	0	32234	0.74	1.00	0.74	0.74	6.0	0.00	6.84	5.06	18	17	0.012	0.001978	0.0047	4.4	7.8	4.7	0.06	6.06	-0.95	-1.03	Q ok
P-64	MH-64	DI-63	1	0	1	0.00	1.00	0.00	0.74	6.0	6.06	6.81	5.04	18	20	0.012	0.001962	0.0050	4.6	8.0	4.9	0.07	6.13	-1.13	-1.23	Q ok
P-51	DI-51	DI-52	3030	31	3061	0.07	1.00	0.07	0.07	6.0	0.00	6.84	0.48	15	26	0.012	0.000047	0.0050	4.0	4.9	2.4	0.18	6.18	3.70	3.57	Q ok
P-52	DI-52	DI-53	4699	521	5220	0.12	0.96	0.12	0.19	6.0	6.18	6.78	1.26	15	69	0.012	0.000323	0.0049	4.0	4.9	3.3	0.35	6.53	3.37	3.03	Q ok
P-53	DI-53	MH-54	4484	537	5021	0.12	0.95	0.11	0.30	6.0	6.53	6.70	1.98	15	51	0.012	0.000799	0.0051	4.1	5.0	3.7	0.23	6.76	2.83	2.57	Q ok
P-54	MH-54	DI-55	1	0	1	0.00	1.00	0.00	1.06	6.0	6.76	6.61	7.03	24	41	0.012	0.000823	0.0049	5.4	17.1	5.0	0.14	6.89	2.37	2.17	Q ok
P-55	DI-55	MH-60	5685	291	5976	0.14	1.00	0.14	1.20	6.0	6.89	6.58	7.90	24	23	0.012	0.001040	0.0052	5.6	17.7	5.5	0.07	6.96	1.97	1.85	Q ok
P-56	B5 South	MH-54	33482	0	33482	0.77	1.00	0.77	0.77	6.0	0.00	6.84	5.26	18	17	0.012	0.002135	0.0053	4.7	8.3	5.0	0.06	6.06	2.56	2.47	Q ok
P-78	DI-78	DI-79	3667	223	3890	0.09	1.00	0.09	0.09	6.0	0.00	6.84	0.61	15	84	0.012	0.000076	0.0200	8.1	9.9	4.0	0.35	6.35	7.12	5.44	Q ok
P-79	DI-79	DI-71	3253	204	3457	0.08	1.00	0.08	0.17	6.0	6.35	6.72	1.13	18	29	0.012	0.000098	0.0200	9.1	16.1	4.5	0.11	6.46	5.24	4.66	Q ok
P-71	DI-71	DI-72	3698	198	3896	0.09	1.00	0.09	0.35	6.0	6.46	6.70	2.34	18	42	0.012	0.000424	0.0200	9.1	16.1	6.4	0.11	6.57	4.46	3.62	Q ok
P-72	DI-72	DI-73	2021	16	2037	0.05	1.00	0.05	0.40	6.0	6.57	6.67	2.65	18	29	0.012	0.000540	0.0200	9.1	16.1	6.4	0.08	6.65	3.42	2.84	Q ok
P-73	DI-73	MH-74	1071	0	1071	0.02	1.00	0.02	0.42	6.0	6.65	6.67	2.81	18	17	0.012	0.000609	0.0200	9.1	16.1	6.4	0.04	6.69	2.64	2.30	Q ok
P-74	MH-74	DI-75	1	0	1	0.00	1.00	0.00	1.04	6.0	6.69	6.64	6.90	18	17	0.012	0.003678	0.0200	9.1	16.1	8.8	0.03	6.72	2.10	1.76	Q ok
P-75	DI-75	DI-76	2135	0	2135	0.05	1.00	0.05	1.09	6.0	6.72	6.64	7.23	18	43	0.012	0.004033	0.0200	9.1	16.1	8.8	0.08	6.81	1.56	0.70	Q ok
P-76	DI-76	DI-77	1993	48	2041	0.05	1.00	0.05	1.14	6.0	6.81	6.61	7.50	18	51	0.012	0.004349	0.0200	9.1	16.1	8.8	0.10	6.90	0.50	-0.52	Q ok
P-70	DI-70	DI-71	3812	274	4086	0.09	0.99	0.09	0.09	6.0	0.00	6.84	0.63	15	86	0.012	0.000082	0.0200	8.1	9.9	4.0	0.36	6.36	6.38	4.66	Q ok
P-80	DI-80	MH-74	22886	15258	38144	0.88	0.71	0.62	0.62	6.0	0.00	6.84	4.23	18	24	0.012	0.001382	0.0050	4.6	8.0	4.6	0.09	6.09	2.42	2.30	Q ok
P-90	DI-90	DI-91	6026	1962	7988	0.18	0.84	0.15	0.15	6.0	0.00	6.84	1.05	15	79	0.012	0.000225	0.0200	8.1	9.9	4.8	0.27	6.27	2.54	0.96	Q ok
P-91	DI-91	MH-87	6475	2667	9142	0.21	0.80	0.17	0.77	6.0	6.27	6.75	5.20	18	81	0.012	0.002089	0.0200	9.1	16.1	7.7	0.17	6.45	-0.04	-1.66	Q ok
P-92	B6 North	DI-91	19569	0	19569	0.45	1.00	0.45	0.45	6.0	0.00	6.84	3.07	18	63	0.012	0.000729	0.0049	4.5	8.0	4.2	0.25	6.25	0.47	0.16	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 25 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-95	TD-04	MH-86	21353	32030	53383	1.23	0.54	0.66	0.66	6.0	0.00	6.84	4.50	12	16	0.011	0.011420	0.0506	12.1	9.5	11.7	0.02	6.02	8.01	7.20	Q ok
P-38	DI-38	DI-39	1483	0	1483	0.03	1.00	0.03	0.03	6.0	0.00	6.84	0.23	15	99	0.012	0.000011	0.0200	8.1	9.9	4.0	0.42	6.42	2.75	0.77	Q ok
P-39	DI-39	DI-40	3833	220	4053	0.09	1.00	0.09	0.13	6.0	6.42	6.72	0.85	15	70	0.012	0.000149	0.0200	8.1	9.9	4.8	0.24	6.66	0.57	-0.83	Q ok
P-40	DI-40	DI-85	4668	293	4961	0.11	0.99	0.11	0.24	6.0	6.66	6.64	1.59	18	26	0.012	0.000196	0.0208	9.3	16.4	5.6	0.08	6.74	-1.03	-1.57	Q ok
P-35	MH-35	DI-36	1	0	1	0.00	1.00	0.00	4.43	6.0	7.46	6.41	28.35	**36**	94	0.012	0.001539	0.0050	7.2	51.1	7.4	0.21	7.68	-0.16	-0.63	Q ok
P-36	DI-36	DI-37	1851	0	1851	0.04	1.00	0.04	4.47	6.0	7.68	6.35	28.36	**36**	98	0.012	0.001540	0.0050	7.2	51.1	7.4	0.22	7.90	-0.73	-1.22	Q ok
P-37	DI-37	DI-85	3893	195	4088	0.09	1.00	0.09	4.56	6.0	7.90	6.29	28.69	36	70	0.012	0.001576	0.0050	7.2	51.1	7.4	0.16	8.06	-1.32	-1.67	Q ok
P-30	DI-30	MH-35	1403	0	1403	0.03	1.00	0.03	0.03	6.0	0.00	6.84	0.22	18	47	0.012	0.000004	0.0200	9.1	16.1	4.5	0.18	6.18	0.98	0.04	Q ok
P-11	DI-11	DI-12	4746	684	5430	0.12	0.94	0.12	0.12	6.0	0.00	6.84	0.80	15	20	0.012	0.000131	0.0065	4.6	5.6	3.2	0.10	6.10	2.91	2.78	Q ok
P-12	DI-12	DI-13	4957	1287	6244	0.14	0.87	0.12	0.24	6.0	6.10	6.81	1.65	15	92	0.012	0.000554	0.0065	4.6	5.7	3.9	0.39	6.50	2.68	2.08	Q ok
P-13	DI-13	MH-14	4947	1296	6243	0.14	0.87	0.12	0.37	6.0	6.50	6.70	2.45	15	54	0.012	0.001228	0.0065	4.6	5.6	4.5	0.20	6.70	1.98	1.63	Q ok
P-14	MH-14	DI-15	1	0	1	0.00	1.00	0.00	1.10	6.0	6.70	6.64	7.30	24	38	0.012	0.000886	0.0066	6.3	19.9	5.7	0.11	6.81	1.53	1.28	Q ok
P-15	DI-15	DI-16	3998	870	4868	0.11	0.89	0.10	1.20	6.0	6.81	6.61	7.92	24	73	0.012	0.001045	0.0064	6.3	19.7	5.8	0.21	7.02	1.18	0.71	Q ok
P-16	DI-16	MH-17	5113	501	5614	0.13	0.97	0.12	1.32	6.0	7.02	6.55	8.67	24	31	0.012	0.001252	0.0071	6.6	20.6	6.0	0.09	7.11	0.61	0.39	Q ok
P-18	B7 South	MH-14	31929	0	31929	0.73	1.00	0.73	0.73	6.0	0.00	6.84	5.01	18	17	0.012	0.001941	0.0053	4.7	8.3	4.9	0.06	6.06	1.72	1.63	Q ok
P-01	DI-01	DI-02	7520	1261	8781	0.20	0.92	0.19	0.19	6.0	0.00	6.84	1.27	15	77	0.012	0.000331	0.0065	4.6	5.6	3.8	0.34	6.34	2.91	2.41	Q ok
P-02	DI-02	DI-03	2113	487	2600	0.06	0.89	0.05	0.24	6.0	6.34	6.75	1.61	15	38	0.012	0.000532	0.0066	4.6	5.7	3.9	0.16	6.50	2.31	2.06	Q ok
P-03	DI-03	MH-04	4989	1312	6301	0.14	0.87	0.13	0.36	6.0	6.50	6.70	2.44	15	46	0.012	0.001217	0.0065	4.6	5.7	4.5	0.17	6.67	1.96	1.66	Q ok
P-04	MH-04	DI-05	1	0	1	0.00	1.00	0.00	0.84	6.0	6.67	6.64	5.56	18	46	0.012	0.002385	0.0065	5.2	9.2	5.5	0.14	6.81	1.56	1.26	Q ok
P-05	DI-05	DI-06	3831	995	4826	0.11	0.87	0.10	0.93	6.0	6.81	6.61	6.17	24	73	0.012	0.000634	0.0064	6.3	19.7	5.3	0.23	7.04	1.16	0.69	Q ok
P-06	DI-06	MH-17	5161	592	5753	0.13	0.96	0.13	1.60	6.0	7.04	6.55	10.46	24	30	0.012	0.001821	0.0067	6.4	20.0	6.3	0.08	7.12	0.59	0.39	Q ok
P-17	MH-17	MH-35	1	0	1	0.00	1.00	0.00	2.92	6.0	7.12	6.52	19.05	*36*	115	0.012	0.000695	0.0030	5.6	39.9	5.6	0.34	7.46	0.29	-0.06	Q ok
Check P-17 for Sanitary Crossing for Conflict																										Check P-1
P-08	DI-08	MH-07	1526	0	1526	0.04	1.00	0.04	0.04	6.0	0.00	6.84	0.24	15	58	0.012	0.000012	0.0066	4.6	5.7	2.3	0.43	6.43	1.36	0.98	Q ok
P-07	MH-07	DI-06	1	0	1	0.00	1.00	0.00	0.54	6.0	0.00	6.84	3.67	18	14	0.012	0.001040	0.0064	5.2	9.1	4.8	0.05	6.05	0.88	0.79	Q ok
P-09	B9/J	MH-04	20585	0	20585	0.47	1.00	0.47	0.47	6.0	0.00	6.84	3.23	18	17	0.012	0.000807	0.0053	4.7	8.3	4.3	0.07	6.07	1.75	1.66	Q ok
P-10	B9/J	MH-07	21845	0	21845	0.50	1.00	0.50	0.50	6.0	0.00	6.84	3.43	18	17	0.012	0.000909	0.0053	4.7	8.3	4.3	0.07	6.07	1.07	0.98	Q ok
P-20	TD-05	DI-21	5394	0	5394	0.12	1.00	0.12	0.12	6.0	0.00	6.84	0.85	8	39	0.011	0.003517	0.0500	9.1	3.2	7.5	0.09	6.09	8.50	6.55	Q ok
P-21	DI-21	MH-22	6185	3410	9595	0.22	0.74	0.16	0.29	6.0	6.09	6.81	1.96	15	31	0.012	0.000784	0.0200	8.1	9.9	6.0	0.09	6.17	4.54	3.92	Q ok
P-22	MH-22	MH-23	1	0	1	0.00	1.00	0.00	0.46	6.0	6.17	6.78	3.13	18	42	0.012	0.000756	0.0200	9.1	16.1	6.8	0.10	6.27	3.72	2.88	Q ok
P-23	MH-23	MH-24	1	0	1	0.00	1.00	0.00	1.28	6.0	6.27	6.75	8.66	18	66	0.012	0.005793	0.0200	9.1	16.1	9.3	0.12	6.39	2.68	1.36	Q ok
P-24	MH-24	MH-35	1	0	1	0.00	1.00	0.00	1.47	6.0	6.39	6.72	9.90	18	56	0.012	0.007569	0.0200	9.1	16.1	9.6	0.10	6.49	1.16	0.04	Q ok
P-25	DI-25	MH-22	6504	3883	10387	0.24	0.73	0.17	0.17	6.0	0.00	6.84	1.19	15	31	0.012	0.000288	0.0200	8.1	9.9	4.8	0.11	6.11	4.54	3.92	Q ok
P-26	B8/K	MH-23	16317	0	16317	0.37	1.00	0.37	0.37	6.0	0.00	6.84	2.56	18	56	0.012	0.000507	0.0050	4.6	8.0	3.9	0.24	6.24	3.06	2.78	Q ok
P-27	B6 South	MH-23	19451	0	19451	0.45	1.00	0.45	0.45	6.0	0.00	6.84	3.05	18	56	0.012	0.000720	0.0050	4.6	8.0	4.2	0.22	6.22	3.06	2.78	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 25 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-28	DI-28	MH-24	3596	533	4129	0.09	0.94	0.09	0.09	6.0	0.00	6.84	0.61	18	34	0.012	0.000028	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok
P-29	DI-29	MH-24	4110	551	4661	0.11	0.94	0.10	0.10	6.0	0.00	6.84	0.69	18	34	0.012	0.000037	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok

KEY

	Upsized from Semi-Final Design to have capacity for 50-yr design storm
	Optional Upsize-50-yr design storm results in >85% Full
	No Change from Semi-Final Design

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	5.84	5.84	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	5.94	7.00	HGL ok
P-42	MH-42	DI-43	2.00	5.78	5.78	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	5.84	7.86	HGL ok
P-43	DI-43	DI-44	2.00	5.69	5.69	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	5.78	7.11	HGL ok
P-44	DI-44	DI-45	2.00	5.56	5.56	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	5.69	7.03	HGL ok
P-45	DI-45	MH-46	2.00	5.43	5.43	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	5.56	7.59	HGL ok
P-46	MH-46	DI-47	2.00	5.30	5.30	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	5.43	8.54	HGL ok
P-47	DI-47	MH-60	2.40	5.04	5.04	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	5.30	9.09	HGL ok
P-60	MH-60	MH-61	2.40	4.86	4.86	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	5.04	9.84	HGL ok
P-61	MH-61	DI-62	2.40	4.64	4.64	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	4.86	11.03	HGL ok
P-62	DI-62	DI-63	2.40	4.44	4.44	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	4.64	10.34	HGL ok
P-63	DI-63	DI-77	1.93	4.12	4.12	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	4.44	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.77	3.77	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	4.12	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.36	3.36	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	3.77	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.26	3.26	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	3.36	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.20**	**3.20**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**3.26**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	5.84	5.84	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	5.91	8.07	HGL ok
P-50	B7 North	1.00	1.20	5.43	5.43	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	5.49	10.00	HGL ok
P-65	B7 West	MH-64	1.20	4.56	4.56	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	4.61	10.00	HGL ok
P-64	MH-64	DI-63	1.20	4.44	4.44	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	4.56	10.14	HGL ok
P-51	DI-51	DI-52	1.00	5.41	5.41	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.41	7.11	HGL ok
P-52	DI-52	DI-53	1.00	5.38	5.38	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	5.41	7.03	HGL ok
P-53	DI-53	MH-54	1.00	5.32	5.32	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	5.38	7.59	HGL ok
P-54	MH-54	DI-55	1.60	5.20	5.20	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	5.32	8.54	HGL ok
P-55	DI-55	MH-60	1.60	5.04	5.04	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	5.20	9.09	HGL ok
P-56	B5 South	MH-54	1.20	5.32	5.32	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	5.37	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.87	6.44	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.45	11.60	HGL ok
P-79	DI-79	DI-71	1.20	5.12	5.86	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	5.87	11.15	HGL ok
P-71	DI-71	DI-72	1.20	5.08	5.08	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	5.12	11.15	HGL ok
P-72	DI-72	DI-73	1.20	5.04	5.04	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	5.08	10.99	HGL ok
P-73	DI-73	MH-74	1.20	5.01	5.01	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	5.04	10.84	HGL ok
P-74	MH-74	DI-75	1.20	4.87	4.87	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	5.01	11.24	HGL ok
P-75	DI-75	DI-76	1.20	4.52	4.52	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	4.87	10.63	HGL ok
P-76	DI-76	DI-77	1.20	4.12	4.12	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	4.52	10.34	HGL ok
P-70	DI-70	DI-71	1.00	5.12	5.66	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.67	11.60	HGL ok
P-80	DI-80	MH-74	1.20	5.01	5.01	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	5.06	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.54	3.54	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	3.56	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.26	3.26	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	3.54	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.54	3.54	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	3.59	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.36	8.00	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	8.25	10.50	HGL ok
P-38	DI-38	DI-39	1.00	3.80	3.80	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.80	10.67	HGL ok
P-39	DI-39	DI-40	1.00	3.78	3.78	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	3.80	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.77	3.77	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	3.78	9.98	HGL ok
P-35	MH-35	DI-36	2.40	4.35	4.35	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	4.77	11.72	HGL ok
P-36	DI-36	DI-37	2.40	4.05	4.05	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	4.35	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.77	3.77	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	4.05	10.16	HGL ok
P-30	DI-30	MH-35	1.20	4.77	4.77	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.78	11.24	HGL ok
P-11	DI-11	DI-12	1.00	5.54	5.54	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.55	6.84	HGL ok
P-12	DI-12	DI-13	1.00	5.48	5.48	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	5.54	6.99	HGL ok
P-13	DI-13	MH-14	1.00	5.38	5.38	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	5.48	7.91	HGL ok
P-14	MH-14	DI-15	1.60	5.27	5.27	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	5.38	8.68	HGL ok
P-15	DI-15	DI-16	1.60	5.13	5.13	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	5.27	9.01	HGL ok
P-16	DI-16	MH-17	1.60	4.96	4.96	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	5.13	9.77	HGL ok
P-18	B7 South	MH-14	1.20	5.38	5.38	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	5.43	10.00	HGL ok
P-01	DI-01	DI-02	1.00	5.54	5.54	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	5.57	6.84	HGL ok
P-02	DI-02	DI-03	1.00	5.50	5.50	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	5.54	7.35	HGL ok
P-03	DI-03	MH-04	1.00	5.41	5.41	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	5.50	7.91	HGL ok
P-04	MH-04	DI-05	1.20	5.25	5.25	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	5.41	8.60	HGL ok
P-05	DI-05	DI-06	1.60	5.12	5.12	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	5.25	9.01	HGL ok
P-06	DI-06	MH-17	1.60	4.96	4.96	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	5.12	9.87	HGL ok
P-17	MH-17	MH-35	1.60	4.77	4.77	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	4.96	10.61	HGL ok
P-08	DI-08	MH-07	1.00	5.17	5.17	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.17	11.39	HGL ok
P-07	MH-07	DI-06	1.20	5.12	5.12	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	5.17	10.19	HGL ok
P-09	B9/J	MH-04	1.20	5.41	5.41	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	5.43	10.00	HGL ok
P-10	B9/J	MH-07	1.20	5.17	5.17	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	5.19	10.00	HGL ok
P-20	TD-05	DI-21	0.53	5.96	7.08	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	7.24	10.50	HGL ok
P-21	DI-21	MH-22	1.00	5.82	5.82	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	5.96	9.46	HGL ok
P-22	MH-22	MH-23	1.20	5.76	5.76	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	5.82	9.72	HGL ok
P-23	MH-23	MH-24	1.20	5.32	5.32	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	5.76	10.97	HGL ok
P-24	MH-24	MH-35	1.20	4.77	4.77	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	5.32	11.20	HGL ok
P-25	DI-25	MH-22	1.00	5.82	5.82	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.83	9.46	HGL ok
P-26	B8/K	MH-23	1.20	5.76	5.76	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	5.79	10.00	HGL ok
P-27	B6 South	MH-23	1.20	5.76	5.76	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	5.81	10.00	HGL ok
P-28	DI-28	MH-24	1.20	5.32	5.32	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.33	10.95	HGL ok
P-29	DI-29	MH-24	1.20	5.32	5.32	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.33	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	6.04	6.04	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	6.14	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	5.98	5.98	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	6.04	7.86	HGL ok
P-43	DI-43	DI-44	2.00	5.89	5.89	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	5.98	7.11	HGL ok
P-44	DI-44	DI-45	2.00	5.76	5.76	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	5.89	7.03	HGL ok
P-45	DI-45	MH-46	2.00	5.63	5.63	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	5.76	7.59	HGL ok
P-46	MH-46	DI-47	2.00	5.50	5.50	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	5.63	8.54	HGL ok
P-47	DI-47	MH-60	2.40	5.24	5.24	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	5.50	9.09	HGL ok
P-60	MH-60	MH-61	2.40	5.06	5.06	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	5.24	9.84	HGL ok
P-61	MH-61	DI-62	2.40	4.84	4.84	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	5.06	11.03	HGL ok
P-62	DI-62	DI-63	2.40	4.64	4.64	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	4.84	10.34	HGL ok
P-63	DI-63	DI-77	1.93	4.32	4.32	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	4.64	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.97	3.97	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	4.32	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.56	3.56	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	3.97	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.46	3.46	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	3.56	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.40**	**3.40**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**3.46**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	6.04	6.04	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	6.11	8.07	HGL ok
P-50	B7 North	1.00	1.20	5.63	5.63	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	5.69	10.00	HGL ok
P-65	B7 West	MH-64	1.20	4.76	4.76	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	4.81	10.00	HGL ok
P-64	MH-64	DI-63	1.20	4.64	4.64	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	4.76	10.14	HGL ok
P-51	DI-51	DI-52	1.00	5.61	5.61	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.61	7.11	HGL ok
P-52	DI-52	DI-53	1.00	5.58	5.58	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	5.61	7.03	HGL ok
P-53	DI-53	MH-54	1.00	5.52	5.52	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	5.58	7.59	HGL ok
P-54	MH-54	DI-55	1.60	5.40	5.40	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	5.52	8.54	HGL ok
P-55	DI-55	MH-60	1.60	5.24	5.24	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	5.40	9.09	HGL ok
P-56	B5 South	MH-54	1.20	5.52	5.52	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	5.57	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.87	6.44	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.45	11.60	HGL ok
P-79	DI-79	DI-71	1.20	5.32	5.86	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	5.87	11.15	HGL ok
P-71	DI-71	DI-72	1.20	5.28	5.28	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	5.32	11.15	HGL ok
P-72	DI-72	DI-73	1.20	5.24	5.24	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	5.28	10.99	HGL ok
P-73	DI-73	MH-74	1.20	5.21	5.21	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	5.24	10.84	HGL ok
P-74	MH-74	DI-75	1.20	5.07	5.07	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	5.21	11.24	HGL ok
P-75	DI-75	DI-76	1.20	4.72	4.72	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	5.07	10.63	HGL ok
P-76	DI-76	DI-77	1.20	4.32	4.32	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	4.72	10.34	HGL ok
P-70	DI-70	DI-71	1.00	5.32	5.66	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.67	11.60	HGL ok
P-80	DI-80	MH-74	1.20	5.21	5.21	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	5.26	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.74	3.74	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	3.76	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.46	3.46	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	3.74	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.74	3.74	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	3.79	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.56	8.00	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	8.25	10.50	HGL ok
P-38	DI-38	DI-39	1.00	4.00	4.00	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.00	10.67	HGL ok
P-39	DI-39	DI-40	1.00	3.98	3.98	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	4.00	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.97	3.97	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	3.98	9.98	HGL ok
P-35	MH-35	DI-36	2.40	4.55	4.55	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	4.97	11.72	HGL ok
P-36	DI-36	DI-37	2.40	4.25	4.25	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	4.55	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.97	3.97	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	4.25	10.16	HGL ok
P-30	DI-30	MH-35	1.20	4.97	4.97	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.98	11.24	HGL ok
P-11	DI-11	DI-12	1.00	5.74	5.74	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.75	6.84	HGL ok
P-12	DI-12	DI-13	1.00	5.68	5.68	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	5.74	6.99	HGL ok
P-13	DI-13	MH-14	1.00	5.58	5.58	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	5.68	7.91	HGL ok
P-14	MH-14	DI-15	1.60	5.47	5.47	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	5.58	8.68	HGL ok
P-15	DI-15	DI-16	1.60	5.33	5.33	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	5.47	9.01	HGL ok
P-16	DI-16	MH-17	1.60	5.16	5.16	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	5.33	9.77	HGL ok
P-18	B7 South	MH-14	1.20	5.58	5.58	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	5.63	10.00	HGL ok
P-01	DI-01	DI-02	1.00	5.74	5.74	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	5.77	6.84	HGL ok
P-02	DI-02	DI-03	1.00	5.70	5.70	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	5.74	7.35	HGL ok
P-03	DI-03	MH-04	1.00	5.61	5.61	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	5.70	7.91	HGL ok
P-04	MH-04	DI-05	1.20	5.45	5.45	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	5.61	8.60	HGL ok
P-05	DI-05	DI-06	1.60	5.32	5.32	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	5.45	9.01	HGL ok
P-06	DI-06	MH-17	1.60	5.16	5.16	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	5.32	9.87	HGL ok
P-17	MH-17	MH-35	1.60	4.97	4.97	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	5.16	10.61	HGL ok
P-08	DI-08	MH-07	1.00	5.37	5.37	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.37	11.39	HGL ok
P-07	MH-07	DI-06	1.20	5.32	5.32	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	5.37	10.19	HGL ok
P-09	B9/J	MH-04	1.20	5.61	5.61	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	5.63	10.00	HGL ok
P-10	B9/J	MH-07	1.20	5.37	5.37	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	5.39	10.00	HGL ok
P-20	TD-05	DI-21	0.53	6.16	7.08	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	7.24	10.50	HGL ok
P-21	DI-21	MH-22	1.00	6.02	6.02	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	6.16	9.46	HGL ok
P-22	MH-22	MH-23	1.20	5.96	5.96	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	6.02	9.72	HGL ok
P-23	MH-23	MH-24	1.20	5.52	5.52	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	5.96	10.97	HGL ok
P-24	MH-24	MH-35	1.20	4.97	4.97	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	5.52	11.20	HGL ok
P-25	DI-25	MH-22	1.00	6.02	6.02	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.03	9.46	HGL ok
P-26	B8/K	MH-23	1.20	5.96	5.96	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	5.99	10.00	HGL ok
P-27	B6 South	MH-23	1.20	5.96	5.96	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	6.01	10.00	HGL ok
P-28	DI-28	MH-24	1.20	5.52	5.52	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.53	10.95	HGL ok
P-29	DI-29	MH-24	1.20	5.52	5.52	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.53	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	9.54	9.54	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	9.64	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	9.48	9.48	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	9.54	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.39	9.39	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	9.48	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.26	9.26	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	9.39	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.13	9.13	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	9.26	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.00	9.00	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	9.13	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.74	8.74	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	9.00	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.56	8.56	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	8.74	9.84	HGL ok
P-61	MH-61	DI-62	2.40	8.34	8.34	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	8.56	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.14	8.14	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	8.34	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.82	7.82	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	8.14	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.47	7.47	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	7.82	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.06	7.06	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	7.47	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.96	6.96	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	7.06	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**6.90**	**6.90**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**6.96**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.54	9.54	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	9.61	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.13	9.13	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	9.19	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	8.26	8.26	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	8.31	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.14	8.14	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	8.26	10.14	HGL ok
P-51	DI-51	DI-52	1.00	9.11	9.11	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.11	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.08	9.08	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	9.11	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.02	9.02	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	9.08	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.90	8.90	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	9.02	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.74	8.74	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	8.90	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.02	9.02	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	9.07	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	8.83	8.83	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.83	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.82	8.82	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	8.83	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.78	8.78	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	8.82	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.74	8.74	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	8.78	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.71	8.71	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	8.74	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.57	8.57	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	8.71	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.22	8.22	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	8.57	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.82	7.82	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	8.22	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.82	8.82	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.83	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.71	8.71	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	8.76	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.24	7.24	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.26	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.96	6.96	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	7.24	8.33	HGL ok
P-92	B6 North	DI-91	1.20	7.24	7.24	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	7.29	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.06	8.00	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	8.25	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.50	7.50	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.50	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.48	7.48	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	7.50	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.47	7.47	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	7.48	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.05	8.05	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	8.47	11.72	HGL ok
P-36	DI-36	DI-37	2.40	7.75	7.75	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	8.05	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.47	7.47	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	7.75	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.47	8.47	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.48	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.24	9.24	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.25	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.18	9.18	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	9.24	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.08	9.08	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	9.18	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.97	8.97	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	9.08	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.83	8.83	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	8.97	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.66	8.66	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	8.83	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.08	9.08	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	9.13	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.24	9.24	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.27	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.20	9.20	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	9.24	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.11	9.11	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	9.20	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.95	8.95	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	9.11	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.82	8.82	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	8.95	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.66	8.66	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	8.82	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.47	8.47	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	8.66	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.87	8.87	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.87	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.82	8.82	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	8.87	10.19	HGL ok
P-09	B9/J	MH-04	1.20	9.11	9.11	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.13	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	8.87	8.87	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.89	10.00	HGL ok
P-20	TD-05	DI-21	0.53	9.66	9.66	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	9.82	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	9.52	9.52	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	9.66	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.46	9.46	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	9.52	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.02	9.02	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	9.46	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.47	8.47	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	9.02	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.52	9.52	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.53	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.46	9.46	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.49	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.46	9.46	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	9.51	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.02	9.02	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.03	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.02	9.02	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.03	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	10.04	10.04	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	10.14	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	9.98	9.98	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	10.04	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.89	9.89	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	9.98	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.76	9.76	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	9.89	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.63	9.63	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	9.76	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.50	9.50	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	9.63	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.24	9.24	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	9.50	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.06	9.06	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	9.24	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	8.84	8.84	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	9.06	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.64	8.64	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	8.84	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.32	8.32	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	8.64	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.97	7.97	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	8.32	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.56	7.56	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	7.97	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.46	7.46	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	7.56	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.40**	**7.40**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**7.46**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.04	10.04	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	10.11	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.63	9.63	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	9.69	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	8.76	8.76	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	8.81	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.64	8.64	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	8.76	10.14	HGL ok
P-51	DI-51	DI-52	1.00	9.61	9.61	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.61	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.58	9.58	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	9.61	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.52	9.52	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	9.58	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.40	9.40	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	9.52	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.24	9.24	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	9.40	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.52	9.52	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	9.57	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.33	9.33	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.33	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.32	9.32	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	9.33	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.28	9.28	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	9.32	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.24	9.24	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	9.28	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.21	9.21	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	9.24	10.84	HGL ok
P-74	MH-74	DI-75	1.20	9.07	9.07	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	9.21	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.72	8.72	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	9.07	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.32	8.32	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	8.72	10.34	HGL ok
P-70	DI-70	DI-71	1.00	9.32	9.32	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.33	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.21	9.21	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	9.26	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.74	7.74	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	7.76	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.46	7.46	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	7.74	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	7.74	7.74	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	7.79	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.56	8.00	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	8.25	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.00	8.00	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.00	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.98	7.98	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.00	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.97	7.97	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	7.98	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.55	8.55	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	8.97	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.25	8.25	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	8.55	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.97	7.97	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	8.25	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.97	8.97	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.98	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.74	9.74	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.75	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.68	9.68	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	9.74	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.58	9.58	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	9.68	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.47	9.47	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	9.58	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.33	9.33	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	9.47	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.16	9.16	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	9.33	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.58	9.58	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	9.63	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.74	9.74	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.77	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.70	9.70	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	9.74	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.61	9.61	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	9.70	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.45	9.45	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	9.61	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.32	9.32	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	9.45	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.16	9.16	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	9.32	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	8.97	8.97	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	9.16	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.37	9.37	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.37	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.32	9.32	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	9.37	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	9.61	9.61	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.63	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.37	9.37	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.39	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.16	10.16	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	10.32	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.02	10.02	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	10.16	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.96	9.96	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	10.02	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.52	9.52	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	9.96	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.97	8.97	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	9.52	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.02	10.02	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.03	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.96	9.96	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	9.99	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.96	9.96	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	10.01	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.52	9.52	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.53	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.52	9.52	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.53	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR Date: 2/23/23 Sheet No.: 2 of 5
Checked by: TMC Date: 3/23/23 Cm. No.: 20077
Design Freq.: 25 -year (50-year for sumps)

No. (Location)	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D: 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe: TW (ft)	Outlet W. S. Elevation: HGL Dn (ft)	Outflow Pipe Diameter: D_o (in)	Outflow Pipe Design Flow: Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$: V_o (fps)	Skew angle vs.: Δ_o (deg)	Outflow Pipe Length: L (ft)	Friction Slope: S_{fo} (ft/ft)	Friction Loss: H_f (ft)	Angle of Curvature: O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$: H_c (ft)	Contraction Loss: H_o (ft)	Q*V for determining controlling inflow pipe: Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe: Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe: Q3V3 (ft^4/s^2)	Controlling Inflow Velocity: Vi	Expansion Loss: Hi (ft)	Controlling In-flow skew: Δ_i (deg)	Bend Loss: H_Δ (ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$: H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss: $H_{t\ adj}$ (ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$: H (ft)	Inlet W. S. Elevation: HGL Up (ft)	Top of Grate: T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	10.44	10.44	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	10.54	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.38	10.38	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	10.44	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.29	10.29	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	10.38	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.16	10.16	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	10.29	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.03	10.03	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	10.16	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.90	9.90	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	10.03	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.64	9.64	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	9.90	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.46	9.46	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	9.64	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.24	9.24	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	9.46	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.04	9.04	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	9.24	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.72	8.72	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	9.04	10.08	HGL ok
P-77	DI-77	DI-85	3.20	8.37	8.37	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	8.72	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.96	7.96	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	8.37	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.86	7.86	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	7.96	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.80**	**7.80**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**7.86**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.44	10.44	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	10.51	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.03	10.03	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	10.09	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.16	9.16	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	9.21	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.04	9.04	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	9.16	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.01	10.01	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.01	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.98	9.98	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	10.01	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.92	9.92	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	9.98	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.80	9.80	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	9.92	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.64	9.64	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	9.80	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.92	9.92	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	9.97	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.73	9.73	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.73	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.72	9.72	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	9.73	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.68	9.68	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	9.72	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.64	9.64	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	9.68	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.61	9.61	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	9.64	10.84	HGL ok
P-74	MH-74	DI-75	1.20	9.47	9.47	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	9.61	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.12	9.12	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	9.47	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.72	8.72	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	9.12	10.34	HGL ok
P-70	DI-70	DI-71	1.00	9.72	9.72	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.73	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.61	9.61	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	9.66	11.00	HGL ok
P-90	DI-90	DI-91	1.00	8.14	8.14	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.16	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.86	7.86	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	8.14	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.14	8.14	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	8.19	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.96	8.00	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	8.25	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.40	8.40	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.40	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.38	8.38	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.40	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.37	8.37	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	8.38	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.95	8.95	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	9.37	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.65	8.65	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	8.95	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.37	8.37	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	8.65	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.37	9.37	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.38	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.14	10.14	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.15	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.08	10.08	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	10.14	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.98	9.98	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	10.08	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.87	9.87	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	9.98	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.73	9.73	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	9.87	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.56	9.56	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	9.73	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.98	9.98	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	10.03	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.14	10.14	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.17	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.10	10.10	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	10.14	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.01	10.01	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	10.10	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.85	9.85	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	10.01	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.72	9.72	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	9.85	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.56	9.56	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	9.72	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.37	9.37	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	9.56	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.77	9.77	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.77	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.72	9.72	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	9.77	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.01	10.01	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.03	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.77	9.77	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.79	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.56	10.56	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	10.72	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.42	10.42	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	10.56	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.36	10.36	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	10.42	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.92	9.92	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	10.36	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.37	9.37	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	9.92	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.42	10.42	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.43	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.36	10.36	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.39	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.36	10.36	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	10.41	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.92	9.92	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.93	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.92	9.92	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.93	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ ft	Tot. H Loss, $H = H_f + H_{t\,adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	10.94	10.94	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	11.04	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.88	10.88	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	10.94	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.79	10.79	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	10.88	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.66	10.66	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	10.79	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.53	10.53	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	10.66	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.40	10.40	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	10.53	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.14	10.14	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	10.40	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.96	9.96	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	10.14	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.74	9.74	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	9.96	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.54	9.54	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	9.74	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.22	9.22	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	9.54	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	8.87	8.87	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	9.22	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	8.46	8.46	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	8.87	9.98	HGL ok
P-86	MH-86	MH-87	4.00	8.36	8.36	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	8.46	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**8.30**	**8.30**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**8.36**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.94	10.94	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	11.01	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.53	10.53	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	10.59	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.66	9.66	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	9.71	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.54	9.54	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	9.66	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.51	10.51	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.51	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.48	10.48	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	10.51	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.42	10.42	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	10.48	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.30	10.30	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	10.42	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.14	10.14	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	10.30	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.42	10.42	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	10.47	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.23	10.23	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.23	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.22	10.22	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	10.23	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.18	10.18	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	10.22	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.14	10.14	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	10.18	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.11	10.11	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	10.14	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	9.97	9.97	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	10.11	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.62	9.62	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	9.97	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.22	9.22	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	9.62	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.22	10.22	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.23	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.11	10.11	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	10.16	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	8.64	8.64	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.66	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	8.36	8.36	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	8.64	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.64	8.64	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	8.69	10.00	HGL ok
P-95	TD-04	MH-86	0.80	8.46	8.46	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	8.70	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.90	8.90	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.90	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.88	8.88	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.90	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.87	8.87	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	8.88	9.98	HGL ok
P-35	MH-35	DI-36	2.40	9.45	9.45	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	9.87	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.15	9.15	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	9.45	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.87	8.87	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	9.15	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.87	9.87	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.88	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.64	10.64	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.65	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.58	10.58	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	10.64	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.48	10.48	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	10.58	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.37	10.37	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	10.48	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.23	10.23	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	10.37	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.06	10.06	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	10.23	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.48	10.48	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	10.53	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.64	10.64	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.67	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.60	10.60	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	10.64	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.51	10.51	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	10.60	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.35	10.35	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	10.51	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.22	10.22	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	10.35	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.06	10.06	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	10.22	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.87	9.87	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	10.06	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.27	10.27	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.27	11.39	HGL ok
P-07	MH-07	DI-06	1.20	10.22	10.22	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	10.27	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.51	10.51	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.53	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.27	10.27	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.29	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.06	11.06	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	11.22	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.92	10.92	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	11.06	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.86	10.86	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	10.92	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.42	10.42	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	10.86	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.87	9.87	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	10.42	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	10.92	10.92	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.93	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.86	10.86	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	10.89	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.86	10.86	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	10.91	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.42	10.42	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.43	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.42	10.42	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.43	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.64	11.64	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	11.74	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.58	11.58	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	11.64	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.49	11.49	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	11.58	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.36	11.36	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	11.49	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.23	11.23	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	11.36	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.10	11.10	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	11.23	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.84	10.84	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	11.10	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.66	10.66	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	10.84	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.44	10.44	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	10.66	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.24	10.24	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	10.44	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.92	9.92	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	10.24	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.57	9.57	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	9.92	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.16	9.16	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	9.57	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.06	9.06	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	9.16	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.00**	**9.00**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**9.06**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	11.64	11.64	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	11.71	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.23	11.23	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	11.29	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.36	10.36	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	10.41	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.24	10.24	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	10.36	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.21	11.21	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.21	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.18	11.18	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	11.21	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.12	11.12	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	11.18	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.00	11.00	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	11.12	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.84	10.84	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	11.00	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.12	11.12	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	11.17	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.93	10.93	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.93	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	10.92	10.92	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	10.93	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.88	10.88	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	10.92	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.84	10.84	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	10.88	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.81	10.81	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	10.84	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.67	10.67	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	10.81	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.32	10.32	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	10.67	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.92	9.92	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	10.32	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.92	10.92	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.93	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	10.81	10.81	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	10.86	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.34	9.34	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.36	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.06	9.06	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	9.34	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.34	9.34	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	9.39	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.16	9.16	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	9.40	10.50	HGL ok
P-38	DI-38	DI-39	1.00	9.60	9.60	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.60	10.67	HGL ok
P-39	DI-39	DI-40	1.00	9.58	9.58	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.60	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.57	9.57	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	9.58	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.15	10.15	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	10.57	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.85	9.85	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	10.15	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.57	9.57	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	9.85	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.57	10.57	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.58	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.34	11.34	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.35	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.28	11.28	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	11.34	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.18	11.18	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	11.28	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.07	11.07	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	11.18	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.93	10.93	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	11.07	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.76	10.76	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	10.93	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.18	11.18	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	11.23	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.34	11.34	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.37	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.30	11.30	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	11.34	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.21	11.21	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	11.30	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.05	11.05	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	11.21	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.92	10.92	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	11.05	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.76	10.76	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	10.92	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.57	10.57	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	10.76	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.97	10.97	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.97	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	10.92	10.92	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	10.97	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.21	11.21	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.23	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.97	10.97	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.99	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.76	11.76	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	11.92	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.62	11.62	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	11.76	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.56	11.56	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	11.62	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.12	11.12	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	11.56	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.57	10.57	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	11.12	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.62	11.62	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.63	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.56	11.56	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	11.59	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.56	11.56	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	11.61	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.12	11.12	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.13	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.12	11.12	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.13	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inle WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvatu O deg	Curved align; add Hc = $0.002{*}O{*}V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ ft	Tot. H Loss, $H = H_f + H_{t\,adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	12.14	12.14	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	12.24	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.08	12.08	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	12.14	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.99	11.99	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	12.08	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.86	11.86	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	11.99	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.73	11.73	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	11.86	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.60	11.60	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	11.73	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.34	11.34	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	11.60	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.16	11.16	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	11.34	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.94	10.94	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	11.16	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.74	10.74	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	10.94	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.42	10.42	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	10.74	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.07	10.07	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	10.42	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.66	9.66	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	10.07	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.56	9.56	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	9.66	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.50**	**9.50**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**9.56**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.14	12.14	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	12.21	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.73	11.73	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	11.79	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.86	10.86	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	10.91	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.74	10.74	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	10.86	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.71	11.71	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.71	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.68	11.68	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	11.71	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.62	11.62	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	11.68	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.50	11.50	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	11.62	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.34	11.34	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	11.50	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.62	11.62	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	11.67	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.43	11.43	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.43	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.42	11.42	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.43	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.38	11.38	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	11.42	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.34	11.34	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	11.38	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.31	11.31	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	11.34	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.17	11.17	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	11.31	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.82	10.82	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	11.17	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.42	10.42	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	10.82	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.42	11.42	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.43	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.31	11.31	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	11.36	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.84	9.84	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.86	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.56	9.56	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	9.84	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.84	9.84	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	9.89	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.66	9.66	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	9.90	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.10	10.10	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.10	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.08	10.08	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.10	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.07	10.07	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	10.08	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.65	10.65	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	11.07	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.35	10.35	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	10.65	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for Inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.07	10.07	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	10.35	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.07	11.07	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.08	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.84	11.84	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.85	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.78	11.78	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	11.84	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.68	11.68	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	11.78	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.57	11.57	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	11.68	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.43	11.43	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	11.57	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.26	11.26	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	11.43	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.68	11.68	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	11.73	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.84	11.84	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.87	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.80	11.80	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	11.84	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.71	11.71	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	11.80	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.55	11.55	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	11.71	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.42	11.42	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	11.55	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.26	11.26	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	11.42	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.07	11.07	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	11.26	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.47	11.47	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.47	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.42	11.42	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	11.47	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.71	11.71	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.73	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.47	11.47	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.49	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.26	12.26	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	12.42	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.12	12.12	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	12.26	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.06	12.06	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	12.12	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.62	11.62	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	12.06	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.07	11.07	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	11.62	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.12	12.12	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.13	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.06	12.06	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.09	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.06	12.06	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	12.11	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.62	11.62	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.63	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.62	11.62	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.63	10.95	HGL Too High!

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	13.44	13.44	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	13.54	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.38	13.38	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	13.44	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.29	13.29	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	13.38	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.16	13.16	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	13.29	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.03	13.03	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	13.16	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.90	12.90	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	13.03	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.64	12.64	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	12.90	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.46	12.46	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	12.64	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.24	12.24	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	12.46	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.04	12.04	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	12.24	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.72	11.72	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	12.04	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.37	11.37	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	11.72	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.96	10.96	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	11.37	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.86	10.86	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	10.96	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.80**	**10.80**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	0.5	**0.06**	**0.06**	**10.86**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.44	13.44	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	13.51	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.03	13.03	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	13.09	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.16	12.16	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	12.21	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.04	12.04	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	12.16	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.01	13.01	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.01	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.98	12.98	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	13.01	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.92	12.92	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	12.98	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.80	12.80	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	12.92	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.64	12.64	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	12.80	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.92	12.92	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	12.97	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.73	12.73	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.73	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.72	12.72	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.73	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.68	12.68	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	12.72	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.64	12.64	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	12.68	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.61	12.61	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	12.64	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.47	12.47	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	12.61	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.12	12.12	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	12.47	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.72	11.72	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	12.12	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.72	12.72	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.73	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.61	12.61	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	12.66	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.14	11.14	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.16	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.86	10.86	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	11.14	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.14	11.14	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	11.19	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.96	10.96	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	11.20	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.40	11.40	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.40	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.38	11.38	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.40	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.37	11.37	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	11.38	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.95	11.95	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	12.37	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.65	11.65	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	11.95	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.37	11.37	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	11.65	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.37	12.37	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.38	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.14	13.14	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.15	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.08	13.08	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	13.14	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.98	12.98	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	13.08	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.87	12.87	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	12.98	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.73	12.73	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	12.87	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.56	12.56	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	12.73	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.98	12.98	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	13.03	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.14	13.14	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.17	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.10	13.10	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	13.14	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.01	13.01	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	13.10	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.85	12.85	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	13.01	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.72	12.72	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	12.85	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.56	12.56	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	12.72	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.37	12.37	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	12.56	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.77	12.77	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.77	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.72	12.72	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	12.77	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.01	13.01	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.03	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.77	12.77	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.79	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.56	13.56	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	13.72	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.42	13.42	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	13.56	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.36	13.36	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	13.42	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.92	12.92	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	13.36	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.37	12.37	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	12.92	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.42	13.42	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.43	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.36	13.36	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	13.39	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.36	13.36	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	13.41	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.92	12.92	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.93	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.92	12.92	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.93	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 25 -year (50-year for sumps)

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\ adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	8.38	8.38	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	8.48	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	8.32	8.32	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	8.38	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	8.23	8.23	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	8.32	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	8.10	8.10	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	8.23	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	7.97	7.97	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	8.10	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	7.84	7.84	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	7.97	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	7.58	7.58	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	7.84	9.09	HGL ok
P-60	MH-60	MH-61	2.40	7.40	7.40	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	7.58	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.18	7.18	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	7.40	11.03	HGL ok
P-62	DI-62	DI-63	2.40	6.98	6.98	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	7.18	10.34	HGL ok
P-63	DI-63	DI-77	1.93	6.66	6.66	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	6.98	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.31	6.31	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	6.66	10.08	HGL ok
P-85	DI-85	MH-86	4.00	5.90	5.90	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	6.31	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.80	5.80	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	5.90	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.74**	**5.74**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**5.80**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	8.38	8.38	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	8.45	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	7.97	7.97	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	8.03	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.10	7.10	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	7.15	10.00	HGL ok
P-64	MH-64	DI-63	1.20	6.98	6.98	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	7.10	10.14	HGL ok
P-51	DI-51	DI-52	1.00	7.95	7.95	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.95	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	7.92	7.92	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	7.95	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	7.86	7.86	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	7.92	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	7.74	7.74	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	7.86	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	7.58	7.58	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	7.74	9.09	HGL ok
P-56	B5 South	MH-54	1.20	7.86	7.86	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	7.91	10.00	HGL ok
P-78	DI-78	DI-79	1.00	7.67	7.67	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.67	11.60	HGL ok
P-79	DI-79	DI-71	1.20	7.66	7.66	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	7.67	11.15	HGL ok
P-71	DI-71	DI-72	1.20	7.62	7.62	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	7.66	11.15	HGL ok
P-72	DI-72	DI-73	1.20	7.58	7.58	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	7.62	10.99	HGL ok
P-73	DI-73	MH-74	1.20	7.55	7.55	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	7.58	10.84	HGL ok
P-74	MH-74	DI-75	1.20	7.41	7.41	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	7.55	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.06	7.06	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	7.41	10.63	HGL ok
P-76	DI-76	DI-77	1.20	6.66	6.66	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	7.06	10.34	HGL ok
P-70	DI-70	DI-71	1.00	7.66	7.66	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.67	11.60	HGL ok
P-80	DI-80	MH-74	1.20	7.55	7.55	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	7.60	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.08	6.08	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	6.10	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.80	5.80	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	6.08	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.08	6.08	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	6.13	10.00	HGL ok
P-95	TD-04	MH-86	0.80	5.90	8.00	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	8.25	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.34	6.34	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.34	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.32	6.32	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.34	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.31	6.31	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	6.32	9.98	HGL ok
P-35	MH-35	DI-36	2.40	6.89	6.89	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	7.31	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.59	6.59	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	6.89	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.31	6.31	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	6.59	10.16	HGL ok
P-30	DI-30	MH-35	1.20	7.31	7.31	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.32	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.08	8.08	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.09	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	8.02	8.02	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	8.08	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	7.92	7.92	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	8.02	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	7.81	7.81	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	7.92	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	7.67	7.67	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	7.81	9.01	HGL ok
P-16	DI-16	MH-17	1.60	7.50	7.50	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	7.67	9.77	HGL ok
P-18	B7 South	MH-14	1.20	7.92	7.92	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	7.97	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.08	8.08	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.11	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	8.04	8.04	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	8.08	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	7.95	7.95	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	8.04	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	7.79	7.79	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	7.95	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	7.66	7.66	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	7.79	9.01	HGL ok
P-06	DI-06	MH-17	1.60	7.50	7.50	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	7.66	9.87	HGL ok
P-17	MH-17	MH-35	1.60	7.31	7.31	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	7.50	10.61	HGL ok
P-08	DI-08	MH-07	1.00	7.71	7.71	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.71	11.39	HGL ok
P-07	MH-07	DI-06	1.20	7.66	7.66	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	7.71	10.19	HGL ok
P-09	B9/J	MH-04	1.20	7.95	7.95	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.97	10.00	HGL ok
P-10	B9/J	MH-07	1.20	7.71	7.71	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.73	10.00	HGL ok
P-20	TD-05	DI-21	0.53	8.50	8.50	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	8.66	10.50	HGL ok
P-21	DI-21	MH-22	1.00	8.36	8.36	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	8.50	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	8.30	8.30	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	8.36	9.72	HGL ok
P-23	MH-23	MH-24	1.20	7.86	7.86	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	8.30	10.97	HGL ok
P-24	MH-24	MH-35	1.20	7.31	7.31	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	7.86	11.20	HGL ok
P-25	DI-25	MH-22	1.00	8.36	8.36	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.37	9.46	HGL ok
P-26	B8/K	MH-23	1.20	8.30	8.30	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.33	10.00	HGL ok
P-27	B6 South	MH-23	1.20	8.30	8.30	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	8.35	10.00	HGL ok
P-28	DI-28	MH-24	1.20	7.86	7.86	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.87	10.95	HGL ok
P-29	DI-29	MH-24	1.20	7.86	7.86	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.87	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvatu O deg	Curved align; add Hc = $0.002{*}O{*}V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ ft	Tot. H Loss, $H = H_f + H_{t\,adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	**HGL Check**
P-41	MH-41	MH-42	1.60	8.58	8.58	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	8.68	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	8.52	8.52	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	8.58	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	8.43	8.43	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	8.52	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	8.30	8.30	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	8.43	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	8.17	8.17	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	8.30	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	8.04	8.04	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	8.17	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	7.78	7.78	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	8.04	9.09	HGL ok
P-60	MH-60	MH-61	2.40	7.60	7.60	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	7.78	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.38	7.38	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	7.60	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.18	7.18	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	7.38	10.34	HGL ok
P-63	DI-63	DI-77	1.93	6.86	6.86	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	7.18	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.51	6.51	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	6.86	10.08	HGL ok
P-85	DI-85	MH-86	4.00	6.10	6.10	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	6.51	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.00	6.00	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	6.10	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.94**	**5.94**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**6.00**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	8.58	8.58	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	8.65	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	8.17	8.17	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	8.23	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.30	7.30	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	7.35	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.18	7.18	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	7.30	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.15	8.15	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.15	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	8.12	8.12	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	8.15	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.06	8.06	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	8.12	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	7.94	7.94	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	8.06	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	7.78	7.78	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	7.94	9.09	HGL ok
P-56	B5 South	MH-54	1.20	8.06	8.06	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	8.11	10.00	HGL ok
P-78	DI-78	DI-79	1.00	7.87	7.87	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.87	11.60	HGL ok
P-79	DI-79	DI-71	1.20	7.86	7.86	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	7.87	11.15	HGL ok
P-71	DI-71	DI-72	1.20	7.82	7.82	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	7.86	11.15	HGL ok
P-72	DI-72	DI-73	1.20	7.78	7.78	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	7.82	10.99	HGL ok
P-73	DI-73	MH-74	1.20	7.75	7.75	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	7.78	10.84	HGL ok
P-74	MH-74	DI-75	1.20	7.61	7.61	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	7.75	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.26	7.26	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	7.61	10.63	HGL ok
P-76	DI-76	DI-77	1.20	6.86	6.86	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	7.26	10.34	HGL ok
P-70	DI-70	DI-71	1.00	7.86	7.86	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.87	11.60	HGL ok
P-80	DI-80	MH-74	1.20	7.75	7.75	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	7.80	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.28	6.28	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	6.30	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.00	6.00	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	6.28	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.28	6.28	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	6.33	10.00	HGL ok
P-95	TD-04	MH-86	0.80	6.10	8.00	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	8.25	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.54	6.54	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.54	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.52	6.52	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.54	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.51	6.51	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	6.52	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.09	7.09	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	7.51	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.79	6.79	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	7.09	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.51	6.51	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	6.79	10.16	HGL ok
P-30	DI-30	MH-35	1.20	7.51	7.51	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.52	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.28	8.28	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.29	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	8.22	8.22	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	8.28	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	8.12	8.12	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	8.22	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.01	8.01	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	8.12	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	7.87	7.87	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	8.01	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	7.70	7.70	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	7.87	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.12	8.12	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	8.17	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.28	8.28	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.31	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	8.24	8.24	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	8.28	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	8.15	8.15	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	8.24	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	7.99	7.99	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	8.15	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	7.86	7.86	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	7.99	9.01	HGL ok
P-06	DI-06	MH-17	1.60	7.70	7.70	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	7.86	9.87	HGL ok
P-17	MH-17	MH-35	1.60	7.51	7.51	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	7.70	10.61	HGL ok
P-08	DI-08	MH-07	1.00	7.91	7.91	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.91	11.39	HGL ok
P-07	MH-07	DI-06	1.20	7.86	7.86	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	7.91	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.15	8.15	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.17	10.00	HGL ok
P-10	B9/J	MH-07	1.20	7.91	7.91	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	7.93	10.00	HGL ok
P-20	TD-05	DI-21	0.53	8.70	8.70	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	8.86	10.50	HGL ok
P-21	DI-21	MH-22	1.00	8.56	8.56	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	8.70	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	8.50	8.50	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	8.56	9.72	HGL ok
P-23	MH-23	MH-24	1.20	8.06	8.06	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	8.50	10.97	HGL ok
P-24	MH-24	MH-35	1.20	7.51	7.51	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	8.06	11.20	HGL ok
P-25	DI-25	MH-22	1.00	8.56	8.56	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.57	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	8.50	8.50	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	8.53	10.00	HGL ok
P-27	B6 South	MH-23	1.20	8.50	8.50	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	8.55	10.00	HGL ok
P-28	DI-28	MH-24	1.20	8.06	8.06	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.07	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.06	8.06	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.07	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	12.08	12.08	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	12.18	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.02	12.02	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	12.08	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.93	11.93	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	12.02	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.80	11.80	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	11.93	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.67	11.67	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	11.80	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.54	11.54	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	11.67	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.28	11.28	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	11.54	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.10	11.10	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	11.28	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.88	10.88	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	11.10	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.68	10.68	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	10.88	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.36	10.36	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	10.68	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.01	10.01	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	10.36	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.60	9.60	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	10.01	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.50	9.50	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	9.60	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.44**	**9.44**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**9.50**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.08	12.08	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	12.15	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.67	11.67	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	11.73	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.80	10.80	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	10.85	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.68	10.68	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	10.80	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.65	11.65	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.65	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.62	11.62	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	11.65	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.56	11.56	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	11.62	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.44	11.44	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	11.56	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.28	11.28	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	11.44	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.56	11.56	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	11.61	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.37	11.37	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.37	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.36	11.36	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.37	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.32	11.32	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	11.36	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.28	11.28	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	11.32	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.25	11.25	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	11.28	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.11	11.11	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	11.25	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.76	10.76	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	11.11	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.36	10.36	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	10.76	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.36	11.36	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.37	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.25	11.25	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	11.30	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.78	9.78	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.80	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.50	9.50	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	9.78	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.78	9.78	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	9.83	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.60	9.60	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	9.84	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.04	10.04	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.04	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.02	10.02	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.04	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.01	10.01	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	10.02	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.59	10.59	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	11.01	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.29	10.29	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	10.59	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.01	10.01	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	10.29	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.01	11.01	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.02	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.78	11.78	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.79	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.72	11.72	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	11.78	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.62	11.62	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	11.72	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.51	11.51	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	11.62	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.37	11.37	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	11.51	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.20	11.20	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	11.37	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.62	11.62	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	11.67	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.78	11.78	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.81	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.74	11.74	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	11.78	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.65	11.65	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	11.74	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.49	11.49	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	11.65	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.36	11.36	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	11.49	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.20	11.20	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	11.36	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.01	11.01	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	11.20	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.41	11.41	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.41	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.36	11.36	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	11.41	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.65	11.65	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.67	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.41	11.41	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.43	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.20	12.20	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	12.36	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.06	12.06	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	12.20	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.00	12.00	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	12.06	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.56	11.56	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	12.00	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.01	11.01	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	11.56	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.06	12.06	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.07	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.00	12.00	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.03	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.00	12.00	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	12.05	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.56	11.56	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.57	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.56	11.56	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.57	10.95	HGL Too High!

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002^*O^*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	12.58	12.58	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	12.68	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.52	12.52	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	12.58	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.43	12.43	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	12.52	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.30	12.30	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	12.43	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.17	12.17	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	12.30	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.04	12.04	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	12.17	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.78	11.78	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	12.04	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.60	11.60	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	11.78	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.38	11.38	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	11.60	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.18	11.18	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	11.38	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.86	10.86	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	11.18	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.51	10.51	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	10.86	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.10	10.10	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	10.51	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.00	10.00	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	10.10	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.94**	**9.94**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**10.00**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.58	12.58	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	12.65	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.17	12.17	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	12.23	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.30	11.30	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	11.35	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.18	11.18	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	11.30	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.15	12.15	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.15	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.12	12.12	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	12.15	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.06	12.06	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	12.12	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.94	11.94	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	12.06	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.78	11.78	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	11.94	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.06	12.06	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	12.11	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.87	11.87	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.87	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.86	11.86	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.87	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.82	11.82	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	11.86	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.78	11.78	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	11.82	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.75	11.75	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	11.78	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.61	11.61	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	11.75	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.26	11.26	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	11.61	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.86	10.86	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	11.26	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.86	11.86	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.87	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.75	11.75	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	11.80	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.28	10.28	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.30	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.00	10.00	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	10.28	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.28	10.28	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	10.33	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.10	10.10	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	10.34	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.54	10.54	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.54	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.52	10.52	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.54	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.51	10.51	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	10.52	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.09	11.09	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	11.51	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.79	10.79	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	11.09	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.51	10.51	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	10.79	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.51	11.51	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.52	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.28	12.28	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.29	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.22	12.22	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	12.28	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.12	12.12	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	12.22	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.01	12.01	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	12.12	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.87	11.87	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	12.01	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.70	11.70	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	11.87	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.12	12.12	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	12.17	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.28	12.28	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.31	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.24	12.24	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	12.28	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.15	12.15	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	12.24	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.99	11.99	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	12.15	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.86	11.86	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	11.99	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.70	11.70	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	11.86	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.51	11.51	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	11.70	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.91	11.91	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.91	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.86	11.86	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	11.91	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.15	12.15	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.17	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.91	11.91	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.93	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.70	12.70	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	12.86	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.56	12.56	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	12.70	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.50	12.50	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	12.56	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.06	12.06	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	12.50	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.51	11.51	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	12.06	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.56	12.56	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.57	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.50	12.50	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.53	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.50	12.50	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	12.55	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.06	12.06	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.07	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.06	12.06	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.07	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR   Date: 2/23/23   Sheet No.: 2 of 5
Checked by: TMC   Date: 3/23/23   Cm. No.: 20077
Design Freq.: 25 -year (50-year for sumps)

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	12.98	12.98	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	13.08	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.92	12.92	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	12.98	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.83	12.83	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	12.92	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.70	12.70	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	12.83	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.57	12.57	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	12.70	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.44	12.44	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	12.57	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.18	12.18	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	12.44	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.00	12.00	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	12.18	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.78	11.78	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	12.00	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.58	11.58	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	11.78	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.26	11.26	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	11.58	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.91	10.91	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	11.26	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.50	10.50	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	10.91	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.40	10.40	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	10.50	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.34**	**10.34**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**10.40**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.98	12.98	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	13.05	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.57	12.57	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	12.63	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.70	11.70	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	11.75	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.58	11.58	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	11.70	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.55	12.55	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.55	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.52	12.52	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	12.55	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.46	12.46	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	12.52	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.34	12.34	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	12.46	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.18	12.18	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	12.34	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.46	12.46	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	12.51	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.27	12.27	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.27	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.26	12.26	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.27	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.22	12.22	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	12.26	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.18	12.18	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	12.22	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.15	12.15	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	12.18	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.01	12.01	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	12.15	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.66	11.66	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	12.01	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.26	11.26	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	11.66	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.26	12.26	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.27	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.15	12.15	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	12.20	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.68	10.68	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.70	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.40	10.40	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	10.68	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.68	10.68	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	10.73	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.50	10.50	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	10.74	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.94	10.94	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.94	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.92	10.92	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.94	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.91	10.91	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	10.92	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.49	11.49	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	11.91	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.19	11.19	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	11.49	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.91	10.91	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	11.19	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.91	11.91	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.92	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.68	12.68	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.69	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.62	12.62	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	12.68	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.52	12.52	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	12.62	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.41	12.41	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	12.52	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.27	12.27	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	12.41	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.10	12.10	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	12.27	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.52	12.52	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	12.57	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.68	12.68	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.71	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.64	12.64	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	12.68	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.55	12.55	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	12.64	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.39	12.39	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	12.55	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.26	12.26	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	12.39	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.10	12.10	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	12.26	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.91	11.91	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	12.10	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.31	12.31	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.31	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.26	12.26	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	12.31	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.55	12.55	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.57	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.31	12.31	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.33	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.10	13.10	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	13.26	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.96	12.96	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	13.10	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.90	12.90	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	12.96	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.46	12.46	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	12.90	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.91	11.91	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	12.46	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.96	12.96	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.97	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.90	12.90	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	12.93	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.90	12.90	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	12.95	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.46	12.46	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.47	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.46	12.46	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.47	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D — 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe — TW (ft)	Outlet W. S. Elevation — HGL Dn (ft)	Outflow Pipe Diameter — D_o (in)	Outflow Pipe Design Flow — Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$ — V_o (fps)	Skew angle vs. — Δ_o (deg)	Outflow Pipe Length — L (ft)	Friction Slope — S_{fo} (ft/ft)	Friction Loss — H_f (ft)	Angle of Curvature — O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ — H_c (ft)	Contraction Loss — H_o (ft)	Q*V for determining controlling inflow pipe — Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe — Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe — Q3V3 (ft^4/s^2)	Controlling Inflow Velocity — Vi	Expansion Loss — Hi (ft)	Controlling In-flow skew — Δ_i (deg)	Bend Loss — H_Δ (ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ — H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss — $H_{t\ adj}$ (ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$ — H (ft)	Inlet W. S. Elevation — HGL Up (ft)	Top of Grate — T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	13.48	13.48	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	13.58	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.42	13.42	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	13.48	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.33	13.33	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	13.42	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.20	13.20	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	13.33	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.07	13.07	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	13.20	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.94	12.94	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	13.07	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.68	12.68	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	12.94	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.50	12.50	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	12.68	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.28	12.28	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	12.50	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.08	12.08	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	12.28	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.76	11.76	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	12.08	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.41	11.41	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	11.76	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.00	11.00	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	11.41	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.90	10.90	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	11.00	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.84**	**10.84**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**10.90**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.48	13.48	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	13.55	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.07	13.07	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	13.13	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.20	12.20	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	12.25	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.08	12.08	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	12.20	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.05	13.05	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.05	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.02	13.02	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	13.05	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.96	12.96	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	13.02	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.84	12.84	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	12.96	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.68	12.68	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	12.84	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.96	12.96	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	13.01	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.77	12.77	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.77	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.76	12.76	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.77	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.72	12.72	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	12.76	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.68	12.68	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	12.72	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.65	12.65	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	12.68	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.51	12.51	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	12.65	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.16	12.16	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	12.51	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.76	11.76	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	12.16	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.76	12.76	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.77	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.65	12.65	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	12.70	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.18	11.18	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.20	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.90	10.90	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	11.18	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.18	11.18	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	11.23	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.00	11.00	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	11.24	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.44	11.44	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.44	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.42	11.42	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.44	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.41	11.41	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	11.42	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.99	11.99	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	12.41	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.69	11.69	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	11.99	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.41	11.41	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	11.69	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.41	12.41	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.42	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.18	13.18	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.19	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.12	13.12	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	13.18	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.02	13.02	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	13.12	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.91	12.91	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	13.02	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.77	12.77	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	12.91	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.60	12.60	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	12.77	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.02	13.02	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	13.07	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.18	13.18	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.21	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.14	13.14	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	13.18	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.05	13.05	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	13.14	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.89	12.89	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	13.05	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.76	12.76	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	12.89	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.60	12.60	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	12.76	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.41	12.41	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	12.60	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.81	12.81	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.81	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.76	12.76	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	12.81	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.05	13.05	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.07	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.81	12.81	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.83	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.60	13.60	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	13.76	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.46	13.46	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	13.60	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.40	13.40	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	13.46	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.96	12.96	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	13.40	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.41	12.41	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	12.96	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.46	13.46	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.47	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.40	13.40	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	13.43	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.40	13.40	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	13.45	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.96	12.96	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.97	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.96	12.96	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.97	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add $Hc = 0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	14.18	14.18	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	14.28	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.12	14.12	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	14.18	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	14.03	14.03	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	14.12	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.90	13.90	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	14.03	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.77	13.77	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	13.90	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.64	13.64	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	13.77	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.38	13.38	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	13.64	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	13.20	13.20	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	13.38	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.98	12.98	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	13.20	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.78	12.78	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	12.98	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.46	12.46	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	12.78	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.11	12.11	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	12.46	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.70	11.70	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	12.11	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	11.60	11.60	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	11.70	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**11.54**	**11.54**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	0.5	**0.06**	**0.06**	**11.60**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.18	14.18	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	14.25	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.77	13.77	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	13.83	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.90	12.90	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	12.95	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.78	12.78	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	12.90	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.75	13.75	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.75	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.72	13.72	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	13.75	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.66	13.66	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	13.72	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.54	13.54	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	13.66	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.38	13.38	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	13.54	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.66	13.66	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	13.71	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.47	13.47	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.47	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.46	13.46	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.47	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.42	13.42	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	13.46	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.38	13.38	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	13.42	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.35	13.35	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	13.38	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	13.21	13.21	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	13.35	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.86	12.86	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	13.21	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.46	12.46	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	12.86	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.46	13.46	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.47	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.35	13.35	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	13.40	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.88	11.88	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.90	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	11.60	11.60	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	11.88	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.88	11.88	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	11.93	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.70	11.70	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	11.94	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.14	12.14	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.14	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.12	12.12	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.14	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.11	12.11	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	12.12	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.69	12.69	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	13.11	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.39	12.39	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	12.69	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 25 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.11	12.11	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	12.39	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.11	13.11	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.12	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.88	13.88	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.89	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.82	13.82	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	13.88	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.72	13.72	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	13.82	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.61	13.61	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	13.72	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.47	13.47	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	13.61	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.30	13.30	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	13.47	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.72	13.72	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	13.77	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.88	13.88	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.91	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.84	13.84	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	13.88	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.75	13.75	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	13.84	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.59	13.59	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	13.75	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.46	13.46	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	13.59	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.30	13.30	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	13.46	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.11	13.11	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	13.30	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.51	13.51	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.51	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.46	13.46	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	13.51	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.75	13.75	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.77	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.51	13.51	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.53	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.30	14.30	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	14.46	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.16	14.16	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	14.30	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	14.10	14.10	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	14.16	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.66	13.66	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	14.10	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.11	13.11	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	13.66	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.16	14.16	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.17	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	14.10	14.10	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	14.13	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	14.10	14.10	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	14.15	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.66	13.66	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.67	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.66	13.66	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.67	10.95	HGL Too High!

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County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	14.68	14.68	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	14.78	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.62	14.62	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	14.68	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	14.53	14.53	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	14.62	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.40	14.40	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	14.53	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	14.27	14.27	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	14.40	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	14.14	14.14	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	14.27	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.88	13.88	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	14.14	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	13.70	13.70	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	13.88	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	13.48	13.48	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	13.70	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	13.28	13.28	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	13.48	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.96	12.96	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	13.28	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.61	12.61	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	12.96	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	12.20	12.20	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	12.61	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	12.10	12.10	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	12.20	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**12.04**	**12.04**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	**0.5**	**0.06**	**0.06**	**12.10**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.68	14.68	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	14.75	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	14.27	14.27	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	14.33	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	13.40	13.40	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	13.45	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	13.28	13.28	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	13.40	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	14.25	14.25	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.25	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	14.22	14.22	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	14.25	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.16	14.16	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	14.22	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	14.04	14.04	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	14.16	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.88	13.88	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	14.04	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.16	14.16	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	14.21	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.97	13.97	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.97	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.96	13.96	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.97	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.92	13.92	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	13.96	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.88	13.88	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	13.92	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.85	13.85	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	13.88	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	13.71	13.71	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	13.85	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	13.36	13.36	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	13.71	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.96	12.96	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	13.36	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.96	13.96	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.97	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.85	13.85	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	13.90	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	12.38	12.38	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.40	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	12.10	12.10	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	12.38	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	12.38	12.38	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	12.43	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	12.20	12.20	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	12.44	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.64	12.64	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.64	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.62	12.62	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.64	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.61	12.61	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	12.62	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	13.19	13.19	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	13.61	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.89	12.89	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	13.19	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.61	12.61	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	12.89	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.61	13.61	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.62	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.38	14.38	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.39	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	14.32	14.32	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	14.38	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	14.22	14.22	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	14.32	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	14.11	14.11	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	14.22	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.97	13.97	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	14.11	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.80	13.80	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	13.97	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	14.22	14.22	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	14.27	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.38	14.38	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	14.41	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.34	14.34	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	14.38	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	14.25	14.25	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	14.34	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	14.09	14.09	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	14.25	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.96	13.96	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	14.09	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.80	13.80	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	13.96	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.61	13.61	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	13.80	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	14.01	14.01	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.01	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.96	13.96	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	14.01	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	14.25	14.25	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	14.27	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	14.01	14.01	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	14.03	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.80	14.80	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	14.96	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.66	14.66	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	14.80	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	14.60	14.60	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	14.66	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.16	14.16	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	14.60	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.61	13.61	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	14.16	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.66	14.66	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.67	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	14.60	14.60	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	14.63	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	14.60	14.60	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	14.65	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.16	14.16	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.17	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.16	14.16	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.17	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	15.98	15.98	24	6.1	2.0	69	92	0.0006	0.06	0	0.00	0.01	12.1	0.0	0.0	2.0	0.0	90	0.04	0.08	1.0	0.5	0.04	0.10	16.08	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	15.92	15.92	30	12.1	2.5	13	30	0.0007	0.02	0	0.00	0.02	12.0	12.7	0.0	2.0	0.0	51.7	0.03	0.08	1.0	0.5	0.04	0.06	15.98	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	15.83	15.83	30	12.6	2.6	0	25	0.0008	0.02	0	0.00	0.03	29.7	0.0	0.0	2.5	0.0	13	0.02	0.08	1.0	1.0	0.08	0.10	15.92	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	15.70	15.70	30	13.3	2.7	6	69	0.0009	0.06	0	0.00	0.03	32.4	0.0	0.0	2.6	0.0	0	0.00	0.06	1.0	1.0	0.06	0.13	15.83	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	15.57	15.57	30	13.8	2.8	13	52	0.0010	0.05	0	0.00	0.03	35.8	0.0	0.0	2.7	0.0	6	0.01	0.08	1.0	1.0	0.08	0.13	15.70	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	15.44	15.44	30	18.1	3.7	83	42	0.0017	0.07	0	0.00	0.05	38.8	14.3	0.0	2.8	0.0	13	0.02	0.12	1.0	0.5	0.06	0.13	15.57	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	15.18	15.18	36	18.6	2.6	90	23	0.0007	0.02	0	0.00	0.03	66.6	0.0	0.0	3.7	0.1	83	0.14	0.24	1.0	1.0	0.24	0.26	15.44	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	15.00	15.00	36	25.7	3.6	82	75	0.0013	0.09	0	0.00	0.05	49.2	19.9	0.0	2.6	0.0	90	0.08	0.16	1.0	0.5	0.08	0.18	15.18	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	14.78	14.78	36	25.4	3.6	7	76	0.0012	0.09	0	0.00	0.05	93.4	0.0	0.0	3.6	0.1	82	0.14	0.26	1.0	0.5	0.13	0.22	15.00	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	14.58	14.58	36	25.4	3.6	89	50	0.0012	0.06	0	0.00	0.05	91.6	0.0	0.0	3.6	0.1	7	0.02	0.14	1.0	1.0	0.14	0.20	14.78	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	14.26	14.26	36	29.8	4.2	92	25	0.0017	0.04	0	0.00	0.07	91.2	14.4	0.0	3.6	0.1	89	0.14	0.28	1.0	1.0	0.28	0.32	14.58	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	13.91	13.91	48	36.6	2.9	91	50	0.0006	0.03	0	0.00	0.03	125.9	31.9	0.0	4.2	0.1	92	0.19	0.32	1.0	1.0	0.32	0.35	14.26	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	13.50	13.50	60	64.6	3.3	17	186	0.0005	0.10	0	0.00	0.04	106.3	1.4	116.4	4.1	0.1	90	0.18	0.31	1.0	1.0	0.31	0.41	13.91	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	13.40	13.40	60	67.3	3.4	0	45	0.0006	0.03	0	0.00	0.05	212.7	25.8	0.0	3.3	0.1	17	0.03	0.14	1.0	0.5	0.07	0.09	13.50	10.50	HGL Too High!
P-87	**MH-87**	OUTFALL	**4.00**	**13.34**	**13.34**	**60**	**71.4**	**3.6**	**0**	**9**	**0.0006**	**0.01**	**0**	**0.00**	**0.05**	**230.6**	**15.3**	**0.0**	**3.4**	**0.1**	**0**	**0.00**	**0.12**	**1.0**	0.5	**0.06**	**0.06**	**13.40**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	15.98	15.98	24	6.3	2.0	51.7	64	0.0007	0.04	0	0.00	0.02	7.7	2.0	0.0	1.6	0.0	51	0.02	0.05	1.0	0.5	0.02	0.07	16.05	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	15.57	15.57	18	5.0	2.8	83	16	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.06	15.63	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	14.70	14.70	18	5.1	2.9	75	17	0.0020	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	14.75	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	14.58	14.58	18	5.0	2.9	74	20	0.0020	0.04	0	0.00	0.03	14.5	0.0	0.0	2.9	0.0	75	0.08	0.16	1.0	0.5	0.08	0.12	14.70	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	15.55	15.55	15	0.5	0.4	1	26	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.55	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	15.52	15.52	15	1.3	1.0	7	69	0.0003	0.02	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.00	1.3	1.0	0.01	0.03	15.55	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	15.46	15.46	15	2.0	1.6	13	51	0.0008	0.04	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	7	0.00	0.02	1.3	1.0	0.02	0.06	15.52	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	15.34	15.34	24	7.0	2.2	83	41	0.0008	0.03	0	0.00	0.02	3.2	15.6	0.0	3.0	0.0	83	0.09	0.16	1.0	0.5	0.08	0.11	15.46	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	15.18	15.18	24	7.9	2.5	90	23	0.0010	0.02	0	0.00	0.02	15.7	0.0	0.0	2.2	0.0	83	0.05	0.10	1.3	1.0	0.14	0.16	15.34	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	15.46	15.46	18	5.3	3.0	83	17	0.0021	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	15.51	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	15.27	15.27	15	0.6	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.27	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	15.26	15.26	18	1.1	0.6	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	15.27	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	15.22	15.22	18	2.3	1.3	2	42	0.0004	0.02	0	0.00	0.01	0.7	0.3	0.0	0.6	0.0	82	0.00	0.01	1.3	1.0	0.02	0.04	15.26	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	15.18	15.18	18	2.6	1.5	8	29	0.0005	0.02	0	0.00	0.01	3.1	0.0	0.0	1.3	0.0	2	0.00	0.02	1.3	1.0	0.02	0.04	15.22	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	15.15	15.15	18	2.8	1.6	8	17	0.0006	0.01	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	15.18	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	15.01	15.01	18	6.9	3.9	5	17	0.0037	0.06	0	0.00	0.06	4.5	10.1	0.0	2.4	0.0	82	0.06	0.15	1.0	0.5	0.07	0.14	15.15	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	14.66	14.66	18	7.2	4.1	9	43	0.0040	0.17	0	0.00	0.06	27.0	0.0	0.0	3.9	0.1	5	0.02	0.17	1.0	1.0	0.17	0.34	15.01	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	14.26	14.26	18	7.5	4.2	2	51	0.0043	0.22	0	0.00	0.07	29.6	0.0	0.0	4.1	0.1	9	0.03	0.19	1.0	1.0	0.19	0.41	14.66	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	15.26	15.26	15	0.6	0.5	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.27	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	15.15	15.15	18	4.2	2.4	82	24	0.0014	0.03	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.06	15.20	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	13.68	13.68	15	1.0	0.9	0	79	0.0002	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.70	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	13.40	13.40	18	5.2	2.9	86	81	0.0021	0.17	0	0.00	0.03	0.9	5.3	0.0	1.7	0.0	90	0.03	0.08	1.3	1.0	0.11	0.28	13.68	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	13.68	13.68	18	3.1	1.7	90	63	0.0007	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	13.73	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	13.50	13.50	12	4.5	5.7	90	16	0.0114	0.18	0	0.00	0.13	0.0	0.0	0.0	0.0	0.0	0	0.00	0.13	1.0	0.5	0.06	0.25	13.74	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	13.94	13.94	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.94	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	13.92	13.92	15	0.9	0.7	89	70	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	13.94	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	13.91	13.91	18	1.6	0.9	0	26	0.0002	0.01	0	0.00	0.00	0.6	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.01	0.02	13.92	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	14.49	14.49	36	28.3	4.0	2	94	0.0015	0.14	0	0.00	0.06	0.0	51.3	55.5	5.6	0.2	78	0.32	0.55	1.0	0.5	0.28	0.42	14.91	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	14.49	14.49	36	28.4	4.0	3	98	0.0015	0.15	0	0.00	0.06	113.7	0.0	0.0	4.0	0.1	2	0.00	0.15	1.0	1.0	0.15	0.30	14.49	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	25	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	13.91	13.91	36	28.7	4.1	90	70	0.0016	0.11	0	0.00	0.06	113.8	0.0	0.0	4.0	0.1	3	0.02	0.18	1.0	1.0	0.18	0.29	14.19	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	14.91	14.91	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.92	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	15.68	15.68	15	0.8	0.7	5	20	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.69	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	15.62	15.62	15	1.6	1.3	6	92	0.0006	0.05	0	0.00	0.01	0.5	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.01	0.06	15.68	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	15.52	15.52	15	2.5	2.0	14	54	0.0012	0.07	0	0.00	0.02	2.2	0.0	0.0	1.3	0.0	6	0.00	0.03	1.3	1.0	0.04	0.10	15.62	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	15.41	15.41	24	7.3	2.3	9	38	0.0009	0.03	0	0.00	0.02	4.9	14.2	0.0	2.8	0.0	82	0.08	0.15	1.0	0.5	0.07	0.11	15.52	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	15.27	15.27	24	7.9	2.5	91	73	0.0010	0.08	0	0.00	0.02	16.9	0.0	0.0	2.3	0.0	9	0.01	0.06	1.0	1.0	0.06	0.14	15.41	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	15.10	15.10	24	8.7	2.8	90	31	0.0013	0.04	0	0.00	0.03	20.0	0.0	0.0	2.5	0.0	91	0.07	0.13	1.0	1.0	0.13	0.17	15.27	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	15.52	15.52	18	5.0	2.8	82	17	0.0019	0.03	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	0.5	0.02	0.05	15.57	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	15.68	15.68	15	1.3	1.0	4	77	0.0003	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	15.71	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	15.64	15.64	15	1.6	1.3	11	38	0.0005	0.02	0	0.00	0.01	1.3	0.0	0.0	1.0	0.0	4	0.00	0.01	1.3	1.0	0.02	0.04	15.68	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	15.55	15.55	15	2.4	2.0	14	46	0.0012	0.06	0	0.00	0.02	2.1	0.0	0.0	1.3	0.0	11	0.00	0.03	1.3	1.0	0.04	0.09	15.64	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	15.39	15.39	18	5.6	3.1	7	46	0.0024	0.11	0	0.00	0.04	4.9	5.9	0.0	1.8	0.0	83	0.04	0.09	1.0	0.5	0.05	0.16	15.55	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	15.26	15.26	24	6.2	2.0	90	73	0.0006	0.05	0	0.00	0.01	17.5	0.0	0.0	3.1	0.1	7	0.02	0.08	1.0	1.0	0.08	0.13	15.39	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	15.10	15.10	24	10.5	3.3	90	30	0.0018	0.05	0	0.00	0.04	12.1	7.6	0.0	2.0	0.0	90	0.04	0.11	1.0	1.0	0.11	0.16	15.26	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	14.91	14.91	36	19.0	2.7	102	115	0.0007	0.08	0	0.00	0.03	34.8	23.9	0.0	3.3	0.1	90	0.12	0.21	1.0	0.5	0.10	0.18	15.10	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	15.31	15.31	15	0.2	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.31	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	15.26	15.26	18	3.7	2.1	67	14	0.0010	0.01	0	0.00	0.02	0.0	6.7	0.0	1.9	0.0	67	0.03	0.07	1.0	0.5	0.04	0.05	15.31	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	15.55	15.55	18	3.2	1.8	83	17	0.0008	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	15.57	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	15.31	15.31	18	3.4	1.9	67	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	15.33	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	16.10	16.10	8	0.8	2.4	47	39	0.0035	0.14	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	1.0	0.02	0.16	16.26	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	15.96	15.96	15	2.0	1.6	90	31	0.0008	0.02	0	0.00	0.01	2.1	0.0	0.0	2.4	0.0	47	0.04	0.08	1.3	1.0	0.11	0.13	16.10	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	15.90	15.90	18	3.1	1.8	0	42	0.0008	0.03	0	0.00	0.01	3.1	1.2	0.0	1.6	0.0	90	0.03	0.05	1.0	0.5	0.03	0.06	15.96	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	15.46	15.46	18	8.7	4.9	0	66	0.0058	0.38	0	0.00	0.09	5.5	3.7	5.3	1.8	0.0	0	0.00	0.11	1.0	0.5	0.06	0.44	15.90	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	14.91	14.91	18	9.9	5.6	78	56	0.0076	0.42	0	0.00	0.12	42.4	0.2	0.3	4.9	0.1	0	0.00	0.25	1.0	0.5	0.13	0.55	15.46	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	15.96	15.96	15	1.2	1.0	90	31	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.97	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	15.90	15.90	18	2.6	1.4	90	56	0.0005	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.03	15.93	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	15.90	15.90	18	3.1	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	15.95	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	15.46	15.46	18	0.6	0.3	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.47	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	15.46	15.46	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.47	10.95	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) Storm Frequency: 25 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
RELOCATED INLET IN SMR																										
P4	**DI19**	**MH1**	CP-1	2405	0	2405	0.06	1.00	0.06	0.06	6.0	0.00	6.84	0.4	15	27.3	0.012	0.000029	0.005	4.1	5.0	2.5	0.19	6.19	4.49	4.35	Q ok
P5	MH1	MH2	CP-1	1	0	1	0.00	1.00	0.00	0.06	6.0	6.19	6.78	0.4	18	82.7	0.012	0.000011	0.005	4.5	8.0	2.2	0.62	6.81	4.25	3.84	Q ok
P7	MH2	MH3	CP-1	1	0	1	0.00	1.00	0.00	0.06	6.0	6.81	6.61	0.4	18	73.8	0.012	0.000010	0.005	4.6	8.1	2.2	0.55	7.36	3.81	3.44	Q ok
P10	MH3	MH4	CP-2	1	0	1	0.00	1.00	0.00	0.27	6.0	7.36	6.43	1.7	18	53.7	0.012	0.000235	0.005	4.6	8.1	3.4	0.26	7.62	3.34	3.07	Q ok
P13	MH4	MH5	CP-2	1	0	1	0.00	1.00	0.00	0.62	6.0	7.62	6.38	3.9	18	59.3	0.012	0.001199	0.005	4.3	7.7	4.3	0.23	7.85	2.97	2.70	Q ok
P15	MH5	MH41	CP-2	1	0	1	0.00	1.00	0.00	0.98	6.0	7.85	6.32	6.2	*24*	**50.0**	0.012	0.000635	0.020	11.0	34.7	8.3	0.10	7.95	2.60	1.60	Q ok
P9	DI3	MH3	CP-1	4110	3259	7369	0.17	0.67	0.11	0.11	6.0	0.00	6.84	0.8	15	18.3	0.012	0.000123	0.005	4.0	4.9	2.8	0.11	6.11	3.68	3.59	Q ok
P8	DI17	MH3	CP-1	3878	2100	5978	0.14	0.75	0.10	0.10	6.0	0.00	6.84	0.7	15	31.3	0.012	0.000101	0.005	4.2	5.2	2.9	0.18	6.18	3.71	3.54	Q ok
P12	DI4	MH4	CP-1	7109	2561	9670	0.22	0.82	0.18	0.18	6.0	0.00	6.73	1.2	15	20.1	0.012	0.000307	0.005	4.0	4.9	3.3	0.10	6.10	3.48	3.38	Q ok
P11	DI18	MH4	CP-1	6435	2210	8645	0.20	0.83	0.16	0.16	6.0	0.00	6.70	1.1	15	28.4	0.012	0.000248	0.005	4.1	5.1	3.1	0.15	6.15	3.48	3.33	Q ok
P14	DI5	MH5	CP-1	4974	2549	7523	0.17	0.76	0.13	0.13	6.0	0.00	6.84	0.9	15	22.6	0.012	0.000164	0.005	4.0	4.9	3.0	0.12	6.12	3.68	3.57	Q ok
P18	DI6	MH6	CP-1	6937	1863	8800	0.20	0.87	0.17	0.17	6.0	0.00	6.84	1.2	15	38.0	0.012	0.000292	0.005	4.0	4.9	3.3	0.19	6.19	4.57	4.38	Q ok
P16	MH6	MH5	CP-2	1	0	1	0.00	1.00	0.00	0.23	6.0	6.19	6.78	1.6	18	40.0	0.012	0.000186	0.011	6.8	12.1	4.8	0.14	6.33	3.77	3.32	Q ok
RELOCATED INLET IN SMR																											
P17	**DI49**	**MH6**	CP-2	2236	105	2341	0.05	1.00	0.05	0.05	6.0	0.00	6.84	0.4	15	33.0	0.012	0.000028	0.005	4.0	4.9	2.0	0.28	6.28	4.19	4.02	Q ok
P32	DI23	MH12	CP-2	5495	1914	7409	0.17	0.83	0.14	0.14	6.0	0.00	6.84	1.0	15	33.31	0.012	0.0002	0.005	4.1	5.0	3.1	0.18	6.18	3.98	3.81	Q ok
P31	DI9	MH12	CP-2	4483	551	5034	0.12	0.95	0.11	0.11	6.0	0.00	6.84	0.8	15	18.3	0.012	0.0001	0.005	4.0	4.9	2.8	0.11	6.11	3.86	3.77	Q ok
P30	MH12	MH11	CP-2	1	0	1	0.00	1.00	0.00	0.25	6.0	6.18	6.78	1.7	18	50.1	0.012	0.0002	0.005	4.5	8.0	3.4	0.24	6.43	3.67	3.42	Q ok
P27	MH11	MH10	CP-2	1	0	1	0.00	1.00	0.00	0.52	6.0	6.43	6.72	3.5	18	73.2	0.012	0.0009	0.005	4.6	8.1	4.4	0.27	6.70	3.39	3.02	Q ok
P25	MH10	MH9	CP-2	1	0	1	0.00	1.00	0.00	0.59	6.0	6.70	6.64	3.9	24	69.68	0.012	0.0003	0.006	6.3	19.7	4.7	0.25	6.95	2.92	2.47	Q ok
P22	MH9	MH8	CP-2	1	0	1	0.00	1.00	0.00	0.75	6.0	6.95	6.58	4.9	24	108.3	0.012	0.0004	0.005	5.5	17.3	4.7	0.38	7.33	2.47	1.93	Q ok
P-80	DI-80	MH-08		9967	0	9967	0.23	1.00	0.23	0.23	6.0	0.00	6.84	1.6	15	49	0.012	0.0005	0.009	5.5	6.8	4.5	0.18	6.18	4.53	4.07	Q ok
P28	DI22	MH11	CP-1	5555	1955	7510	0.17	0.82	0.14	0.14	6.0	0.00	6.84	1.0	15	30.3	0.012	0.0002	0.005	4.0	4.9	3.0	0.17	6.17	3.64	3.49	Q ok
P29	DI8	MH11	CP-1	5120	570	5690	0.13	0.96	0.13	0.13	6.0	0.00	6.84	0.9	15	18.3	0.012	0.0002	0.005	4.0	4.9	2.8	0.11	6.11	3.64	3.55	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) Storm Frequency: 25 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P26	DI21	MH10	CP-1	2755	930	3685	0.08	0.83	0.07	0.07	6.0	0.00	6.84	0.5	15	18.3	0.012	0.0000	0.005	4.0	4.9	2.4	0.13	6.13	4.02	3.93	Q ok
P23	DI20	MH9	CP-2	3213	1102	4315	0.10	0.83	0.08	0.08	6.0	0.00	6.84	0.6	15	29.3	0.012	0.0001	0.005	4.0	4.9	2.4	0.20	6.20	4.53	4.38	Q ok
P24	DI7	MH9	CP-2	3164	527	3691	0.08	0.92	0.08	0.08	6.0	0.00	6.84	0.5	15	28.02	0.012	0.0001	0.005	4.0	4.9	2.4	0.19	6.19	4.38	4.24	Q ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	6.12	6.12	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.12	7.41	
P5	MH1	MH2	1.20	6.12	6.12	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	6.12	7.93	HGL ok
P7	MH2	MH3	1.20	6.12	6.12	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.12	7.65	HGL ok
P10	MH3	MH4	1.20	6.10	6.10	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	6.12	7.28	HGL ok
P13	MH4	MH5	1.20	6.02	6.02	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	6.10	7.09	HGL Too High!
P15	MH5	MH41	1.60	5.94	5.94	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	6.02	7.40	HGL ok
P9	DI3	MH3	1.00	6.12	6.12	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.12	6.62	HGL Too High!
P8	DI17	MH3	1.00	6.12	6.12	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.13	6.96	HGL Too High!
P12	DI4	MH4	1.00	6.10	6.10	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.11	6.48	HGL Too High!
P11	DI18	MH4	1.00	6.10	6.10	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.11	6.56	HGL Too High!
P14	DI5	MH5	1.00	6.02	6.02	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.02	6.61	HGL Too High!
P18	DI6	MH6	1.00	6.03	6.03	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.05	7.13	HGL ok
P16	MH6	MH5	1.20	6.02	6.02	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	6.03	7.55	HGL ok
P17	DI49	MH6	1.00	6.03	6.03	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.03	7.08	HGL ok
P32	DI23	MH12	1.00	6.08	6.08	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.09	7.11	HGL ok
P31	DI9	MH12	1.00	6.08	6.08	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.08	7.13	HGL ok
P30	MH12	MH11	1.60	6.06	6.06	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	6.08	7.48	HGL ok
P27	MH11	MH10	1.60	5.99	5.99	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	6.06	7.21	HGL ok
P25	MH10	MH9	1.60	5.96	5.96	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	5.99	7.54	HGL ok
P22	MH9	MH8	1.60	5.91	5.91	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	5.96	7.85	HGL ok
P-80	DI-80	MH-08	1.00	5.91	5.91	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	5.94	7.34	HGL ok
P28	DI22	MH11	1.00	6.06	6.06	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.07	6.74	HGL Too High!
P29	DI8	MH11	1.00	6.06	6.06	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.07	6.92	HGL Too High!
P26	DI21	MH10	1.00	5.99	5.99	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.99	7.23	HGL ok
P23	DI20	MH9	1.00	5.96	5.96	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	5.97	7.38	HGL ok
P24	DI7	MH9	1.00	5.96	5.96	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.97	7.48	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	6.32	6.32	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.32	7.41	
P5	MH1	MH2	1.20	6.32	6.32	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	6.32	7.93	HGL ok
P7	MH2	MH3	1.20	6.32	6.32	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.32	7.65	HGL ok
P10	MH3	MH4	1.20	6.30	6.30	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	6.32	7.28	HGL Too High!
P13	MH4	MH5	1.20	6.22	6.22	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	6.30	7.09	HGL Too High!
P15	MH5	MH41	1.60	6.14	6.14	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	6.22	7.40	HGL ok
P9	DI3	MH3	1.00	6.32	6.32	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.32	6.62	HGL Too High!
P8	DI17	MH3	1.00	6.32	6.32	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.33	6.96	HGL Too High!
P12	DI4	MH4	1.00	6.30	6.30	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.31	6.48	HGL Too High!
P11	DI18	MH4	1.00	6.30	6.30	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.31	6.56	HGL Too High!
P14	DI5	MH5	1.00	6.22	6.22	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.22	6.61	HGL Too High!
P18	DI6	MH6	1.00	6.23	6.23	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.25	7.13	HGL Too High!
P16	MH6	MH5	1.20	6.22	6.22	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	6.23	7.55	HGL ok
P17	DI49	MH6	1.00	6.23	6.23	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.23	7.08	HGL Too High!
P32	DI23	MH12	1.00	6.28	6.28	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.29	7.11	HGL Too High!
P31	DI9	MH12	1.00	6.28	6.28	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.28	7.13	HGL Too High!
P30	MH12	MH11	1.60	6.26	6.26	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	6.28	7.48	HGL ok
P27	MH11	MH10	1.60	6.19	6.19	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	6.26	7.21	HGL Too High!
P25	MH10	MH9	1.60	6.16	6.16	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	6.19	7.54	HGL ok
P22	MH9	MH8	1.60	6.11	6.11	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	6.16	7.85	HGL ok
P-80	DI-80	MH-08	1.00	6.11	6.11	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	6.14	7.34	HGL ok
P28	DI22	MH11	1.00	6.26	6.26	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.27	6.74	HGL Too High!
P29	DI8	MH11	1.00	6.26	6.26	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.27	6.92	HGL Too High!
P26	DI21	MH10	1.00	6.19	6.19	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.19	7.23	HGL ok
P23	DI20	MH9	1.00	6.16	6.16	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	6.17	7.38	HGL ok
P24	DI7	MH9	1.00	6.16	6.16	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.17	7.48	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.82	9.82	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	7.41	
P5	MH1	MH2	1.20	9.82	9.82	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.82	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.82	9.82	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.82	7.65	HGL Too High!
P10	MH3	MH4	1.20	9.80	9.80	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	9.82	7.28	HGL Too High!
P13	MH4	MH5	1.20	9.72	9.72	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	9.80	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.64	9.64	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	9.72	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.82	9.82	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.82	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.82	9.82	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.83	6.96	HGL Too High!
P12	DI4	MH4	1.00	9.80	9.80	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.81	6.48	HGL Too High!
P11	DI18	MH4	1.00	9.80	9.80	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.81	6.56	HGL Too High!
P14	DI5	MH5	1.00	9.72	9.72	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.72	6.61	HGL Too High!
P18	DI6	MH6	1.00	9.73	9.73	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.75	7.13	HGL Too High!
P16	MH6	MH5	1.20	9.72	9.72	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	9.73	7.55	HGL Too High!
P17	DI49	MH6	1.00	9.73	9.73	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.73	7.08	HGL Too High!
P32	DI23	MH12	1.00	9.78	9.78	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.79	7.11	HGL Too High!
P31	DI9	MH12	1.00	9.78	9.78	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.78	7.13	HGL Too High!
P30	MH12	MH11	1.60	9.76	9.76	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	9.78	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.69	9.69	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	9.76	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.66	9.66	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	9.69	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.61	9.61	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	9.66	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.61	9.61	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	9.64	7.34	HGL Too High!
P28	DI22	MH11	1.00	9.76	9.76	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.77	6.74	HGL Too High!
P29	DI8	MH11	1.00	9.76	9.76	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.77	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.69	9.69	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.69	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.66	9.66	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.67	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.66	9.66	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.67	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.32	10.32	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	7.41	
P5	MH1	MH2	1.20	10.32	10.32	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.32	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.32	10.32	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.32	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.30	10.30	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	10.32	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.22	10.22	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	10.30	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.14	10.14	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	10.22	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.32	10.32	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.32	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.32	10.32	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.33	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.30	10.30	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.31	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.30	10.30	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.31	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.22	10.22	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.22	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.23	10.23	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.25	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.22	10.22	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	10.23	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.23	10.23	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.23	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.28	10.28	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.29	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.28	10.28	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.28	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.26	10.26	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	10.28	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.19	10.19	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	10.26	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.16	10.16	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	10.19	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.11	10.11	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	10.16	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.11	10.11	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	10.14	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.26	10.26	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.27	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.26	10.26	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.27	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.19	10.19	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.19	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.16	10.16	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.17	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.16	10.16	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.17	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.72	10.72	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.72	7.41	
P5	MH1	MH2	1.20	10.72	10.72	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.72	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.72	10.72	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.72	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.70	10.70	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	10.72	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.62	10.62	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	10.70	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.54	10.54	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	10.62	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.72	10.72	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.72	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.72	10.72	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.73	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.70	10.70	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.71	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.70	10.70	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.71	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.62	10.62	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.62	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.63	10.63	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.65	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.62	10.62	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	10.63	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.63	10.63	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.63	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.68	10.68	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.69	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.68	10.68	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.68	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.66	10.66	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	10.68	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.59	10.59	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	10.66	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.56	10.56	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	10.59	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.51	10.51	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	10.56	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.51	10.51	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	10.54	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.66	10.66	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.67	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.66	10.66	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.67	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.59	10.59	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.59	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.56	10.56	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.57	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.56	10.56	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.57	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.22	11.22	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.22	7.41	
P5	MH1	MH2	1.20	11.22	11.22	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.22	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.22	11.22	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.22	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.20	11.20	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	11.22	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.12	11.12	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	11.20	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.04	11.04	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	11.12	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.22	11.22	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.22	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.22	11.22	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.23	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.20	11.20	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.21	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.20	11.20	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.21	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.12	11.12	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.12	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.13	11.13	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.15	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.12	11.12	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	11.13	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.13	11.13	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.13	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.18	11.18	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.19	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.18	11.18	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.18	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.16	11.16	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	11.18	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.09	11.09	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	11.16	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.06	11.06	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	11.09	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.01	11.01	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	11.06	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.01	11.01	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	11.04	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.16	11.16	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.17	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.16	11.16	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.17	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.09	11.09	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.09	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.06	11.06	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.07	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.06	11.06	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.07	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.92	11.92	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.92	7.41	
P5	MH1	MH2	1.20	11.92	11.92	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.92	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.92	11.92	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.92	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.90	11.90	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	11.92	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.82	11.82	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	11.90	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.74	11.74	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	11.82	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.92	11.92	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.92	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.92	11.92	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.93	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.90	11.90	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.91	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.90	11.90	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.91	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.82	11.82	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.82	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.83	11.83	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.85	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.82	11.82	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	11.83	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.83	11.83	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.83	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.88	11.88	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.89	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.88	11.88	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.88	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.86	11.86	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	11.88	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.79	11.79	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	11.86	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.76	11.76	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	11.79	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.71	11.71	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	11.76	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.71	11.71	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	11.74	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.86	11.86	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.87	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.86	11.86	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.87	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.79	11.79	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.79	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.76	11.76	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.77	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.76	11.76	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.77	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.42	12.42	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.42	7.41	
P5	MH1	MH2	1.20	12.42	12.42	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.42	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.42	12.42	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.42	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.40	12.40	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	12.42	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.32	12.32	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	12.40	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.24	12.24	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	12.32	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.42	12.42	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.42	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.42	12.42	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.43	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.40	12.40	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.41	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.40	12.40	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.41	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.32	12.32	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.32	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.33	12.33	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.35	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.32	12.32	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	12.33	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.33	12.33	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.33	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.38	12.38	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.39	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.38	12.38	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.38	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.36	12.36	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	12.38	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.29	12.29	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	12.36	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.26	12.26	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	12.29	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.21	12.21	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	12.26	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.21	12.21	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	12.24	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.36	12.36	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.37	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.36	12.36	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.37	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.29	12.29	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.29	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.26	12.26	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.27	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.26	12.26	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.27	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.72	13.72	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.72	7.41	
P5	MH1	MH2	1.20	13.72	13.72	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.72	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.72	13.72	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.72	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.70	13.70	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	13.72	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.62	13.62	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	13.70	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.54	13.54	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	13.62	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.72	13.72	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.72	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.72	13.72	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.73	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.70	13.70	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.71	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.70	13.70	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.71	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.62	13.62	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.62	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.63	13.63	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.65	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.62	13.62	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	13.63	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.63	13.63	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.63	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.68	13.68	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.69	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.68	13.68	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.68	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.66	13.66	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	13.68	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.59	13.59	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	13.66	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.56	13.56	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	13.59	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.51	13.51	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	13.56	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.51	13.51	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	13.54	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.66	13.66	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.67	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.66	13.66	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.67	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.59	13.59	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.59	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.56	13.56	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.57	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.56	13.56	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.57	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	8.66	8.66	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.66	7.41	
P5	MH1	MH2	1.20	8.66	8.66	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	8.66	7.93	HGL Too High!
P7	MH2	MH3	1.20	8.66	8.66	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.66	7.65	HGL Too High!
P10	MH3	MH4	1.20	8.64	8.64	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	8.66	7.28	HGL Too High!
P13	MH4	MH5	1.20	8.56	8.56	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	8.64	7.09	HGL Too High!
P15	MH5	MH41	1.60	8.48	8.48	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	8.56	7.40	HGL Too High!
P9	DI3	MH3	1.00	8.66	8.66	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.66	6.62	HGL Too High!
P8	DI17	MH3	1.00	8.66	8.66	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.67	6.96	HGL Too High!
P12	DI4	MH4	1.00	8.64	8.64	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.65	6.48	HGL Too High!
P11	DI18	MH4	1.00	8.64	8.64	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.65	6.56	HGL Too High!
P14	DI5	MH5	1.00	8.56	8.56	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.56	6.61	HGL Too High!
P18	DI6	MH6	1.00	8.57	8.57	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.59	7.13	HGL Too High!
P16	MH6	MH5	1.20	8.56	8.56	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	8.57	7.55	HGL Too High!
P17	DI49	MH6	1.00	8.57	8.57	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.57	7.08	HGL Too High!
P32	DI23	MH12	1.00	8.62	8.62	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.63	7.11	HGL Too High!
P31	DI9	MH12	1.00	8.62	8.62	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.62	7.13	HGL Too High!
P30	MH12	MH11	1.60	8.60	8.60	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	8.62	7.48	HGL Too High!
P27	MH11	MH10	1.60	8.53	8.53	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	8.60	7.21	HGL Too High!
P25	MH10	MH9	1.60	8.50	8.50	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	8.53	7.54	HGL Too High!
P22	MH9	MH8	1.60	8.45	8.45	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	8.50	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	8.45	8.45	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	8.48	7.34	HGL Too High!
P28	DI22	MH11	1.00	8.60	8.60	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.61	6.74	HGL Too High!
P29	DI8	MH11	1.00	8.60	8.60	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.61	6.92	HGL Too High!
P26	DI21	MH10	1.00	8.53	8.53	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.53	7.23	HGL Too High!
P23	DI20	MH9	1.00	8.50	8.50	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	8.51	7.38	HGL Too High!
P24	DI7	MH9	1.00	8.50	8.50	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.51	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	8.86	8.86	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.86	7.41	
P5	MH1	MH2	1.20	8.86	8.86	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	8.86	7.93	HGL Too High!
P7	MH2	MH3	1.20	8.86	8.86	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	8.86	7.65	HGL Too High!
P10	MH3	MH4	1.20	8.84	8.84	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	8.86	7.28	HGL Too High!
P13	MH4	MH5	1.20	8.76	8.76	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	8.84	7.09	HGL Too High!
P15	MH5	MH41	1.60	8.68	8.68	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	8.76	7.40	HGL Too High!
P9	DI3	MH3	1.00	8.86	8.86	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.86	6.62	HGL Too High!
P8	DI17	MH3	1.00	8.86	8.86	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.87	6.96	HGL Too High!
P12	DI4	MH4	1.00	8.84	8.84	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.85	6.48	HGL Too High!
P11	DI18	MH4	1.00	8.84	8.84	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.85	6.56	HGL Too High!
P14	DI5	MH5	1.00	8.76	8.76	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.76	6.61	HGL Too High!
P18	DI6	MH6	1.00	8.77	8.77	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.79	7.13	HGL Too High!
P16	MH6	MH5	1.20	8.76	8.76	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	8.77	7.55	HGL Too High!
P17	DI49	MH6	1.00	8.77	8.77	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.77	7.08	HGL Too High!
P32	DI23	MH12	1.00	8.82	8.82	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.83	7.11	HGL Too High!
P31	DI9	MH12	1.00	8.82	8.82	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.82	7.13	HGL Too High!
P30	MH12	MH11	1.60	8.80	8.80	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	8.82	7.48	HGL Too High!
P27	MH11	MH10	1.60	8.73	8.73	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	8.80	7.21	HGL Too High!
P25	MH10	MH9	1.60	8.70	8.70	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	8.73	7.54	HGL Too High!
P22	MH9	MH8	1.60	8.65	8.65	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	8.70	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	8.65	8.65	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	8.68	7.34	HGL Too High!
P28	DI22	MH11	1.00	8.80	8.80	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.81	6.74	HGL Too High!
P29	DI8	MH11	1.00	8.80	8.80	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.81	6.92	HGL Too High!
P26	DI21	MH10	1.00	8.73	8.73	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.73	7.23	HGL Too High!
P23	DI20	MH9	1.00	8.70	8.70	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	8.71	7.38	HGL Too High!
P24	DI7	MH9	1.00	8.70	8.70	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.71	7.48	HGL Too High!

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No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.36	12.36	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	7.41	
P5	MH1	MH2	1.20	12.36	12.36	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.36	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.36	12.36	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.36	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.34	12.34	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	12.36	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.26	12.26	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	12.34	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.18	12.18	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	12.26	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.36	12.36	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.36	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.36	12.36	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.37	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.34	12.34	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.35	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.34	12.34	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.35	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.26	12.26	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.26	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.27	12.27	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.29	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.26	12.26	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	12.27	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.27	12.27	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.27	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.32	12.32	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.33	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.32	12.32	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.32	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.30	12.30	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	12.32	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.23	12.23	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	12.30	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.20	12.20	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	12.23	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.15	12.15	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	12.20	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.15	12.15	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	12.18	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.30	12.30	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.31	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.30	12.30	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.31	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.23	12.23	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.23	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.20	12.20	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.21	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.20	12.20	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.21	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.86	12.86	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.86	7.41	
P5	MH1	MH2	1.20	12.86	12.86	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.86	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.86	12.86	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.86	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.84	12.84	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	12.86	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.76	12.76	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	12.84	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.68	12.68	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	12.76	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.86	12.86	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.86	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.86	12.86	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.87	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.84	12.84	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.85	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.84	12.84	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.85	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.76	12.76	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.76	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.77	12.77	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.79	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.76	12.76	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	12.77	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.77	12.77	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.77	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.82	12.82	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.83	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.82	12.82	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.82	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.80	12.80	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	12.82	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.73	12.73	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	12.80	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.70	12.70	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	12.73	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.65	12.65	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	12.70	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.65	12.65	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	12.68	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.80	12.80	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.81	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.80	12.80	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.81	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.73	12.73	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.73	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.70	12.70	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.71	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.70	12.70	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.71	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.26	13.26	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.26	7.41	
P5	MH1	MH2	1.20	13.26	13.26	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.26	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.26	13.26	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.26	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.24	13.24	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	13.26	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.16	13.16	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	13.24	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.08	13.08	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	13.16	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.26	13.26	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.26	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.26	13.26	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.27	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.24	13.24	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.25	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.24	13.24	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.25	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.16	13.16	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.16	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.17	13.17	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.19	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.16	13.16	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	13.17	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.17	13.17	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.17	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.22	13.22	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.23	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.22	13.22	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.22	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.20	13.20	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	13.22	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.13	13.13	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	13.20	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.10	13.10	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	13.13	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.05	13.05	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	13.10	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.05	13.05	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	13.08	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.20	13.20	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.21	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.20	13.20	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.21	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.13	13.13	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.13	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.10	13.10	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.11	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.10	13.10	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.11	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.76	13.76	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.76	7.41	
P5	MH1	MH2	1.20	13.76	13.76	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.76	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.76	13.76	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.76	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.74	13.74	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	13.76	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.66	13.66	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	13.74	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.58	13.58	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	13.66	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.76	13.76	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.76	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.76	13.76	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.77	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.74	13.74	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.75	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.74	13.74	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.75	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.66	13.66	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.66	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.67	13.67	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.69	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.66	13.66	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	13.67	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.67	13.67	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.67	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.72	13.72	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.73	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.72	13.72	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.72	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.70	13.70	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	13.72	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.63	13.63	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	13.70	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.60	13.60	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	13.63	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.55	13.55	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	13.60	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.55	13.55	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	13.58	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.70	13.70	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.71	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.70	13.70	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.71	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.63	13.63	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.63	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.60	13.60	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.61	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.60	13.60	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.61	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	14.46	14.46	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.46	7.41	
P5	MH1	MH2	1.20	14.46	14.46	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	14.46	7.93	HGL Too High!
P7	MH2	MH3	1.20	14.46	14.46	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	14.46	7.65	HGL Too High!
P10	MH3	MH4	1.20	14.44	14.44	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	14.46	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.36	14.36	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	14.44	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.28	14.28	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	14.36	7.40	HGL Too High!
P9	DI3	MH3	1.00	14.46	14.46	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.46	6.62	HGL Too High!
P8	DI17	MH3	1.00	14.46	14.46	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.47	6.96	HGL Too High!
P12	DI4	MH4	1.00	14.44	14.44	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.45	6.48	HGL Too High!
P11	DI18	MH4	1.00	14.44	14.44	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.45	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.36	14.36	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.36	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.37	14.37	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.39	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.36	14.36	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	14.37	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.37	14.37	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.37	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.42	14.42	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.43	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.42	14.42	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.42	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.40	14.40	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	14.42	7.48	HGL Too High!
P27	MH11	MH10	1.60	14.33	14.33	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	14.40	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.30	14.30	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	14.33	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.25	14.25	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	14.30	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.25	14.25	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	14.28	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.40	14.40	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.41	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.40	14.40	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.41	6.92	HGL Too High!
P26	DI21	MH10	1.00	14.33	14.33	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.33	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.30	14.30	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.31	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.30	14.30	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.31	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	14.96	14.96	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.96	7.41	
P5	MH1	MH2	1.20	14.96	14.96	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	14.96	7.93	HGL Too High!
P7	MH2	MH3	1.20	14.96	14.96	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	14.96	7.65	HGL Too High!
P10	MH3	MH4	1.20	14.94	14.94	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	14.96	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.86	14.86	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	14.94	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.78	14.78	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	14.86	7.40	HGL Too High!
P9	DI3	MH3	1.00	14.96	14.96	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.96	6.62	HGL Too High!
P8	DI17	MH3	1.00	14.96	14.96	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.97	6.96	HGL Too High!
P12	DI4	MH4	1.00	14.94	14.94	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.95	6.48	HGL Too High!
P11	DI18	MH4	1.00	14.94	14.94	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.95	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.86	14.86	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.86	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.87	14.87	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.89	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.86	14.86	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	14.87	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.87	14.87	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.87	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.92	14.92	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.93	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.92	14.92	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.92	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.90	14.90	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	14.92	7.48	HGL Too High!
P27	MH11	MH10	1.60	14.83	14.83	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	14.90	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.80	14.80	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	14.83	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.75	14.75	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	14.80	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.75	14.75	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	14.78	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.90	14.90	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.91	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.90	14.90	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.91	6.92	HGL Too High!
P26	DI21	MH10	1.00	14.83	14.83	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.83	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.80	14.80	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.81	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.80	14.80	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.81	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 25 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc =	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	16.26	16.26	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.26	7.41	
P5	MH1	MH2	1.20	16.26	16.26	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	16.26	7.93	HGL Too High!
P7	MH2	MH3	1.20	16.26	16.26	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	16.26	7.65	HGL Too High!
P10	MH3	MH4	1.20	16.24	16.24	18	1.7	1.0	8	53.7	0.0002	0.01	0	0.00	0.00	0.1	0.5	0.4	0.6	0.0	87	0.00	0.01	1.0	0.5	0.01	0.02	16.26	7.28	HGL Too High!
P13	MH4	MH5	1.20	16.16	16.16	18	3.9	2.2	84	59.3	0.0012	0.07	0	0.00	0.02	1.7	1.2	1.0	1.0	0.0	8	0.00	0.03	1.0	0.5	0.01	0.08	16.24	7.09	HGL Too High!
P15	MH5	MH41	1.60	16.08	16.08	24	6.2	2.0	90	50	0.0006	0.03	0	0.00	0.02	8.8	0.7	1.4	2.2	0.0	84	0.05	0.09	1.0	0.5	0.05	0.08	16.16	7.40	HGL Too High!
P9	DI3	MH3	1.00	16.26	16.26	15	0.8	0.6	87	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.26	6.62	HGL Too High!
P8	DI17	MH3	1.00	16.26	16.26	15	0.7	0.6	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.27	6.96	HGL Too High!
P12	DI4	MH4	1.00	16.24	16.24	15	1.2	1.0	99	20.1	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.25	6.48	HGL Too High!
P11	DI18	MH4	1.00	16.24	16.24	15	1.1	0.9	86	28.4	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.25	6.56	HGL Too High!
P14	DI5	MH5	1.00	16.16	16.16	15	0.9	0.7	21	22.6	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.16	6.61	HGL Too High!
P18	DI6	MH6	1.00	16.17	16.17	15	1.2	1.0	23	38	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.19	7.13	HGL Too High!
P16	MH6	MH5	1.20	16.16	16.16	18	1.6	0.9	86	40	0.0002	0.01	0	0.00	0.00	1.2	0.1	0.0	1.0	0.0	23	0.00	0.01	1.0	0.5	0.01	0.01	16.17	7.55	HGL Too High!
P17	DI49	MH6	1.00	16.17	16.17	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.17	7.08	HGL Too High!
P32	DI23	MH12	1.00	16.22	16.22	15	1.0	0.8	64	33.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.23	7.11	HGL Too High!
P31	DI9	MH12	1.00	16.22	16.22	15	0.8	0.6	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.22	7.13	HGL Too High!
P30	MH12	MH11	1.60	16.20	16.20	24	1.7	0.5	1	50.1	0.0002	0.01	0	0.00	0.00	0.5	0.8	0.0	0.8	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	16.22	7.48	HGL Too High!
P27	MH11	MH10	1.60	16.13	16.13	24	3.5	1.1	5	73.2	0.0009	0.07	0	0.00	0.00	0.9	0.8	0.6	0.5	0.0	1	0.00	0.01	1.0	0.5	0.00	0.07	16.20	7.21	HGL Too High!
P25	MH10	MH9	1.60	16.10	16.10	24	3.9	1.2	5	69.7	0.0003	0.02	0	0.00	0.01	3.9	0.2	0.0	1.1	0.0	5	0.00	0.01	1.0	0.5	0.01	0.02	16.13	7.54	HGL Too High!
P22	MH9	MH8	1.60	16.05	16.05	24	4.9	1.6	51	108	0.0004	0.04	0	0.00	0.01	4.9	0.3	0.2	1.2	0.0	5	0.00	0.02	1.0	0.5	0.01	0.05	16.10	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	16.05	16.05	15	1.6	1.3	35	49	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.03	16.08	7.34	HGL Too High!
P28	DI22	MH11	1.00	16.20	16.20	15	1.0	0.8	90	30.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.21	6.74	HGL Too High!
P29	DI8	MH11	1.00	16.20	16.20	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.21	6.92	HGL Too High!
P26	DI21	MH10	1.00	16.13	16.13	15	0.5	0.4	93	18.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.13	7.23	HGL Too High!
P23	DI20	MH9	1.00	16.10	16.10	15	0.6	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	16.11	7.38	HGL Too High!
P24	DI7	MH9	1.00	16.10	16.10	15	0.5	0.4	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.11	7.48	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 50 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-41	MH-41	MH-42	1	0	1	0.00	1.00	0.00	1.06	6.0	7.91	6.70	7.08	24	92	0.012	0.000834	0.0033	4.5	14.0	4.4	0.35	8.26	1.50	1.20	Q ok
P-42	MH-42	DI-43	1	0	1	0.00	1.00	0.00	2.09	6.0	8.26	6.58	13.75	30	30	0.012	0.000958	0.0030	5.0	24.3	5.1	0.10	8.36	1.10	1.01	Q ok
P-43	DI-43	DI-44	4208	31	4239	0.10	1.00	0.10	2.19	6.0	8.36	6.55	14.32	30	25	0.012	0.001039	0.0032	5.1	25.1	5.2	0.08	8.44	0.91	0.83	Q ok
P-44	DI-44	DI-45	4675	523	5198	0.12	1.00	0.12	2.31	6.0	8.44	6.55	15.10	30	69	0.012	0.001156	0.0030	5.0	24.5	5.2	0.22	8.66	0.73	0.52	Q ok
P-45	DI-45	MH-46	4490	535	5025	0.12	1.00	0.12	2.42	6.0	8.66	6.45	15.63	30	52	0.012	0.001238	0.0031	5.0	24.6	5.4	0.16	8.82	0.42	0.26	Q ok
P-46	MH-46	DI-47	1	0	1	0.00	1.00	0.00	3.16	6.0	8.82	6.42	20.28	30	42	0.012	0.002084	0.0031	5.0	24.7	5.6	0.12	8.94	0.16	0.03	Q ok
P-47	DI-47	MH-60	4551	287	4838	0.11	1.00	0.11	3.27	6.0	8.94	6.39	20.90	36	23	0.012	0.000836	0.0030	5.6	39.9	5.6	0.07	9.01	-0.07	-0.14	Q ok
P-60	MH-60	MH-61	1	0	1	0.00	1.00	0.00	4.48	6.0	9.01	6.36	28.50	36	75	0.012	0.001556	0.0039	6.4	44.9	6.8	0.18	9.20	-0.24	-0.53	Q ok
P-61	MH-61	DI-62	1	0	1	0.00	1.00	0.00	4.48	6.0	9.20	6.30	28.22	36	76	0.012	0.001525	0.0039	6.4	45.4	6.7	0.19	9.38	-0.63	-0.93	Q ok
P-62	DI-62	DI-63	1435	40	1475	0.03	1.00	0.03	4.51	6.0	9.38	6.24	28.15	36	50	0.012	0.001518	0.0040	6.5	45.7	6.8	0.12	9.51	-1.03	-1.23	Q ok
P-63	DI-63	DI-77	1999	107	2106	0.05	1.00	0.05	5.30	6.0	9.51	6.21	32.91	36	25	0.012	0.002074	0.0036	6.1	43.4	6.8	0.06	9.57	-1.33	-1.42	Q ok
P-77	DI-77	DI-85	2311	122	2433	0.06	1.00	0.06	6.55	6.0	9.57	6.17	40.46	48	50	0.012	0.000676	0.0030	6.8	85.2	6.6	0.13	9.69	-1.52	-1.67	Q ok
P-85	DI-85	MH-86	5006	304	5310	0.12	1.00	0.12	11.61	6.0	9.69	6.14	71.32	60	186	0.012	0.000639	0.0030	7.9	154.8	7.6	0.41	10.10	-1.77	-2.33	Q ok
P-86	MH-86	MH-87	1	0	1	0.00	1.00	0.00	12.33	6.0	10.10	6.03	74.35	60	45	0.012	0.000694	0.0031	8.0	157.4	7.8	0.10	10.20	-2.43	-2.57	Q ok
P-87	**MH-87**	**OUTFALL**	**1**	**0**	**1**	**0.00**	**1.00**	**0.00**	**13.13**	**6.0**	**10.20**	**6.01**	**78.92**	**60**	**9**	**0.012**	**0.000782**	**0.0033**	**8.3**	**162.9**	**8.2**	**0.02**	**10.22**	**-2.67**	**-2.70**	**Q ok**
P-48	MSS MH-08	MH-49	1	0	1	0.00	1.00	0.00	1.03	6.0	7.26	6.89	7.12	24	64	0.012	0.000845	0.0070	6.5	20.6	5.9	0.18	7.45	1.65	1.20	Q ok
P-50	B7 North	1.00	32048	0	32048	0.74	1.00	0.74	0.74	6.0	0.00	7.29	5.36	18	16	0.012	0.002221	0.0050	4.6	8.0	4.9	0.05	6.05	0.35	0.27	Q ok
P-65	B7 West	MH-64	32234	0	32234	0.74	1.00	0.74	0.74	6.0	0.00	7.29	5.39	18	17	0.012	0.002247	0.0047	4.4	7.8	4.8	0.06	6.06	-0.95	-1.03	Q ok
P-64	MH-64	DI-63	1	0	1	0.00	1.00	0.00	0.74	6.0	6.06	7.26	5.37	18	20	0.012	0.002228	0.0050	4.6	8.0	4.9	0.07	6.13	-1.13	-1.23	Q ok
P-51	DI-51	DI-52	3030	31	3061	0.07	1.00	0.07	0.07	6.0	0.00	7.29	0.51	15	26	0.012	0.000054	0.0050	4.0	4.9	2.4	0.18	6.18	3.70	3.57	Q ok
P-52	DI-52	DI-53	4699	521	5220	0.12	1.00	0.12	0.19	6.0	6.18	7.23	1.37	15	69	0.012	0.000386	0.0049	4.0	4.9	3.4	0.34	6.52	3.37	3.03	Q ok
P-53	DI-53	MH-54	4484	537	5021	0.12	1.00	0.12	0.31	6.0	6.52	7.14	2.18	15	51	0.012	0.000969	0.0051	4.1	5.0	3.9	0.22	6.73	2.83	2.57	Q ok
P-54	MH-54	DI-55	1	0	1	0.00	1.00	0.00	1.07	6.0	6.73	7.07	7.60	24	41	0.012	0.000961	0.0049	5.4	17.1	5.3	0.13	6.86	2.37	2.17	Q ok
P-55	DI-55	MH-60	5685	291	5976	0.14	1.00	0.14	1.21	6.0	6.86	7.01	8.49	24	23	0.012	0.001201	0.0052	5.6	17.7	5.6	0.07	6.93	1.97	1.85	Q ok
P-56	B5 South	MH-54	33482	0	33482	0.77	1.00	0.77	0.77	6.0	0.00	7.29	5.60	18	17	0.012	0.002425	0.0053	4.7	8.3	5.1	0.06	6.06	2.56	2.47	Q ok
P-78	DI-78	DI-79	3667	223	3890	0.09	1.00	0.09	0.09	6.0	0.00	7.29	0.65	15	84	0.012	0.000087	0.0200	8.1	9.9	4.0	0.35	6.35	7.12	5.44	Q ok
P-79	DI-79	DI-71	3253	204	3457	0.08	1.00	0.08	0.17	6.0	6.35	7.17	1.21	18	29	0.012	0.000113	0.0200	9.1	16.1	5.5	0.09	6.44	5.24	4.66	Q ok
P-71	DI-71	DI-72	3698	198	3896	0.09	1.00	0.09	0.35	6.0	6.44	7.17	2.52	18	42	0.012	0.000491	0.0200	9.1	16.1	6.4	0.11	6.55	4.46	3.62	Q ok
P-72	DI-72	DI-73	2021	16	2037	0.05	1.00	0.05	0.40	6.0	6.55	7.10	2.83	18	29	0.012	0.000619	0.0200	9.1	16.1	6.8	0.07	6.62	3.42	2.84	Q ok
P-73	DI-73	MH-74	1071	0	1071	0.02	1.00	0.02	0.42	6.0	6.62	7.10	3.01	18	17	0.012	0.000698	0.0200	9.1	16.1	6.8	0.04	6.66	2.64	2.30	Q ok
P-74	MH-74	DI-75	1	0	1	0.00	1.00	0.00	1.10	6.0	6.66	7.07	7.77	18	17	0.012	0.004656	0.0200	9.1	16.1	9.0	0.03	6.70	2.10	1.76	Q ok
P-75	DI-75	DI-76	2135	0	2135	0.05	1.00	0.05	1.15	6.0	6.70	7.07	8.11	18	43	0.012	0.005082	0.0200	9.1	16.1	9.0	0.08	6.78	1.56	0.70	Q ok
P-76	DI-76	DI-77	1993	48	2041	0.05	1.00	0.05	1.19	6.0	6.78	7.04	8.41	18	51	0.012	0.005457	0.0200	9.1	16.1	9.0	0.09	6.87	0.50	-0.52	Q ok
P-70	DI-70	DI-71	3812	274	4086	0.09	1.00	0.09	0.09	6.0	0.00	7.29	0.68	15	86	0.012	0.000095	0.0200	8.1	9.9	4.0	0.36	6.36	6.38	4.66	Q ok
P-80	DI-80	MH-74	22886	15258	38144	0.88	0.77	0.67	0.67	6.0	0.00	7.29	4.92	18	24	0.012	0.001868	0.0050	4.6	8.0	4.8	0.08	6.08	2.42	2.30	Q ok
P-90	DI-90	DI-91	6026	1962	7988	0.18	0.91	0.17	0.17	6.0	0.00	7.29	1.22	15	79	0.012	0.000304	0.0200	8.1	9.9	4.8	0.27	6.27	2.54	0.96	Q ok
P-91	DI-91	MH-87	6475	2667	9142	0.21	0.87	0.18	0.80	6.0	6.27	7.20	5.75	18	81	0.012	0.002556	0.0200	9.1	16.1	8.2	0.16	6.44	-0.04	-1.66	Q ok
P-92	B6 North	DI-91	19569	0	19569	0.45	1.00	0.45	0.45	6.0	0.00	7.29	3.27	18	63	0.012	0.000828	0.0049	4.5	8.0	4.2	0.25	6.25	0.47	0.16	Q ok

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Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 50 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-95	TD-04	MH-86	21353	32030	53383	1.23	0.59	0.72	0.72	6.0	0.00	7.29	5.23	12	16	0.011	0.015438	0.0506	12.1	9.5	12.3	0.02	6.02	8.01	7.20	Q ok
P-38	DI-38	DI-39	1483	0	1483	0.03	1.00	0.03	0.03	6.0	0.00	7.29	0.25	15	99	0.012	0.000013	0.0200	8.1	9.9	4.0	0.42	6.42	2.75	0.77	Q ok
P-39	DI-39	DI-40	3833	220	4053	0.09	1.00	0.09	0.13	6.0	6.42	7.17	0.91	15	70	0.012	0.000169	0.0200	8.1	9.9	4.8	0.24	6.66	0.57	-0.83	Q ok
P-40	DI-40	DI-85	4668	293	4961	0.11	1.00	0.11	0.24	6.0	6.66	7.07	1.70	18	26	0.012	0.000224	0.0208	9.3	16.4	5.6	0.08	6.74	-1.03	-1.57	Q ok
P-35	MH-35	DI-36	1	0	1	0.00	1.00	0.00	4.56	6.0	7.43	6.86	31.25	**36**	94	0.012	0.001870	0.0050	7.2	51.1	7.6	0.21	7.64	-0.16	-0.63	Q ok
P-36	DI-36	DI-37	1851	0	1851	0.04	1.00	0.04	4.60	6.0	7.64	6.79	31.25	**36**	98	0.012	0.001871	0.0050	7.2	51.1	7.6	0.22	7.86	-0.73	-1.22	Q ok
P-37	DI-37	DI-85	3893	195	4088	0.09	1.00	0.09	4.69	6.0	7.86	6.70	31.45	36	70	0.012	0.001895	0.0050	7.2	51.1	7.6	0.15	8.01	-1.32	-1.67	Q ok
P-30	DI-30	MH-35	1403	0	1403	0.03	1.00	0.03	0.03	6.0	0.00	7.29	0.23	18	47	0.012	0.000004	0.0200	9.1	16.1	4.5	0.18	6.18	0.98	0.04	Q ok
P-11	DI-11	DI-12	4746	684	5430	0.12	1.00	0.12	0.12	6.0	0.00	7.29	0.91	15	20	0.012	0.000169	0.0065	4.6	5.6	3.2	0.10	6.10	2.91	2.78	Q ok
P-12	DI-12	DI-13	4957	1287	6244	0.14	0.95	0.14	0.26	6.0	6.10	7.26	1.89	15	92	0.012	0.000732	0.0065	4.6	5.7	4.1	0.37	6.47	2.68	2.08	Q ok
P-13	DI-13	MH-14	4947	1296	6243	0.14	0.95	0.14	0.40	6.0	6.47	7.14	2.83	15	54	0.012	0.001636	0.0065	4.6	5.6	4.5	0.20	6.67	1.98	1.63	Q ok
P-14	MH-14	DI-15	1	0	1	0.00	1.00	0.00	1.13	6.0	6.67	7.07	7.99	24	38	0.012	0.001063	0.0066	6.3	19.9	5.8	0.11	6.78	1.53	1.28	Q ok
P-15	DI-15	DI-16	3998	870	4868	0.11	0.97	0.11	1.24	6.0	6.78	7.04	8.72	24	73	0.012	0.001267	0.0064	6.3	19.7	6.1	0.20	6.98	1.18	0.71	Q ok
P-16	DI-16	MH-17	5113	501	5614	0.13	1.00	0.13	1.37	6.0	6.98	6.98	9.55	24	31	0.012	0.001517	0.0071	6.6	20.6	6.4	0.08	7.06	0.61	0.39	Q ok
P-18	B7 South	MH-14	31929	0	31929	0.73	1.00	0.73	0.73	6.0	0.00	7.29	5.34	18	17	0.012	0.002205	0.0053	4.7	8.3	5.0	0.06	6.06	1.72	1.63	Q ok
P-01	DI-01	DI-02	7520	1261	8781	0.20	1.00	0.20	0.20	6.0	0.00	7.29	1.47	15	77	0.012	0.000441	0.0065	4.6	5.6	3.8	0.34	6.34	2.91	2.41	Q ok
P-02	DI-02	DI-03	2113	487	2600	0.06	0.97	0.06	0.26	6.0	6.34	7.20	1.87	15	38	0.012	0.000711	0.0066	4.6	5.7	4.2	0.15	6.49	2.31	2.06	Q ok
P-03	DI-03	MH-04	4989	1312	6301	0.14	0.95	0.14	0.40	6.0	6.49	7.14	2.83	15	46	0.012	0.001633	0.0065	4.6	5.7	4.6	0.17	6.66	1.96	1.66	Q ok
P-04	MH-04	DI-05	1	0	1	0.00	1.00	0.00	0.87	6.0	6.66	7.07	6.15	18	46	0.012	0.002917	0.0065	5.2	9.2	5.6	0.14	6.80	1.56	1.26	Q ok
P-05	DI-05	DI-06	3831	995	4826	0.11	0.95	0.11	0.97	6.0	6.80	7.04	6.86	24	73	0.012	0.000784	0.0064	6.3	19.7	5.6	0.22	7.01	1.16	0.69	Q ok
P-06	DI-06	MH-17	5161	592	5753	0.13	1.00	0.13	1.64	6.0	7.01	6.98	11.47	24	30	0.012	0.002189	0.0067	6.4	20.0	6.5	0.08	7.09	0.59	0.39	Q ok
P-17	MH-17	MH-35	1	0	1	0.00	1.00	0.00	3.01	6.0	7.09	6.95	20.92	*36*	115	0.012	0.000838	0.0030	5.6	39.9	5.6	0.34	7.43	0.29	-0.06	Q ok
Check P-17 for Sanitary Crossing for Conflict																									Check P-1	
P-08	DI-08	MH-07	1526	0	1526	0.04	1.00	0.04	0.04	6.0	0.00	7.29	0.26	15	58	0.012	0.000013	0.0066	4.6	5.7	2.3	0.43	6.43	1.36	0.98	Q ok
P-07	MH-07	DI-06	1	0	1	0.00	1.00	0.00	0.54	6.0	0.00	7.29	3.91	18	14	0.012	0.001181	0.0064	5.2	9.1	5.0	0.05	6.05	0.88	0.79	Q ok
P-09	B9/J	MH-04	20585	0	20585	0.47	1.00	0.47	0.47	6.0	0.00	7.29	3.45	18	17	0.012	0.000916	0.0053	4.7	8.3	4.3	0.07	6.07	1.75	1.66	Q ok
P-10	B9/J	MH-07	21845	0	21845	0.50	1.00	0.50	0.50	6.0	0.00	7.29	3.66	18	17	0.012	0.001032	0.0053	4.7	8.3	4.5	0.06	6.06	1.07	0.98	Q ok
P-20	TD-05	DI-21	5394	0	5394	0.12	1.00	0.12	0.12	6.0	0.00	7.29	0.90	8	39	0.011	0.003995	0.0500	9.1	3.2	7.8	0.08	6.08	8.50	6.55	Q ok
P-21	DI-21	MH-22	6185	3410	9595	0.22	0.81	0.18	0.30	6.0	6.08	7.26	2.20	15	31	0.012	0.000985	0.0200	8.1	9.9	6.0	0.09	6.17	4.54	3.92	Q ok
P-22	MH-22	MH-23	1	0	1	0.00	1.00	0.00	0.49	6.0	6.17	7.23	3.56	18	42	0.012	0.000977	0.0200	9.1	16.1	6.8	0.10	6.27	3.72	2.88	Q ok
P-23	MH-23	MH-24	1	0	1	0.00	1.00	0.00	1.31	6.0	6.27	7.20	9.45	18	66	0.012	0.006898	0.0200	9.1	16.1	9.6	0.12	6.39	2.68	1.36	Q ok
P-24	MH-24	MH-35	1	0	1	0.00	1.00	0.00	1.52	6.0	6.39	7.17	10.86	18	56	0.012	0.009102	0.0200	9.1	16.1	9.7	0.10	6.48	1.16	0.04	Q ok
P-25	DI-25	MH-22	6504	3883	10387	0.24	0.79	0.19	0.19	6.0	0.00	7.29	1.38	15	31	0.012	0.000390	0.0200	8.1	9.9	5.6	0.09	6.09	4.54	3.92	Q ok
P-26	B8/K	MH-23	16317	0	16317	0.37	1.00	0.37	0.37	6.0	0.00	7.29	2.73	18	56	0.012	0.000576	0.0050	4.6	8.0	4.1	0.23	6.23	3.06	2.78	Q ok
P-27	B6 South	MH-23	19451	0	19451	0.45	1.00	0.45	0.45	6.0	0.00	7.29	3.26	18	56	0.012	0.000818	0.0050	4.6	8.0	4.2	0.22	6.22	3.06	2.78	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/2023 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/2023 | Cm. No.: 20077.000
Segment: Central Green Outfall | Storm Frequency: 50 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-28	DI-28	MH-24	3596	533	4129	0.09	1.00	0.09	0.09	6.0	0.00	7.29	0.69	18	34	0.012	0.000037	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok
P-29	DI-29	MH-24	4110	551	4661	0.11	1.00	0.11	0.11	6.0	0.00	7.29	0.78	18	34	0.012	0.000047	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok

KEY

	Upsized from Semi-Final Design to have capacity for 50-yr design storm
	Optional Upsize-50-yr design storm results in >85% Full
	No Change from Semi-Final Design

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)			

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D) ft	Tailwater, link to Inlet WSE of downstream pipe (TW) ft	Outlet W. S. Elevation (HGL Dn) ft	Outflow Pipe Diameter (D_o) in	Outflow Pipe Design Flow (Q_o) cfs	Pressure-flow Vel., $V_o=Q_o/A$ (V_o) fps	Skew angle vs. (Δ_o) deg	Outflow Pipe Length (L) ft	Friction Slope (S_{fo}) ft/ft	Friction Loss (H_f) ft	Angle of Curvature (O) deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c) ft	Contraction Loss (H_o) ft	Q*V for determining controlling inflow pipe (Q1V1) ft^4/s^2	Q*V for determining controlling inflow pipe (Q2V2) ft^4/s^2	Q*V for determining controlling inflow pipe (Q3V3) ft^4/s^2	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi) ft	Controlling In-flow skew (Δ_i) deg	Bend Loss (H_Δ) ft	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ (H_t) cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$) ft	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H) ft	Inlet W. S. Elevation (HGL Up) ft	Top of Grate (T/G) ft	HGL Check
P-41	MH-41	MH-42	1.60	6.47	6.47	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	6.60	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	6.40	6.40	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	6.47	7.86	HGL ok
P-43	DI-43	DI-44	2.00	6.27	6.27	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	6.40	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	6.11	6.11	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	6.27	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	5.94	5.94	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	6.11	7.59	HGL ok
P-46	MH-46	DI-47	2.00	5.78	5.78	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	5.94	8.54	HGL ok
P-47	DI-47	MH-60	2.40	5.45	5.45	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	5.78	9.09	HGL ok
P-60	MH-60	MH-61	2.40	5.23	5.23	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	5.45	9.84	HGL ok
P-61	MH-61	DI-62	2.40	4.96	4.96	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	5.23	11.03	HGL ok
P-62	DI-62	DI-63	2.40	4.71	4.71	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	4.96	10.34	HGL ok
P-63	DI-63	DI-77	1.93	4.31	4.31	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	4.71	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.88	3.88	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	4.31	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.39	3.39	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	3.88	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.28	3.28	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	3.39	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.20**	**3.20**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	*0.5*	**0.07**	**0.08**	**3.28**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	6.47	6.47	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	6.56	8.07	HGL ok
P-50	B7 North	1.00	1.20	5.94	5.94	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	6.01	10.00	HGL ok
P-65	B7 West	MH-64	1.20	4.84	4.84	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	4.90	10.00	HGL ok
P-64	MH-64	DI-63	1.20	4.71	4.71	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	4.84	10.14	HGL ok
P-51	DI-51	DI-52	1.00	5.88	5.88	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.88	7.11	HGL ok
P-52	DI-52	DI-53	1.00	5.84	5.84	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	5.88	7.03	HGL ok
P-53	DI-53	MH-54	1.00	5.77	5.77	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	5.84	7.59	HGL ok
P-54	MH-54	DI-55	1.60	5.64	5.64	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	5.77	8.54	HGL ok
P-55	DI-55	MH-60	1.60	5.45	5.45	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	5.64	9.09	HGL ok
P-56	B5 South	MH-54	1.20	5.77	5.77	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	5.83	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.87	6.44	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.45	11.60	HGL ok
P-79	DI-79	DI-71	1.20	5.56	5.86	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	5.87	11.15	HGL ok
P-71	DI-71	DI-72	1.20	5.52	5.52	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	5.56	11.15	HGL ok
P-72	DI-72	DI-73	1.20	5.48	5.48	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	5.52	10.99	HGL ok
P-73	DI-73	MH-74	1.20	5.44	5.44	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	5.48	10.84	HGL ok
P-74	MH-74	DI-75	1.20	5.26	5.26	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	5.44	11.24	HGL ok
P-75	DI-75	DI-76	1.20	4.83	4.83	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	5.26	10.63	HGL ok
P-76	DI-76	DI-77	1.20	4.31	4.31	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	4.83	10.34	HGL ok
P-70	DI-70	DI-71	1.00	5.56	5.66	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.67	11.60	HGL ok
P-80	DI-80	MH-74	1.20	5.44	5.44	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	5.51	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.61	3.61	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	3.64	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.28	3.28	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	3.61	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.61	3.61	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	3.67	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.39	8.00	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	8.33	10.50	HGL ok
P-38	DI-38	DI-39	1.00	3.92	3.92	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	3.92	10.67	HGL ok
P-39	DI-39	DI-40	1.00	3.91	3.91	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	3.92	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.88	3.88	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	3.91	9.98	HGL ok
P-35	MH-35	DI-36	2.40	4.60	4.60	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	5.11	11.72	HGL ok
P-36	DI-36	DI-37	2.40	4.23	4.23	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	4.60	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.88	3.88	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	4.23	10.16	HGL ok
P-30	DI-30	MH-35	1.20	5.11	5.11	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.11	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.05	6.05	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.06	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	5.97	5.97	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	6.05	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	5.83	5.83	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	5.97	7.91	HGL ok
P-14	MH-14	DI-15	1.60	5.70	5.70	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	5.83	8.68	HGL ok
P-15	DI-15	DI-16	1.60	5.54	5.54	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	5.70	9.01	HGL ok
P-16	DI-16	MH-17	1.60	5.33	5.33	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	5.54	9.77	HGL ok
P-18	B7 South	MH-14	1.20	5.83	5.83	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	5.88	10.00	HGL ok
P-01	DI-01	DI-02	1.00	6.08	6.08	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	6.12	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	6.03	6.03	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	6.08	7.35	HGL ok
P-03	DI-03	MH-04	1.00	5.90	5.90	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	6.03	7.91	HGL ok
P-04	MH-04	DI-05	1.20	5.71	5.71	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	5.90	8.60	HGL ok
P-05	DI-05	DI-06	1.60	5.52	5.52	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	5.71	9.01	HGL ok
P-06	DI-06	MH-17	1.60	5.33	5.33	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	5.52	9.87	HGL ok
P-17	MH-17	MH-35	1.60	5.11	5.11	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	5.33	10.61	HGL ok
P-08	DI-08	MH-07	1.00	5.58	5.58	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.58	11.39	HGL ok
P-07	MH-07	DI-06	1.20	5.52	5.52	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	5.58	10.19	HGL ok
P-09	B9/J	MH-04	1.20	5.90	5.90	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	5.93	10.00	HGL ok
P-10	B9/J	MH-07	1.20	5.58	5.58	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	5.61	10.00	HGL ok
P-20	TD-05	DI-21	0.53	6.52	7.08	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	7.27	10.50	HGL ok
P-21	DI-21	MH-22	1.00	6.36	6.36	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	6.52	9.46	HGL ok
P-22	MH-22	MH-23	1.20	6.29	6.29	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	6.36	9.72	HGL ok
P-23	MH-23	MH-24	1.20	5.77	5.77	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	6.29	10.97	HGL ok
P-24	MH-24	MH-35	1.20	5.11	5.11	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	5.77	11.20	HGL ok
P-25	DI-25	MH-22	1.00	6.36	6.36	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	6.38	9.46	HGL ok
P-26	B8/K	MH-23	1.20	6.29	6.29	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	6.33	10.00	HGL ok
P-27	B6 South	MH-23	1.20	6.29	6.29	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	6.34	10.00	HGL ok
P-28	DI-28	MH-24	1.20	5.77	5.77	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.77	10.95	HGL ok
P-29	DI-29	MH-24	1.20	5.77	5.77	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.77	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H=H_f+H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	**HGL Check**
P-41	MH-41	MH-42	1.60	6.67	6.67	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	6.80	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	6.60	6.60	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	6.67	7.86	HGL ok
P-43	DI-43	DI-44	2.00	6.47	6.47	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	6.60	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	6.31	6.31	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	6.47	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	6.14	6.14	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	6.31	7.59	HGL ok
P-46	MH-46	DI-47	2.00	5.98	5.98	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	6.14	8.54	HGL ok
P-47	DI-47	MH-60	2.40	5.65	5.65	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	5.98	9.09	HGL ok
P-60	MH-60	MH-61	2.40	5.43	5.43	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	5.65	9.84	HGL ok
P-61	MH-61	DI-62	2.40	5.16	5.16	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	5.43	11.03	HGL ok
P-62	DI-62	DI-63	2.40	4.91	4.91	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	5.16	10.34	HGL ok
P-63	DI-63	DI-77	1.93	4.51	4.51	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	4.91	10.08	HGL ok
P-77	DI-77	DI-85	3.20	4.08	4.08	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	4.51	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.59	3.59	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	4.08	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.48	3.48	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	3.59	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.40**	**3.40**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**3.48**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	6.67	6.67	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	6.76	8.07	HGL ok
P-50	B7 North	1.00	1.20	6.14	6.14	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	6.21	10.00	HGL ok
P-65	B7 West	MH-64	1.20	5.04	5.04	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	5.10	10.00	HGL ok
P-64	MH-64	DI-63	1.20	4.91	4.91	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	5.04	10.14	HGL ok
P-51	DI-51	DI-52	1.00	6.08	6.08	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.08	7.11	HGL ok
P-52	DI-52	DI-53	1.00	6.04	6.04	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	6.08	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	5.97	5.97	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	6.04	7.59	HGL ok
P-54	MH-54	DI-55	1.60	5.84	5.84	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	5.97	8.54	HGL ok
P-55	DI-55	MH-60	1.60	5.65	5.65	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	5.84	9.09	HGL ok
P-56	B5 South	MH-54	1.20	5.97	5.97	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	6.03	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.87	6.44	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.45	11.60	HGL ok
P-79	DI-79	DI-71	1.20	5.76	5.86	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	5.87	11.15	HGL ok
P-71	DI-71	DI-72	1.20	5.72	5.72	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	5.76	11.15	HGL ok
P-72	DI-72	DI-73	1.20	5.68	5.68	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	5.72	10.99	HGL ok
P-73	DI-73	MH-74	1.20	5.64	5.64	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	5.68	10.84	HGL ok
P-74	MH-74	DI-75	1.20	5.46	5.46	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	5.64	11.24	HGL ok
P-75	DI-75	DI-76	1.20	5.03	5.03	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	5.46	10.63	HGL ok
P-76	DI-76	DI-77	1.20	4.51	4.51	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	5.03	10.34	HGL ok
P-70	DI-70	DI-71	1.00	5.76	5.76	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.77	11.60	HGL ok
P-80	DI-80	MH-74	1.20	5.64	5.64	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	5.71	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.81	3.81	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	3.84	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.48	3.48	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	3.81	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.81	3.81	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	3.87	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.59	8.00	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	8.33	10.50	HGL ok
P-38	DI-38	DI-39	1.00	4.12	4.12	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.12	10.67	HGL ok
P-39	DI-39	DI-40	1.00	4.11	4.11	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	4.12	10.16	HGL ok
P-40	DI-40	DI-85	1.20	4.08	4.08	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	4.11	9.98	HGL ok
P-35	MH-35	DI-36	2.40	4.80	4.80	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	5.31	11.72	HGL ok
P-36	DI-36	DI-37	2.40	4.43	4.43	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	4.80	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	4.08	4.08	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	4.43	10.16	HGL ok
P-30	DI-30	MH-35	1.20	5.31	5.31	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.31	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.25	6.25	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.26	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	6.17	6.17	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	6.25	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	6.03	6.03	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	6.17	7.91	HGL ok
P-14	MH-14	DI-15	1.60	5.90	5.90	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	6.03	8.68	HGL ok
P-15	DI-15	DI-16	1.60	5.74	5.74	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	5.90	9.01	HGL ok
P-16	DI-16	MH-17	1.60	5.53	5.53	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	5.74	9.77	HGL ok
P-18	B7 South	MH-14	1.20	6.03	6.03	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	6.08	10.00	HGL ok
P-01	DI-01	DI-02	1.00	6.28	6.28	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	6.32	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	6.23	6.23	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	6.28	7.35	HGL ok
P-03	DI-03	MH-04	1.00	6.10	6.10	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	6.23	7.91	HGL ok
P-04	MH-04	DI-05	1.20	5.91	5.91	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	6.10	8.60	HGL ok
P-05	DI-05	DI-06	1.60	5.72	5.72	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	5.91	9.01	HGL ok
P-06	DI-06	MH-17	1.60	5.53	5.53	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	5.72	9.87	HGL ok
P-17	MH-17	MH-35	1.60	5.31	5.31	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	5.53	10.61	HGL ok
P-08	DI-08	MH-07	1.00	5.78	5.78	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.78	11.39	HGL ok
P-07	MH-07	DI-06	1.20	5.72	5.72	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	5.78	10.19	HGL ok
P-09	B9/J	MH-04	1.20	6.10	6.10	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	6.13	10.00	HGL ok
P-10	B9/J	MH-07	1.20	5.78	5.78	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	5.81	10.00	HGL ok
P-20	TD-05	DI-21	0.53	6.72	7.08	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	7.27	10.50	HGL ok
P-21	DI-21	MH-22	1.00	6.56	6.56	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	6.72	9.46	HGL ok
P-22	MH-22	MH-23	1.20	6.49	6.49	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	6.56	9.72	HGL ok
P-23	MH-23	MH-24	1.20	5.97	5.97	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	6.49	10.97	HGL ok
P-24	MH-24	MH-35	1.20	5.31	5.31	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	5.97	11.20	HGL ok
P-25	DI-25	MH-22	1.00	6.56	6.56	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	6.58	9.46	HGL ok
P-26	B8/K	MH-23	1.20	6.49	6.49	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	6.53	10.00	HGL ok
P-27	B6 South	MH-23	1.20	6.49	6.49	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	6.54	10.00	HGL ok
P-28	DI-28	MH-24	1.20	5.97	5.97	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.97	10.95	HGL ok
P-29	DI-29	MH-24	1.20	5.97	5.97	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.97	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	10.17	10.17	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	10.30	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.10	10.10	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	10.17	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.97	9.97	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	10.10	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.81	9.81	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	9.97	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.64	9.64	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	9.81	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.48	9.48	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	9.64	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.15	9.15	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	9.48	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.93	8.93	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	9.15	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	8.66	8.66	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	8.93	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.41	8.41	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	8.66	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.01	8.01	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	8.41	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.58	7.58	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	8.01	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.09	7.09	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	7.58	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.98	6.98	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	7.09	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**6.90**	**6.90**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**6.98**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.17	10.17	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	10.26	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.64	9.64	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	9.71	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	8.54	8.54	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	8.60	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.41	8.41	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	8.54	10.14	HGL ok
P-51	DI-51	DI-52	1.00	9.58	9.58	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.58	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.54	9.54	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	9.58	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.47	9.47	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	9.54	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.34	9.34	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	9.47	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.15	9.15	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	9.34	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.47	9.47	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	9.53	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.28	9.28	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.28	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.26	9.26	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	9.28	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.22	9.22	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	9.26	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.18	9.18	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	9.22	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.14	9.14	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	9.18	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.96	8.96	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	9.14	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.53	8.53	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	8.96	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.01	8.01	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	8.53	10.34	HGL ok
P-70	DI-70	DI-71	1.00	9.26	9.26	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.27	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.14	9.14	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	9.21	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.31	7.31	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	7.34	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.98	6.98	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	7.31	8.33	HGL ok
P-92	B6 North	DI-91	1.20	7.31	7.31	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	7.37	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.09	8.00	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	8.33	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.62	7.62	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.62	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.61	7.61	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	7.62	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.58	7.58	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	7.61	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.30	8.30	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	8.81	11.72	HGL ok
P-36	DI-36	DI-37	2.40	7.93	7.93	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	8.30	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.58	7.58	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	7.93	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.81	8.81	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.81	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.75	9.75	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.76	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.67	9.67	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	9.75	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.53	9.53	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	9.67	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.40	9.40	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	9.53	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.24	9.24	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	9.40	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.03	9.03	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	9.24	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.53	9.53	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	9.58	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.78	9.78	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	9.82	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.73	9.73	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	9.78	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.60	9.60	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	9.73	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.41	9.41	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	9.60	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.22	9.22	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	9.41	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.03	9.03	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	9.22	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	8.81	8.81	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	9.03	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.28	9.28	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.28	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.22	9.22	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	9.28	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	9.60	9.60	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	9.63	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.28	9.28	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.31	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.22	10.22	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	10.40	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.06	10.06	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	10.22	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.99	9.99	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	10.06	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.47	9.47	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	9.99	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	8.81	8.81	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	9.47	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.06	10.06	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.08	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.99	9.99	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	10.03	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.99	9.99	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	10.04	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.47	9.47	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.47	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.47	9.47	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.47	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)		

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add $Hc = 0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ ft	Tot. H Loss, $H = H_f + H_{t\,adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	10.67	10.67	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	10.80	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.60	10.60	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	10.67	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.47	10.47	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	10.60	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.31	10.31	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	10.47	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.14	10.14	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	10.31	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.98	9.98	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	10.14	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.65	9.65	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	9.98	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.43	9.43	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	9.65	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.16	9.16	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	9.43	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.91	8.91	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	9.16	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.51	8.51	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	8.91	10.08	HGL ok
P-77	DI-77	DI-85	3.20	8.08	8.08	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	8.51	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.59	7.59	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	8.08	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.48	7.48	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	7.59	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.40**	**7.40**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**7.48**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.67	10.67	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	10.76	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.14	10.14	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	10.21	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.04	9.04	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	9.10	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	8.91	8.91	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	9.04	10.14	HGL ok
P-51	DI-51	DI-52	1.00	10.08	10.08	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.08	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.04	10.04	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	10.08	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.97	9.97	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	10.04	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.84	9.84	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	9.97	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.65	9.65	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	9.84	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.97	9.97	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.03	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.78	9.78	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.78	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.76	9.76	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	9.78	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.72	9.72	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	9.76	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.68	9.68	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	9.72	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.64	9.64	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	9.68	10.84	HGL ok
P-74	MH-74	DI-75	1.20	9.46	9.46	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	9.64	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.03	9.03	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	9.46	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.51	8.51	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	9.03	10.34	HGL ok
P-70	DI-70	DI-71	1.00	9.76	9.76	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.77	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.64	9.64	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	9.71	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.81	7.81	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	7.84	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.48	7.48	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	7.81	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	7.81	7.81	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	7.87	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.59	8.00	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	8.33	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.12	8.12	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.12	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.11	8.11	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.12	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.08	8.08	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	8.11	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.80	8.80	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	9.31	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.43	8.43	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	8.80	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.08	8.08	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	8.43	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.31	9.31	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.31	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.25	10.25	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.26	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.17	10.17	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	10.25	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.03	10.03	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	10.17	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.90	9.90	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	10.03	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.74	9.74	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	9.90	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.53	9.53	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	9.74	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.03	10.03	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.08	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.28	10.28	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.32	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.23	10.23	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	10.28	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.10	10.10	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	10.23	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.91	9.91	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	10.10	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.72	9.72	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	9.91	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.53	9.53	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	9.72	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.31	9.31	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	9.53	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.78	9.78	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.78	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.72	9.72	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	9.78	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.10	10.10	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.13	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.78	9.78	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.81	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.72	10.72	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	10.90	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.56	10.56	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	10.72	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.49	10.49	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	10.56	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.97	9.97	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	10.49	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.31	9.31	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	9.97	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.56	10.56	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.58	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.49	10.49	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	10.53	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.49	10.49	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	10.54	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.97	9.97	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.97	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	9.97	9.97	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.97	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.07	11.07	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	11.20	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.00	11.00	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	11.07	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.87	10.87	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	11.00	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.71	10.71	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	10.87	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.54	10.54	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	10.71	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.38	10.38	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	10.54	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.05	10.05	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	10.38	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.83	9.83	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	10.05	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.56	9.56	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	9.83	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.31	9.31	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	9.56	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	8.91	8.91	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	9.31	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	8.48	8.48	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	8.91	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.99	7.99	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	8.48	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.88	7.88	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	7.99	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.80**	**7.80**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**7.88**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	11.07	11.07	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	11.16	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.54	10.54	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	10.61	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.44	9.44	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	9.50	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.31	9.31	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	9.44	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.48	10.48	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.48	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.44	10.44	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	10.48	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.37	10.37	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	10.44	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.24	10.24	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	10.37	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.05	10.05	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	10.24	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.37	10.37	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.43	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.18	10.18	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.18	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.16	10.16	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	10.18	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.12	10.12	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	10.16	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.08	10.08	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	10.12	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.04	10.04	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	10.08	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	9.86	9.86	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	10.04	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.43	9.43	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	9.86	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	8.91	8.91	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	9.43	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.16	10.16	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.17	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.04	10.04	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	10.11	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	8.21	8.21	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.24	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	7.88	7.88	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	8.21	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.21	8.21	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	8.27	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.99	8.00	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	8.33	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.52	8.52	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.52	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.51	8.51	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	8.52	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.48	8.48	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	8.51	9.98	HGL ok
P-35	MH-35	DI-36	2.40	9.20	9.20	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	9.71	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.83	8.83	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	9.20	10.67	HGL ok

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.48	8.48	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	8.83	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.71	9.71	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.71	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.65	10.65	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.66	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.57	10.57	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	10.65	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.43	10.43	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	10.57	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.30	10.30	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	10.43	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.14	10.14	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	10.30	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.93	9.93	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	10.14	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.43	10.43	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.48	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.68	10.68	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.72	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.63	10.63	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	10.68	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.50	10.50	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	10.63	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.31	10.31	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	10.50	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.12	10.12	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	10.31	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.93	9.93	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	10.12	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.71	9.71	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	9.93	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.18	10.18	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.18	11.39	HGL ok
P-07	MH-07	DI-06	1.20	10.12	10.12	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	10.18	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.50	10.50	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	10.53	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.18	10.18	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.21	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.12	11.12	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	11.30	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.96	10.96	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	11.12	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.89	10.89	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	10.96	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.37	10.37	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	10.89	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.71	9.71	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	10.37	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	10.96	10.96	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.98	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.89	10.89	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	10.93	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.89	10.89	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	10.94	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.37	10.37	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.37	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.37	10.37	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.37	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23
County:	New Castle	Checked by:	TMC	Date:	3/23/23
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)	

Sheet No.: 2 of 5
Cm. No.: 20077

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe TW (ft)	Outlet W. S. Elevation HGL Dn (ft)	Outflow Pipe Diameter D_o (in)	Outflow Pipe Design Flow Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$ V_o (fps)	Skew angle vs. Δ_o (deg)	Outflow Pipe Length L (ft)	Friction Slope S_{fo} (ft/ft)	Friction Loss H_f (ft)	Angle of Curvatu O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c (ft)	Contraction Loss H_o (ft)	Q*V for determining controlling inflow pipe Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q3V3 (ft^4/s^2)	Controlling Inflow Velocity Vi	Expansion Loss Hi (ft)	Controlling In-flow skew Δ_i (deg)	Bend Loss H_Δ (ft)	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$ H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ (ft)	Tot. H Loss, $H=H_f+H_{t\,adj}$ H (ft)	Inlet W. S. Elevation HGL Up (ft)	Top of Grate T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	11.57	11.57	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	11.70	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.50	11.50	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	11.57	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.37	11.37	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	11.50	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.21	11.21	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	11.37	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.04	11.04	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	11.21	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.88	10.88	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	11.04	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.55	10.55	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	10.88	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.33	10.33	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	10.55	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.06	10.06	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	10.33	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	9.81	9.81	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	10.06	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.41	9.41	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	9.81	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	8.98	8.98	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	9.41	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	8.49	8.49	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	8.98	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	8.38	8.38	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	8.49	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**8.30**	**8.30**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**8.38**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	11.57	11.57	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	11.66	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.04	11.04	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	11.11	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.94	9.94	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.00	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.81	9.81	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	9.94	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.98	10.98	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.98	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.94	10.94	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	10.98	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.87	10.87	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	10.94	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.74	10.74	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	10.87	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.55	10.55	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	10.74	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.87	10.87	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.93	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.68	10.68	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.68	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	10.66	10.66	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	10.68	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.62	10.62	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	10.66	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.58	10.58	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	10.62	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.54	10.54	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	10.58	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.36	10.36	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	10.54	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	9.93	9.93	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	10.36	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.41	9.41	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	9.93	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.66	10.66	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.67	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	10.54	10.54	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	10.61	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	8.71	8.71	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.74	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	8.38	8.38	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	8.71	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.71	8.71	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	8.77	10.00	HGL ok
P-95	TD-04	MH-86	0.80	8.49	8.49	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	8.82	10.50	HGL ok
P-38	DI-38	DI-39	1.00	9.02	9.02	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.02	10.67	HGL ok
P-39	DI-39	DI-40	1.00	9.01	9.01	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.02	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.98	8.98	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	9.01	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	9.70	9.70	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	10.21	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.33	9.33	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	9.70	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.98	8.98	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	9.33	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.21	10.21	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.21	11.24	HGL ok
P-11	DI-11	DI-12	1.00	11.15	11.15	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.16	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.07	11.07	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	11.15	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.93	10.93	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	11.07	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.80	10.80	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	10.93	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.64	10.64	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	10.80	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.43	10.43	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	10.64	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.93	10.93	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.98	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.18	11.18	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	11.22	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.13	11.13	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	11.18	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.00	11.00	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	11.13	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.81	10.81	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	11.00	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.62	10.62	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	10.81	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.43	10.43	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	10.62	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.21	10.21	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	10.43	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.68	10.68	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.68	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	10.62	10.62	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	10.68	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.00	11.00	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.03	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.68	10.68	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.71	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.62	11.62	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	11.80	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.46	11.46	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	11.62	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.39	11.39	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	11.46	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.87	10.87	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	11.39	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.21	10.21	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	10.87	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.46	11.46	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.48	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.39	11.39	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	11.43	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.39	11.39	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	11.44	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.87	10.87	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.87	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.87	10.87	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.87	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)			

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe TW (ft)	Outlet W. S. Elevation HGL Dn (ft)	Outflow Pipe Diameter D_o (in)	Outflow Pipe Design Flow Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$ V_o (fps)	Skew angle vs. Δ_o (deg)	Outflow Pipe Length L (ft)	Friction Slope S_{fo} (ft/ft)	Friction Loss H_f (ft)	Angle of Curvatu O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c (ft)	Contraction Loss H_o (ft)	Q*V for determining controlling inflow pipe Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q3V3 (ft^4/s^2)	Controlling Inflow Velocity Vi	Expansion Loss Hi (ft)	Controlling In-flow skew Δ_i (deg)	Bend Loss H_Δ (ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ (ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ H (ft)	Inlet W. S. Elevation HGL Up (ft)	Top of Grate T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	12.27	12.27	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	12.40	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.20	12.20	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	12.27	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.07	12.07	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	12.20	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.91	11.91	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	12.07	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.74	11.74	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	11.91	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.58	11.58	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	11.74	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.25	11.25	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	11.58	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.03	11.03	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	11.25	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.76	10.76	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	11.03	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.51	10.51	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	10.76	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.11	10.11	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	10.51	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.68	9.68	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	10.11	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.19	9.19	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	9.68	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.08	9.08	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	9.19	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.00**	**9.00**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**9.08**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	12.27	12.27	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	12.36	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.74	11.74	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	11.81	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.64	10.64	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.70	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.51	10.51	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	10.64	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.68	11.68	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.68	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.64	11.64	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	11.68	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.57	11.57	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	11.64	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.44	11.44	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	11.57	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.25	11.25	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	11.44	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.57	11.57	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	11.63	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.38	11.38	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.38	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.36	11.36	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.38	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.32	11.32	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	11.36	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.28	11.28	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	11.32	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.24	11.24	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	11.28	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.06	11.06	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	11.24	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.63	10.63	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	11.06	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.11	10.11	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	10.63	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.36	11.36	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.37	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.24	11.24	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	11.31	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.41	9.41	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.44	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.08	9.08	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	9.41	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.41	9.41	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	9.47	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.19	9.19	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	9.52	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	9.72	9.72	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.72	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	9.71	9.71	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	9.72	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.68	9.68	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	9.71	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.40	10.40	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	10.91	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.03	10.03	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	10.40	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.68	9.68	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	10.03	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.91	10.91	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.91	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.85	11.85	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.86	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.77	11.77	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	11.85	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.63	11.63	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	11.77	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.50	11.50	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	11.63	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.34	11.34	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	11.50	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.13	11.13	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	11.34	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.63	11.63	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	11.68	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.88	11.88	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	11.92	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.83	11.83	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	11.88	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.70	11.70	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	11.83	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.51	11.51	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	11.70	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.32	11.32	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	11.51	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.13	11.13	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	11.32	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.91	10.91	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	11.13	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.38	11.38	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.38	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.32	11.32	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	11.38	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.70	11.70	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	11.73	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.38	11.38	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.41	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.32	12.32	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	12.50	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.16	12.16	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	12.32	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.09	12.09	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	12.16	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.57	11.57	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	12.09	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.91	10.91	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	11.57	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.16	12.16	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.18	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.09	12.09	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	12.13	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.09	12.09	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	12.14	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.57	11.57	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.57	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.57	11.57	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.57	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	**HGL Check**
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	12.77	12.77	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	12.90	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.70	12.70	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	12.77	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.57	12.57	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	12.70	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.41	12.41	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	12.57	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.24	12.24	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	12.41	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.08	12.08	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	12.24	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.75	11.75	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	12.08	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.53	11.53	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	11.75	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.26	11.26	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	11.53	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.01	11.01	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	11.26	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.61	10.61	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	11.01	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.18	10.18	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	10.61	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.69	9.69	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	10.18	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.58	9.58	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	9.69	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.50**	**9.50**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**9.58**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.77	12.77	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	12.86	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.24	12.24	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	12.31	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.14	11.14	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	11.20	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.01	11.01	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	11.14	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.18	12.18	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.18	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.14	12.14	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	12.18	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.07	12.07	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	12.14	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.94	11.94	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	12.07	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.75	11.75	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	11.94	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.07	12.07	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.13	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.88	11.88	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.88	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.86	11.86	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.88	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.82	11.82	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	11.86	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.78	11.78	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	11.82	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.74	11.74	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	11.78	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.56	11.56	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	11.74	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.13	11.13	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	11.56	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.61	10.61	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	11.13	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.86	11.86	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.87	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.74	11.74	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	11.81	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.91	9.91	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.94	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.58	9.58	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	9.91	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.91	9.91	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	9.97	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.69	9.69	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	10.02	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.22	10.22	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.22	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.21	10.21	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.22	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.18	10.18	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	10.21	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.90	10.90	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	11.41	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.53	10.53	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	10.90	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.18	10.18	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	10.53	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.41	11.41	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.41	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.35	12.35	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.36	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.27	12.27	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	12.35	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.13	12.13	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	12.27	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.00	12.00	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	12.13	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.84	11.84	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	12.00	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.63	11.63	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	11.84	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.13	12.13	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.18	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.38	12.38	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.42	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.33	12.33	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	12.38	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.20	12.20	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	12.33	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.01	12.01	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	12.20	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.82	11.82	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	12.01	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.63	11.63	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	11.82	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.41	11.41	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	11.63	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.88	11.88	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.88	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.82	11.82	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	11.88	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.20	12.20	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.23	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.88	11.88	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.91	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.82	12.82	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	13.00	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.66	12.66	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	12.82	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.59	12.59	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	12.66	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.07	12.07	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	12.59	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.41	11.41	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	12.07	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.66	12.66	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.68	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.59	12.59	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	12.63	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.59	12.59	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	12.64	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.07	12.07	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.07	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.07	12.07	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.07	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)			

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D — 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe — TW (ft)	Outlet W. S. Elevation — HGL Dn (ft)	Outflow Pipe Diameter — D_o (in)	Outflow Pipe Design Flow — Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$ — V_o (fps)	Skew angle vs. — Δ_o (deg)	Outflow Pipe Length — L (ft)	Friction Slope — S_{fo} (ft/ft)	Friction Loss — H_f (ft)	Angle of Curvature — O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ — H_c (ft)	Contraction Loss — H_o (ft)	Q*V for determining controlling inflow pipe — Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe — Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe — Q3V3 (ft^4/s^2)	Controlling Inflow Velocity — Vi	Expansion Loss — Hi (ft)	Controlling In-flow skew — Δ_i (deg)	Bend Loss — H_Δ (ft)	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$ — H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss — $H_{t\,adj}$ (ft)	Tot. H Loss, $H=H_f+H_{t\,adj}$ — H (ft)	Inlet W. S. Elevation — HGL Up (ft)	Top of Grate — T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	14.07	14.07	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	14.20	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.00	14.00	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	14.07	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.87	13.87	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	14.00	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.71	13.71	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	13.87	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.54	13.54	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	13.71	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.38	13.38	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	13.54	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.05	13.05	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	13.38	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.83	12.83	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	13.05	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.56	12.56	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	12.83	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.31	12.31	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	12.56	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.91	11.91	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	12.31	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.48	11.48	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	11.91	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.99	10.99	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	11.48	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.88	10.88	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	10.99	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.80**	**10.80**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**10.88**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.07	14.07	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	14.16	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.54	13.54	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	13.61	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.44	12.44	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.50	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.31	12.31	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	12.44	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.48	13.48	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.48	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.44	13.44	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	13.48	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.37	13.37	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	13.44	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.24	13.24	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	13.37	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.05	13.05	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	13.24	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.37	13.37	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.43	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.18	13.18	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.18	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.16	13.16	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.18	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.12	13.12	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	13.16	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.08	13.08	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	13.12	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.04	13.04	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	13.08	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.86	12.86	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	13.04	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.43	12.43	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	12.86	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.91	11.91	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	12.43	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.16	13.16	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.17	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.04	13.04	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	13.11	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.21	11.21	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.24	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.88	10.88	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	11.21	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.21	11.21	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	11.27	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.99	10.99	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	11.32	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.52	11.52	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.52	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.51	11.51	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.52	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.48	11.48	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	11.51	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.20	12.20	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	12.71	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.83	11.83	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	12.20	10.67	HGL Too High!

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.48	11.48	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	11.83	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.71	12.71	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.71	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.65	13.65	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.66	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.57	13.57	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	13.65	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.43	13.43	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	13.57	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.30	13.30	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	13.43	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.14	13.14	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	13.30	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.93	12.93	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	13.14	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.43	13.43	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.48	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.68	13.68	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	13.72	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.63	13.63	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	13.68	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.50	13.50	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	13.63	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.31	13.31	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	13.50	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.12	13.12	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	13.31	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.93	12.93	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	13.12	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.71	12.71	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	12.93	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.18	13.18	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.18	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.12	13.12	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	13.18	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.50	13.50	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.53	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.18	13.18	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.21	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.12	14.12	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	14.30	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.96	13.96	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	14.12	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.89	13.89	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	13.96	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.37	13.37	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	13.89	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.71	12.71	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	13.37	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.96	13.96	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.98	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.89	13.89	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	13.93	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.89	13.89	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	13.94	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.37	13.37	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.37	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.37	13.37	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.37	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add $Hc = 0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	9.01	9.01	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	9.14	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	8.94	8.94	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	9.01	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	8.81	8.81	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	8.94	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	8.65	8.65	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	8.81	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	8.48	8.48	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	8.65	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	8.32	8.32	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	8.48	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	7.99	7.99	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	8.32	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	7.77	7.77	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	7.99	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.50	7.50	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	7.77	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.25	7.25	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	7.50	10.34	HGL ok
P-63	DI-63	DI-77	1.93	6.85	6.85	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	7.25	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.42	6.42	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	6.85	10.08	HGL ok
P-85	DI-85	MH-86	4.00	5.93	5.93	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	6.42	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.82	5.82	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	5.93	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.74**	**5.74**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	0.5	**0.07**	**0.08**	**5.82**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.01	9.01	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	9.10	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	8.48	8.48	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	8.55	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.38	7.38	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	7.44	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.25	7.25	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	7.38	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.42	8.42	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.42	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	8.38	8.38	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	8.42	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.31	8.31	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	8.38	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.18	8.18	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	8.31	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	7.99	7.99	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	8.18	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	8.31	8.31	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	8.37	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.12	8.12	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.12	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.10	8.10	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	8.12	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.06	8.06	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	8.10	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.02	8.02	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	8.06	10.99	HGL ok
P-73	DI-73	MH-74	1.20	7.98	7.98	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	8.02	10.84	HGL ok
P-74	MH-74	DI-75	1.20	7.80	7.80	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	7.98	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.37	7.37	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	7.80	10.63	HGL ok
P-76	DI-76	DI-77	1.20	6.85	6.85	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	7.37	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.10	8.10	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.11	11.60	HGL ok
P-80	DI-80	MH-74	1.20	7.98	7.98	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	8.05	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.15	6.15	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	6.18	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.82	5.82	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	6.15	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.15	6.15	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	6.21	10.00	HGL ok
P-95	TD-04	MH-86	0.80	5.93	8.00	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	8.33	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.46	6.46	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.46	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.45	6.45	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.46	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.42	6.42	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	6.45	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.14	7.14	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	7.65	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.77	6.77	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	7.14	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.42	6.42	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	6.77	10.16	HGL ok
P-30	DI-30	MH-35	1.20	7.65	7.65	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.65	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.59	8.59	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.60	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	8.51	8.51	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	8.59	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	8.37	8.37	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	8.51	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.24	8.24	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	8.37	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.08	8.08	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	8.24	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	7.87	7.87	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	8.08	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.37	8.37	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	8.42	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.62	8.62	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	8.66	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	8.57	8.57	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	8.62	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	8.44	8.44	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	8.57	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.25	8.25	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	8.44	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.06	8.06	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	8.25	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	7.87	7.87	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	8.06	9.87	HGL ok
P-17	MH-17	MH-35	1.60	7.65	7.65	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	7.87	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.12	8.12	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.12	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.06	8.06	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	8.12	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.44	8.44	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.47	10.00	HGL ok
P-10	B9/J	MH-07	1.20	8.12	8.12	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.15	10.00	HGL ok
P-20	TD-05	DI-21	0.53	9.06	9.06	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	9.24	10.50	HGL ok
P-21	DI-21	MH-22	1.00	8.90	8.90	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	9.06	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	8.83	8.83	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	8.90	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	8.31	8.31	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	8.83	10.97	HGL ok
P-24	MH-24	MH-35	1.20	7.65	7.65	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	8.31	11.20	HGL ok
P-25	DI-25	MH-22	1.00	8.90	8.90	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	8.92	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	8.83	8.83	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	8.87	10.00	HGL ok
P-27	B6 South	MH-23	1.20	8.83	8.83	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	8.88	10.00	HGL ok
P-28	DI-28	MH-24	1.20	8.31	8.31	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.31	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.31	8.31	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.31	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	9.21	9.21	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	9.34	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	9.14	9.14	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	9.21	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.01	9.01	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	9.14	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	8.85	8.85	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	9.01	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	8.68	8.68	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	8.85	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	8.52	8.52	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	8.68	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.19	8.19	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	8.52	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	7.97	7.97	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	8.19	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.70	7.70	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	7.97	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.45	7.45	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	7.70	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.05	7.05	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	7.45	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.62	6.62	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	7.05	10.08	HGL ok
P-85	DI-85	MH-86	4.00	6.13	6.13	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	6.62	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.02	6.02	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	6.13	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.94**	**5.94**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**6.02**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.21	9.21	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	9.30	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	8.68	8.68	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	8.75	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.58	7.58	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	7.64	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.45	7.45	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	7.58	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.62	8.62	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.62	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	8.58	8.58	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	8.62	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.51	8.51	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	8.58	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.38	8.38	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	8.51	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.19	8.19	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	8.38	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	8.51	8.51	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	8.57	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.32	8.32	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.32	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.30	8.30	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	8.32	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.26	8.26	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	8.30	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.22	8.22	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	8.26	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.18	8.18	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	8.22	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.00	8.00	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	8.18	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.57	7.57	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	8.00	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.05	7.05	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	7.57	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.30	8.30	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.31	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.18	8.18	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	8.25	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.35	6.35	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	6.38	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.02	6.02	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	6.35	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.35	6.35	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	6.41	10.00	HGL ok
P-95	TD-04	MH-86	0.80	6.13	8.00	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	8.33	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.66	6.66	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.66	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.65	6.65	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	6.66	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.62	6.62	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	6.65	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.34	7.34	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	7.85	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.97	6.97	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	7.34	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.62	6.62	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	6.97	10.16	HGL ok
P-30	DI-30	MH-35	1.20	7.85	7.85	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.85	11.24	HGL ok
P-11	DI-11	DI-12	1.00	8.79	8.79	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.80	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	8.71	8.71	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	8.79	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	8.57	8.57	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	8.71	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.44	8.44	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	8.57	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.28	8.28	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	8.44	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.07	8.07	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	8.28	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.57	8.57	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	8.62	10.00	HGL ok
P-01	DI-01	DI-02	1.00	8.82	8.82	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	8.86	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	8.77	8.77	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	8.82	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	8.64	8.64	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	8.77	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.45	8.45	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	8.64	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.26	8.26	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	8.45	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.07	8.07	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	8.26	9.87	HGL ok
P-17	MH-17	MH-35	1.60	7.85	7.85	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	8.07	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.32	8.32	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.32	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.26	8.26	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	8.32	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.64	8.64	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	8.67	10.00	HGL ok
P-10	B9/J	MH-07	1.20	8.32	8.32	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.35	10.00	HGL ok
P-20	TD-05	DI-21	0.53	9.26	9.26	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	9.44	10.50	HGL ok
P-21	DI-21	MH-22	1.00	9.10	9.10	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	9.26	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.03	9.03	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	9.10	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	8.51	8.51	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	9.03	10.97	HGL ok
P-24	MH-24	MH-35	1.20	7.85	7.85	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	8.51	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.10	9.10	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.12	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.03	9.03	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	9.07	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.03	9.03	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	9.08	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	8.51	8.51	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.51	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.51	8.51	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.51	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	12.71	12.71	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	12.84	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.64	12.64	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	12.71	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.51	12.51	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	12.64	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.35	12.35	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	12.51	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.18	12.18	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	12.35	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.02	12.02	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	12.18	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.69	11.69	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	12.02	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.47	11.47	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	11.69	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.20	11.20	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	11.47	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.95	10.95	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	11.20	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.55	10.55	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	10.95	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.12	10.12	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	10.55	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.63	9.63	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	10.12	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.52	9.52	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	9.63	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.44**	**9.44**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**9.52**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	12.71	12.71	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	12.80	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.18	12.18	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	12.25	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.08	11.08	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	11.14	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.95	10.95	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	11.08	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.12	12.12	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.12	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.08	12.08	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	12.12	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.01	12.01	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	12.08	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.88	11.88	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	12.01	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.69	11.69	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	11.88	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.01	12.01	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.07	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.82	11.82	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.82	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.80	11.80	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.82	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.76	11.76	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	11.80	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.72	11.72	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	11.76	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.68	11.68	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	11.72	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.50	11.50	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	11.68	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.07	11.07	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	11.50	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.55	10.55	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	11.07	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.80	11.80	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.81	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.68	11.68	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	11.75	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.85	9.85	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.88	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.52	9.52	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	9.85	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.85	9.85	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	9.91	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.63	9.63	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	9.96	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.16	10.16	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.16	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.15	10.15	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.16	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.12	10.12	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	10.15	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.84	10.84	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	11.35	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.47	10.47	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	10.84	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 50 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.12	10.12	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	10.47	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.35	11.35	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.35	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.29	12.29	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.30	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.21	12.21	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	12.29	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.07	12.07	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	12.21	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.94	11.94	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	12.07	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.78	11.78	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	11.94	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.57	11.57	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	11.78	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.07	12.07	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.12	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.32	12.32	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.36	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.27	12.27	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	12.32	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.14	12.14	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	12.27	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.95	11.95	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	12.14	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.76	11.76	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	11.95	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.57	11.57	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	11.76	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.35	11.35	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	11.57	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.82	11.82	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.82	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.76	11.76	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	11.82	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.14	12.14	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.17	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.82	11.82	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.85	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.76	12.76	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	12.94	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.60	12.60	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	12.76	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.53	12.53	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	12.60	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.01	12.01	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	12.53	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.35	11.35	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	12.01	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.60	12.60	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.62	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.53	12.53	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	12.57	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.53	12.53	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	12.58	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.01	12.01	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.01	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.01	12.01	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.01	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	13.21	13.21	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	13.34	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.14	13.14	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	13.21	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.01	13.01	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	13.14	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.85	12.85	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	13.01	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.68	12.68	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	12.85	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.52	12.52	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	12.68	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.19	12.19	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	12.52	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.97	11.97	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	12.19	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.70	11.70	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	11.97	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.45	11.45	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	11.70	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.05	11.05	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	11.45	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.62	10.62	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	11.05	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.13	10.13	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	10.62	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.02	10.02	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	10.13	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.94**	**9.94**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**10.02**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.21	13.21	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	13.30	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.68	12.68	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	12.75	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.58	11.58	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	11.64	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.45	11.45	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	11.58	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.62	12.62	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.62	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.58	12.58	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	12.62	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.51	12.51	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	12.58	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.38	12.38	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	12.51	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.19	12.19	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	12.38	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.51	12.51	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.57	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.32	12.32	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.32	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.30	12.30	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.32	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.26	12.26	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	12.30	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.22	12.22	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	12.26	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.18	12.18	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	12.22	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.00	12.00	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	12.18	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.57	11.57	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	12.00	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.05	11.05	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	11.57	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.30	12.30	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.31	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.18	12.18	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	12.25	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.35	10.35	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.38	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.02	10.02	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	10.35	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.35	10.35	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	10.41	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.13	10.13	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	10.46	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.66	10.66	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.66	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.65	10.65	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	10.66	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.62	10.62	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	10.65	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.34	11.34	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	11.85	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.97	10.97	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	11.34	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.62	10.62	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	10.97	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.85	11.85	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.85	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.79	12.79	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.80	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.71	12.71	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	12.79	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.57	12.57	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	12.71	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.44	12.44	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	12.57	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.28	12.28	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	12.44	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.07	12.07	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	12.28	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.57	12.57	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.62	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.82	12.82	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.86	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.77	12.77	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	12.82	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.64	12.64	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	12.77	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.45	12.45	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	12.64	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.26	12.26	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	12.45	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.07	12.07	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	12.26	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.85	11.85	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	12.07	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.32	12.32	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.32	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.26	12.26	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	12.32	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.64	12.64	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	12.67	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.32	12.32	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.35	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.26	13.26	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	13.44	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.10	13.10	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	13.26	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.03	13.03	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	13.10	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.51	12.51	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	13.03	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.85	11.85	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	12.51	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.10	13.10	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.12	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.03	13.03	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	13.07	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.03	13.03	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	13.08	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.51	12.51	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.51	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.51	12.51	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.51	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	13.61	13.61	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	13.74	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.54	13.54	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	13.61	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.41	13.41	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	13.54	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.25	13.25	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	13.41	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.08	13.08	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	13.25	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.92	12.92	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	13.08	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.59	12.59	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	12.92	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.37	12.37	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	12.59	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.10	12.10	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	12.37	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.85	11.85	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	12.10	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.45	11.45	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	11.85	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.02	11.02	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	11.45	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.53	10.53	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	11.02	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.42	10.42	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	10.53	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.34**	**10.34**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**10.42**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.61	13.61	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	13.70	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.08	13.08	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	13.15	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.98	11.98	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.04	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.85	11.85	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	11.98	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.02	13.02	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.02	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.98	12.98	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	13.02	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.91	12.91	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	12.98	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.78	12.78	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	12.91	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.59	12.59	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	12.78	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.91	12.91	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.97	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.72	12.72	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.72	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.70	12.70	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.72	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.66	12.66	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	12.70	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.62	12.62	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	12.66	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.58	12.58	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	12.62	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.40	12.40	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	12.58	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.97	11.97	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	12.40	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.45	11.45	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	11.97	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.70	12.70	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.71	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.58	12.58	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	12.65	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.75	10.75	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.78	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.42	10.42	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	10.75	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.75	10.75	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	10.81	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.53	10.53	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	10.86	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.06	11.06	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.06	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.05	11.05	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.06	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.02	11.02	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	11.05	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.74	11.74	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	12.25	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.37	11.37	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	11.74	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.02	11.02	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	11.37	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.25	12.25	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.25	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.19	13.19	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.20	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.11	13.11	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	13.19	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.97	12.97	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	13.11	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.84	12.84	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	12.97	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.68	12.68	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	12.84	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.47	12.47	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	12.68	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.97	12.97	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.02	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.22	13.22	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	13.26	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.17	13.17	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	13.22	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.04	13.04	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	13.17	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.85	12.85	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	13.04	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.66	12.66	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	12.85	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.47	12.47	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	12.66	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.25	12.25	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	12.47	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.72	12.72	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.72	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.66	12.66	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	12.72	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.04	13.04	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.07	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.72	12.72	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.75	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.66	13.66	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	13.84	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.50	13.50	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	13.66	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.43	13.43	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	13.50	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.91	12.91	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	13.43	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.25	12.25	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	12.91	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.50	13.50	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.52	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.43	13.43	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	13.47	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.43	13.43	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	13.48	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.91	12.91	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.91	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.91	12.91	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.91	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 50 -year (50-year for sumps)

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	14.11	14.11	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	14.24	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.04	14.04	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	14.11	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.91	13.91	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	14.04	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.75	13.75	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	13.91	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.58	13.58	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	13.75	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.42	13.42	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	13.58	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.09	13.09	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	13.42	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.87	12.87	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	13.09	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.60	12.60	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	12.87	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.35	12.35	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	12.60	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.95	11.95	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	12.35	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.52	11.52	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	11.95	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.03	11.03	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	11.52	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.92	10.92	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	11.03	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.84**	**10.84**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**10.92**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.11	14.11	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	14.20	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.58	13.58	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	13.65	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.48	12.48	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.54	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.35	12.35	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	12.48	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.52	13.52	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.52	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.48	13.48	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	13.52	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.41	13.41	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	13.48	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.28	13.28	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	13.41	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.09	13.09	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	13.28	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.41	13.41	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.47	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.22	13.22	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.22	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.20	13.20	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.22	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.16	13.16	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	13.20	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.12	13.12	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	13.16	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.08	13.08	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	13.12	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.90	12.90	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	13.08	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.47	12.47	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	12.90	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.95	11.95	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	12.47	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.20	13.20	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.21	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.08	13.08	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	13.15	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.25	11.25	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.28	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.92	10.92	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	11.25	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.25	11.25	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	11.31	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.03	11.03	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	11.36	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.56	11.56	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.56	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.55	11.55	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	11.56	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.52	11.52	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	11.55	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.24	12.24	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	12.75	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.87	11.87	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	12.24	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.52	11.52	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	11.87	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.75	12.75	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.75	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.69	13.69	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.70	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.61	13.61	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	13.69	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.47	13.47	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	13.61	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.34	13.34	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	13.47	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.18	13.18	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	13.34	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.97	12.97	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	13.18	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.47	13.47	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.52	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.72	13.72	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	13.76	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.67	13.67	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	13.72	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.54	13.54	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	13.67	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.35	13.35	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	13.54	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.16	13.16	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	13.35	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.97	12.97	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	13.16	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.75	12.75	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	12.97	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.22	13.22	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.22	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.16	13.16	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	13.22	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.54	13.54	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	13.57	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.22	13.22	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.25	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.16	14.16	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	14.34	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.00	14.00	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	14.16	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.93	13.93	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	14.00	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.41	13.41	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	13.93	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.75	12.75	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	13.41	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.00	14.00	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	14.02	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.93	13.93	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	13.97	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.93	13.93	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	13.98	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.41	13.41	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.41	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.41	13.41	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.41	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	14.81	14.81	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	14.94	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.74	14.74	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	14.81	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	14.61	14.61	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	14.74	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.45	14.45	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	14.61	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	14.28	14.28	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	14.45	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	14.12	14.12	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	14.28	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.79	13.79	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	14.12	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	13.57	13.57	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	13.79	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	13.30	13.30	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	13.57	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	13.05	13.05	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	13.30	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.65	12.65	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	13.05	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.22	12.22	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	12.65	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.73	11.73	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	12.22	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	11.62	11.62	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	11.73	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**11.54**	**11.54**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**11.62**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.81	14.81	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	14.90	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	14.28	14.28	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	14.35	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	13.18	13.18	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.24	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	13.05	13.05	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	13.18	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	14.22	14.22	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.22	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	14.18	14.18	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	14.22	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.11	14.11	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	14.18	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.98	13.98	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	14.11	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.79	13.79	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	13.98	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.11	14.11	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	14.17	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.92	13.92	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.92	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.90	13.90	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.92	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.86	13.86	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	13.90	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.82	13.82	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	13.86	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.78	13.78	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	13.82	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	13.60	13.60	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	13.78	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	13.17	13.17	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	13.60	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.65	12.65	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	13.17	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.90	13.90	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.91	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.78	13.78	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	13.85	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.95	11.95	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.98	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	11.62	11.62	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	11.95	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.95	11.95	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	12.01	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.73	11.73	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	12.06	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.26	12.26	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.26	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.25	12.25	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.26	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.22	12.22	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	12.25	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.94	12.94	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	13.45	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.57	12.57	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	12.94	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.22	12.22	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	12.57	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.45	13.45	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.45	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.39	14.39	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.40	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	14.31	14.31	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	14.39	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	14.17	14.17	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	14.31	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	14.04	14.04	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	14.17	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.88	13.88	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	14.04	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.67	13.67	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	13.88	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	14.17	14.17	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	14.22	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.42	14.42	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	14.46	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.37	14.37	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	14.42	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	14.24	14.24	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	14.37	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	14.05	14.05	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	14.24	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.86	13.86	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	14.05	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.67	13.67	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	13.86	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.45	13.45	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	13.67	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.92	13.92	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.92	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.86	13.86	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	13.92	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	14.24	14.24	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	14.27	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.92	13.92	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.95	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.86	14.86	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	15.04	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.70	14.70	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	14.86	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	14.63	14.63	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	14.70	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.11	14.11	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	14.63	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.45	13.45	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	14.11	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.70	14.70	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	14.72	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	14.63	14.63	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	14.67	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	14.63	14.63	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	14.68	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.11	14.11	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.11	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.11	14.11	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.11	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	15.31	15.31	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	15.44	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	15.24	15.24	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	15.31	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	15.11	15.11	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	15.24	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.95	14.95	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	15.11	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	14.78	14.78	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	14.95	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	14.62	14.62	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	14.78	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	14.29	14.29	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	14.62	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	14.07	14.07	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	14.29	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	13.80	13.80	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	14.07	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	13.55	13.55	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	13.80	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	13.15	13.15	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	13.55	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.72	12.72	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	13.15	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	12.23	12.23	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	12.72	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	12.12	12.12	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	12.23	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**12.04**	**12.04**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**12.12**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	15.31	15.31	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	15.40	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	14.78	14.78	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	14.85	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	13.68	13.68	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.74	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	13.55	13.55	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	13.68	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	14.72	14.72	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.72	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	14.68	14.68	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	14.72	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.61	14.61	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	14.68	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	14.48	14.48	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	14.61	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	14.29	14.29	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	14.48	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.61	14.61	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	14.67	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	14.42	14.42	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.42	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	14.40	14.40	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	14.42	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	14.36	14.36	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	14.40	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	14.32	14.32	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	14.36	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	14.28	14.28	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	14.32	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	14.10	14.10	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	14.28	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	13.67	13.67	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	14.10	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	13.15	13.15	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	13.67	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	14.40	14.40	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.41	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	14.28	14.28	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	14.35	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	12.45	12.45	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.48	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	12.12	12.12	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	12.45	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	12.45	12.45	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	12.51	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	12.23	12.23	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	12.56	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.76	12.76	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.76	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.75	12.75	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	12.76	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.72	12.72	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	12.75	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	13.44	13.44	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	13.95	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	13.07	13.07	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	13.44	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.72	12.72	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	13.07	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.95	13.95	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.95	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.89	14.89	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.90	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	14.81	14.81	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	14.89	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	14.67	14.67	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	14.81	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	14.54	14.54	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	14.67	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	14.38	14.38	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	14.54	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	14.17	14.17	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	14.38	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	14.67	14.67	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	14.72	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.92	14.92	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	14.96	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.87	14.87	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	14.92	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	14.74	14.74	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	14.87	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	14.55	14.55	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	14.74	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	14.36	14.36	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	14.55	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	14.17	14.17	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	14.36	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.95	13.95	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	14.17	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	14.42	14.42	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.42	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	14.36	14.36	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	14.42	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	14.74	14.74	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	14.77	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	14.42	14.42	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	14.45	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	15.36	15.36	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	15.54	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	15.20	15.20	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	15.36	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	15.13	15.13	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	15.20	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.61	14.61	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	15.13	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.95	13.95	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	14.61	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	15.20	15.20	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	15.22	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	15.13	15.13	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	15.17	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	15.13	15.13	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	15.18	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.61	14.61	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.61	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.61	14.61	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.61	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)		

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D: 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe: TW (ft)	Outlet W. S. Elevation: HGL Dn (ft)	Outflow Pipe Diameter: D_o (in)	Outflow Pipe Design Flow: Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$: V_o (fps)	Skew angle vs.: Δ_o (deg)	Outflow Pipe Length: L (ft)	Friction Slope: S_{fo} (ft/ft)	Friction Loss: H_f (ft)	Angle of Curvature: O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$: H_c (ft)	Contraction Loss: H_o (ft)	Q*V for determining controlling inflow pipe: Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe: Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe: Q3V3 (ft^4/s^2)	Controlling Inflow Velocity: Vi	Expansion Loss: Hi (ft)	Controlling In-flow skew: Δ_i (deg)	Bend Loss: H_Δ (ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$: H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss: $H_{t\,adj}$ (ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$: H (ft)	Inlet W. S. Elevation: HGL Up (ft)	Top of Grate: T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	16.61	16.61	24	7.1	2.3	69	92	0.0008	0.08	0	0.00	0.02	16.1	0.0	0.0	2.3	0.0	90	0.06	0.10	1.0	0.5	0.05	0.13	16.74	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	16.54	16.54	30	13.8	2.8	13	30	0.0010	0.03	0	0.00	0.03	16.0	16.2	0.0	2.3	0.0	51.7	0.04	0.10	1.0	0.5	0.05	0.08	16.61	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	16.41	16.41	30	14.3	2.9	0	25	0.0010	0.03	0	0.00	0.03	38.5	0.0	0.0	2.8	0.0	13	0.02	0.10	1.0	1.0	0.10	0.12	16.54	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	16.25	16.25	30	15.1	3.1	6	69	0.0012	0.08	0	0.00	0.04	41.8	0.0	0.0	2.9	0.0	0	0.00	0.08	1.0	1.0	0.08	0.16	16.41	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	16.08	16.08	30	15.6	3.2	13	52	0.0012	0.06	0	0.00	0.04	46.5	0.0	0.0	3.1	0.1	6	0.01	0.11	1.0	1.0	0.11	0.17	16.25	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	15.92	15.92	30	20.3	4.1	83	42	0.0021	0.09	0	0.00	0.07	49.8	16.3	0.0	3.2	0.1	13	0.03	0.15	1.0	0.5	0.08	0.16	16.08	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	15.59	15.59	36	20.9	3.0	90	23	0.0008	0.02	0	0.00	0.03	83.8	0.0	0.0	4.1	0.1	83	0.18	0.31	1.0	1.0	0.31	0.33	15.92	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	15.37	15.37	36	28.5	4.0	82	75	0.0016	0.12	0	0.00	0.06	61.8	23.0	0.0	3.0	0.0	90	0.09	0.21	1.0	0.5	0.10	0.22	15.59	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	15.10	15.10	36	28.2	4.0	7	76	0.0015	0.12	0	0.00	0.06	114.9	0.0	0.0	4.0	0.1	82	0.17	0.32	1.0	0.5	0.16	0.27	15.37	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	14.85	14.85	36	28.2	4.0	89	50	0.0015	0.08	0	0.00	0.06	112.7	0.0	0.0	4.0	0.1	7	0.02	0.17	1.0	1.0	0.17	0.25	15.10	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	14.45	14.45	36	32.9	4.7	92	25	0.0021	0.05	0	0.00	0.08	112.1	16.3	0.0	4.0	0.1	89	0.17	0.34	1.0	1.0	0.34	0.39	14.85	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	14.02	14.02	48	40.5	3.2	91	50	0.0007	0.03	0	0.00	0.04	153.2	40.0	0.0	4.7	0.1	92	0.24	0.39	1.0	1.0	0.39	0.43	14.45	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	13.53	13.53	60	71.3	3.6	17	186	0.0006	0.12	0	0.00	0.05	130.2	1.6	140.0	4.4	0.1	90	0.22	0.37	1.0	1.0	0.37	0.49	14.02	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	13.42	13.42	60	74.3	3.8	0	45	0.0007	0.03	0	0.00	0.06	259.0	34.8	0.0	3.6	0.1	17	0.04	0.17	1.0	0.5	0.08	0.11	13.53	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**13.34**	**13.34**	**60**	**78.9**	**4.0**	**0**	**9**	**0.0008**	**0.01**	**0**	**0.00**	**0.06**	**281.5**	**18.7**	**0.0**	**3.8**	**0.1**	**0**	**0.00**	**0.14**	**1.0**	**0.5**	**0.07**	**0.08**	**13.42**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	16.61	16.61	24	7.1	2.3	51.7	64	0.0008	0.05	0	0.00	0.02	10.2	2.3	0.0	1.8	0.0	51	0.03	0.06	1.0	0.5	0.03	0.09	16.70	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	16.08	16.08	18	5.4	3.0	83	16	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.07	16.15	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	14.98	14.98	18	5.4	3.1	75	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	15.04	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	14.85	14.85	18	5.4	3.0	74	20	0.0022	0.04	0	0.00	0.04	16.5	0.0	0.0	3.1	0.1	75	0.09	0.18	1.0	0.5	0.09	0.13	14.98	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	16.02	16.02	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.02	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	15.98	15.98	15	1.4	1.1	7	69	0.0004	0.03	0	0.00	0.00	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.03	16.02	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	15.91	15.91	15	2.2	1.8	13	51	0.0010	0.05	0	0.00	0.01	1.5	0.0	0.0	1.1	0.0	7	0.00	0.02	1.3	1.0	0.03	0.08	15.98	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	15.78	15.78	24	7.6	2.4	83	41	0.0010	0.04	0	0.00	0.02	3.9	17.8	0.0	3.2	0.1	83	0.11	0.18	1.0	0.5	0.09	0.13	15.91	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	15.59	15.59	24	8.5	2.7	90	23	0.0012	0.03	0	0.00	0.03	18.4	0.0	0.0	2.4	0.0	83	0.06	0.12	1.3	1.0	0.16	0.19	15.78	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	15.91	15.91	18	5.6	3.2	83	17	0.0024	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	15.97	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	15.72	15.72	15	0.7	0.5	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.72	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	15.70	15.70	18	1.2	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.3	0.0	0.0	0.5	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	15.72	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	15.66	15.66	18	2.5	1.4	2	42	0.0005	0.02	0	0.00	0.01	0.8	0.4	0.0	0.7	0.0	82	0.00	0.02	1.3	1.0	0.02	0.04	15.70	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	15.62	15.62	18	2.8	1.6	8	29	0.0006	0.02	0	0.00	0.01	3.6	0.0	0.0	1.4	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	15.66	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	15.58	15.58	18	3.0	1.7	8	17	0.0007	0.01	0	0.00	0.01	4.5	0.0	0.0	1.6	0.0	8	0.00	0.03	1.0	1.0	0.03	0.04	15.62	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	15.40	15.40	18	7.8	4.4	5	17	0.0047	0.08	0	0.00	0.07	5.1	13.7	0.0	2.8	0.0	82	0.08	0.20	1.0	0.5	0.10	0.18	15.58	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	14.97	14.97	18	8.1	4.6	9	43	0.0051	0.22	0	0.00	0.08	34.1	0.0	0.0	4.4	0.1	5	0.03	0.22	1.0	1.0	0.22	0.44	15.40	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	14.45	14.45	18	8.4	4.8	2	51	0.0055	0.28	0	0.00	0.09	37.2	0.0	0.0	4.6	0.1	9	0.03	0.24	1.0	1.0	0.24	0.51	14.97	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	15.70	15.70	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.71	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	15.58	15.58	18	4.9	2.8	82	24	0.0019	0.04	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.07	15.65	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	13.75	13.75	15	1.2	1.0	0	79	0.0003	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.78	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	13.42	13.42	18	5.8	3.3	86	81	0.0026	0.21	0	0.00	0.04	1.2	6.1	0.0	1.9	0.0	90	0.04	0.10	1.3	1.0	0.13	0.33	13.75	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	13.75	13.75	18	3.3	1.9	90	63	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	13.81	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	13.53	13.53	12	5.2	6.7	90	16	0.0154	0.25	0	0.00	0.17	0.0	0.0	0.0	0.0	0.0	0	0.00	0.17	1.0	0.5	0.09	0.33	13.86	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	14.06	14.06	15	0.2	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.06	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	14.05	14.05	15	0.9	0.7	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.01	14.06	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	14.02	14.02	18	1.7	1.0	0	26	0.0002	0.01	0	0.00	0.00	0.7	0.0	0.0	0.7	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	14.05	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	14.74	14.74	36	31.2	4.4	2	94	0.0019	0.18	0	0.00	0.08	0.0	61.9	66.7	6.1	0.2	78	0.39	0.67	1.0	0.5	0.33	0.51	15.25	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	14.37	14.37	36	31.3	4.4	3	98	0.0019	0.18	0	0.00	0.08	138.1	0.0	0.0	4.4	0.1	2	0.00	0.18	1.0	1.0	0.18	0.37	14.74	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	50	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	14.02	14.02	36	31.5	4.4	90	70	0.0019	0.13	0	0.00	0.08	138.2	0.0	0.0	4.4	0.1	3	0.03	0.21	1.0	1.0	0.21	0.35	14.37	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	15.25	15.25	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.25	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	16.19	16.19	15	0.9	0.7	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.20	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	16.11	16.11	15	1.9	1.5	6	92	0.0007	0.07	0	0.00	0.01	0.7	0.0	0.0	0.7	0.0	5	0.00	0.01	1.3	1.0	0.02	0.08	16.19	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	15.97	15.97	15	2.8	2.3	14	54	0.0016	0.09	0	0.00	0.02	2.9	0.0	0.0	1.5	0.0	6	0.00	0.04	1.3	1.0	0.05	0.14	16.11	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	15.84	15.84	24	8.0	2.5	9	38	0.0011	0.04	0	0.00	0.03	6.5	16.2	0.0	3.0	0.0	82	0.09	0.17	1.0	0.5	0.08	0.12	15.97	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	15.68	15.68	24	8.7	2.8	91	73	0.0013	0.09	0	0.00	0.03	20.3	0.0	0.0	2.5	0.0	9	0.01	0.08	1.0	1.0	0.08	0.17	15.84	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	15.47	15.47	24	9.5	3.0	90	31	0.0015	0.05	0	0.00	0.04	24.2	0.0	0.0	2.8	0.0	91	0.08	0.16	1.0	1.0	0.16	0.21	15.68	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	15.97	15.97	18	5.3	3.0	82	17	0.0022	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	16.02	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	16.22	16.22	15	1.5	1.2	4	77	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	16.26	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	16.17	16.17	15	1.9	1.5	11	38	0.0007	0.03	0	0.00	0.01	1.8	0.0	0.0	1.2	0.0	4	0.00	0.02	1.3	1.0	0.02	0.05	16.22	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	16.04	16.04	15	2.8	2.3	14	46	0.0016	0.08	0	0.00	0.02	2.8	0.0	0.0	1.5	0.0	11	0.00	0.04	1.3	1.0	0.05	0.12	16.17	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	15.85	15.85	18	6.1	3.5	7	46	0.0029	0.13	0	0.00	0.05	6.5	6.7	0.0	1.9	0.0	83	0.04	0.11	1.0	0.5	0.05	0.19	16.04	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	15.66	15.66	24	6.9	2.2	90	73	0.0008	0.06	0	0.00	0.02	21.4	0.0	0.0	3.5	0.1	7	0.02	0.10	1.3	1.0	0.13	0.19	15.85	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	15.47	15.47	24	11.5	3.6	90	30	0.0022	0.07	0	0.00	0.05	15.0	8.7	0.0	2.2	0.0	90	0.05	0.13	1.0	1.0	0.13	0.20	15.66	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	15.25	15.25	36	20.9	3.0	102	115	0.0008	0.10	0	0.00	0.03	41.9	29.0	0.0	3.6	0.1	90	0.14	0.25	1.0	0.5	0.13	0.22	15.47	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	15.72	15.72	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.72	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	15.66	15.66	18	3.9	2.2	67	14	0.0012	0.02	0	0.00	0.02	0.1	7.6	0.0	2.1	0.0	67	0.04	0.08	1.0	0.5	0.04	0.06	15.72	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	16.04	16.04	18	3.4	1.9	83	17	0.0009	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.02	16.07	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	15.72	15.72	18	3.7	2.1	67	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	15.75	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	16.66	16.66	8	0.9	2.6	47	39	0.0040	0.16	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.18	16.84	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	16.50	16.50	15	2.2	1.8	90	31	0.0010	0.03	0	0.00	0.01	2.3	0.0	0.0	2.6	0.0	47	0.05	0.10	1.3	1.0	0.13	0.16	16.66	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	16.43	16.43	18	3.6	2.0	0	42	0.0010	0.04	0	0.00	0.02	3.9	1.6	0.0	1.8	0.0	90	0.03	0.07	1.0	0.5	0.03	0.08	16.50	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	15.91	15.91	18	9.5	5.3	0	66	0.0069	0.46	0	0.00	0.11	7.2	4.2	6.0	2.0	0.0	0	0.00	0.13	1.0	0.5	0.07	0.52	16.43	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	15.25	15.25	18	10.9	6.1	78	56	0.0091	0.51	0	0.00	0.15	50.5	0.3	0.3	5.3	0.2	0	0.00	0.30	1.0	0.5	0.15	0.66	15.91	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	16.50	16.50	15	1.4	1.1	90	31	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	16.52	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	16.43	16.43	18	2.7	1.5	90	56	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.00	0.04	16.47	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	16.43	16.43	18	3.3	1.8	90	56	0.0008	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	16.48	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	15.91	15.91	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.91	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	15.91	15.91	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.91	10.95	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) Storm Frequency: 50 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
RELOCATED INLET IN SMR																										
P4	**DI19**	**MH1**	CP-1	2405	0	2405	0.06	1.00	0.06	0.06	6.0	0.00	7.29	0.4	15	27.3	0.012	0.000033	0.005	4.1	5.0	2.5	0.19	6.19	4.49	4.35	Q ok
P5	MH1	MH2	CP-1	1	0	1	0.00	1.00	0.00	0.06	6.0	6.19	7.23	0.4	18	82.7	0.012	0.000012	0.005	4.5	8.0	2.2	0.62	6.81	4.25	3.84	Q ok
P7	MH2	MH3	CP-1	1	0	1	0.00	1.00	0.00	0.06	6.0	6.81	7.04	0.4	18	73.8	0.012	0.000012	0.005	4.6	8.1	2.2	0.55	7.36	3.81	3.44	Q ok
P10	MH3	MH4	CP-2	1	0	1	0.00	1.00	0.00	0.29	6.0	7.36	6.86	2.0	18	53.7	0.012	0.000307	0.005	4.6	8.1	3.7	0.24	7.60	3.34	3.07	Q ok
P13	MH4	MH5	CP-2	1	0	1	0.00	1.00	0.00	0.67	6.0	7.60	6.79	4.5	18	59.3	0.012	0.001596	0.005	4.3	7.7	4.6	0.22	7.81	2.97	2.70	Q ok
P15	MH5	MH41	CP-2	1	0	1	0.00	1.00	0.00	1.06	6.0	7.81	6.73	7.1	*24*	**50.0**	0.012	0.000842	0.020	11.0	34.7	8.3	0.10	7.91	2.60	1.60	Q ok
P9	DI3	MH3	CP-1	4110	3259	7369	0.17	0.73	0.12	0.12	6.0	0.00	7.29	0.9	15	18.3	0.012	0.000166	0.005	4.0	4.9	3.0	0.10	6.10	3.68	3.59	Q ok
P8	DI17	MH3	CP-1	3878	2100	5978	0.14	0.82	0.11	0.11	6.0	0.00	7.29	0.8	15	31.3	0.012	0.000136	0.005	4.2	5.2	2.9	0.18	6.18	3.71	3.54	Q ok
P12	DI4	MH4	CP-1	7109	2561	9670	0.22	0.90	0.20	0.20	6.0	0.00	6.73	1.3	15	20.1	0.012	0.000365	0.005	4.0	4.9	3.3	0.10	6.10	3.48	3.38	Q ok
P11	DI18	MH4	CP-1	6435	2210	8645	0.20	0.90	0.18	0.18	6.0	0.00	6.70	1.2	15	28.4	0.012	0.000295	0.005	4.1	5.1	3.4	0.14	6.14	3.48	3.33	Q ok
P14	DI5	MH5	CP-1	4974	2549	7523	0.17	0.83	0.14	0.14	6.0	0.00	7.29	1.0	15	22.6	0.012	0.000221	0.005	4.0	4.9	3.0	0.12	6.12	3.68	3.57	Q ok
P18	DI6	MH6	CP-1	6937	1863	8800	0.20	0.94	0.19	0.19	6.0	0.00	7.29	1.4	15	38.0	0.012	0.000395	0.005	4.0	4.9	3.4	0.18	6.18	4.57	4.38	Q ok
P16	MH6	MH5	CP-2	1	0	1	0.00	1.00	0.00	0.24	6.0	6.18	7.23	1.8	18	40.0	0.012	0.000241	0.011	6.8	12.1	4.8	0.14	6.32	3.77	3.32	Q ok
RELOCATED INLET IN SMR																											
P17	**DI49**	**MH6**	CP-2	2236	105	2341	0.05	1.00	0.05	0.05	6.0	0.00	7.29	0.4	15	33.0	0.012	0.000031	0.005	4.0	4.9	2.4	0.23	6.23	4.19	4.02	Q ok
P32	DI23	MH12	CP-2	5495	1914	7409	0.17	0.90	0.15	0.15	6.0	0.00	7.29	1.1	15	33.31	0.012	0.0003	0.005	4.1	5.0	3.1	0.18	6.18	3.98	3.81	Q ok
P31	DI9	MH12	CP-2	4483	551	5034	0.12	1.00	0.12	0.12	6.0	0.00	7.29	0.8	15	18.3	0.012	0.0001	0.005	4.0	4.9	2.8	0.11	6.11	3.86	3.77	Q ok
P30	MH12	MH11	CP-2	1	0	1	0.00	1.00	0.00	0.27	6.0	6.18	7.23	1.9	18	50.1	0.012	0.0003	0.005	4.5	8.0	3.7	0.22	6.41	3.67	3.42	Q ok
P27	MH11	MH10	CP-2	1	0	1	0.00	1.00	0.00	0.55	6.0	6.41	7.17	4.0	18	73.2	0.012	0.0012	0.005	4.6	8.1	4.5	0.27	6.67	3.39	3.02	Q ok
P25	MH10	MH9	CP-2	1	0	1	0.00	1.00	0.00	0.63	6.0	6.67	7.07	4.5	24	69.68	0.012	0.0003	0.006	6.3	19.7	5.1	0.23	6.90	2.92	2.47	Q ok
P22	MH9	MH8	CP-2	1	0	1	0.00	1.00	0.00	0.81	6.0	6.90	7.01	5.6	24	108.3	0.012	0.0005	0.005	5.5	17.3	5.0	0.36	7.26	2.47	1.93	Q ok
P-80	DI-80	MH-08		9967	0	9967	0.23	1.00	0.23	0.23	6.0	0.00	7.29	1.7	15	49	0.012	0.0006	0.009	5.5	6.8	4.5	0.18	6.18	4.53	4.07	Q ok
P28	DI22	MH11	CP-1	5555	1955	7510	0.17	0.90	0.16	0.16	6.0	0.00	7.29	1.1	15	30.3	0.012	0.0003	0.005	4.0	4.9	3.3	0.15	6.15	3.64	3.49	Q ok
P29	DI8	MH11	CP-1	5120	570	5690	0.13	1.00	0.13	0.13	6.0	0.00	7.29	1.0	15	18.3	0.012	0.0002	0.005	4.0	4.9	3.0	0.10	6.10	3.64	3.55	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____

County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077

Segment: Market Street (to Central Green Outfall) Storm Frequency: 50 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P26	DI21	MH10	CP-1	2755	930	3685	0.08	0.91	0.08	0.08	6.0	0.00	7.29	0.6	15	18.3	0.012	0.0001	0.005	4.0	4.9	2.4	0.13	6.13	4.02	3.93	Q ok
P23	DI20	MH9	CP-2	3213	1102	4315	0.10	0.90	0.09	0.09	6.0	0.00	7.29	0.7	15	29.3	0.012	0.0001	0.005	4.0	4.9	2.8	0.17	6.17	4.53	4.38	Q ok
P24	DI7	MH9	CP-2	3164	527	3691	0.08	1.00	0.08	0.08	6.0	0.00	7.29	0.6	15	28.02	0.012	0.0001	0.005	4.0	4.9	2.4	0.19	6.19	4.38	4.24	Q ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	6.85	6.85	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.85	7.41	
P5	MH1	MH2	1.20	6.84	6.84	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	6.85	7.93	HGL ok
P7	MH2	MH3	1.20	6.84	6.84	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	6.84	7.65	HGL Too High!
P10	MH3	MH4	1.20	6.82	6.82	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	6.84	7.28	HGL Too High!
P13	MH4	MH5	1.20	6.71	6.71	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	6.82	7.09	HGL Too High!
P15	MH5	MH41	1.60	6.60	6.60	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	6.71	7.40	HGL Too High!
P9	DI3	MH3	1.00	6.84	6.84	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.85	6.62	HGL Too High!
P8	DI17	MH3	1.00	6.84	6.84	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.85	6.96	HGL Too High!
P12	DI4	MH4	1.00	6.82	6.82	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.83	6.48	HGL Too High!
P11	DI18	MH4	1.00	6.82	6.82	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.83	6.56	HGL Too High!
P14	DI5	MH5	1.00	6.71	6.71	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.72	6.61	HGL Too High!
P18	DI6	MH6	1.00	6.73	6.73	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	6.75	7.13	HGL Too High!
P16	MH6	MH5	1.20	6.71	6.71	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	6.73	7.55	HGL Too High!
P17	DI49	MH6	1.00	6.73	6.73	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.73	7.08	HGL Too High!
P32	DI23	MH12	1.00	6.78	6.78	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.79	7.11	HGL Too High!
P31	DI9	MH12	1.00	6.78	6.78	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.78	7.13	HGL Too High!
P30	MH12	MH11	1.60	6.76	6.76	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	6.78	7.48	HGL Too High!
P27	MH11	MH10	1.60	6.66	6.66	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	6.76	7.21	HGL Too High!
P25	MH10	MH9	1.60	6.63	6.63	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	6.66	7.54	HGL Too High!
P22	MH9	MH8	1.60	6.56	6.56	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	6.63	7.85	HGL ok
P-80	DI-80	MH-08	1.00	6.56	6.56	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	6.59	7.34	HGL Too High!
P28	DI22	MH11	1.00	6.76	6.76	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.77	6.74	HGL Too High!
P29	DI8	MH11	1.00	6.76	6.76	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.76	6.92	HGL Too High!
P26	DI21	MH10	1.00	6.66	6.66	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.67	7.23	HGL Too High!
P23	DI20	MH9	1.00	6.63	6.63	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	6.63	7.38	HGL Too High!
P24	DI7	MH9	1.00	6.63	6.63	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.63	7.48	HGL Too High!

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Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	7.05	7.05	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.05	7.41	
P5	MH1	MH2	1.20	7.04	7.04	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	7.05	7.93	HGL Too High!
P7	MH2	MH3	1.20	7.04	7.04	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.04	7.65	HGL Too High!
P10	MH3	MH4	1.20	7.02	7.02	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	7.04	7.28	HGL Too High!
P13	MH4	MH5	1.20	6.91	6.91	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	7.02	7.09	HGL Too High!
P15	MH5	MH41	1.60	6.80	6.80	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	6.91	7.40	HGL Too High!
P9	DI3	MH3	1.00	7.04	7.04	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.05	6.62	HGL Too High!
P8	DI17	MH3	1.00	7.04	7.04	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.05	6.96	HGL Too High!
P12	DI4	MH4	1.00	7.02	7.02	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.03	6.48	HGL Too High!
P11	DI18	MH4	1.00	7.02	7.02	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.03	6.56	HGL Too High!
P14	DI5	MH5	1.00	6.91	6.91	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.92	6.61	HGL Too High!
P18	DI6	MH6	1.00	6.93	6.93	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	6.95	7.13	HGL Too High!
P16	MH6	MH5	1.20	6.91	6.91	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	6.93	7.55	HGL Too High!
P17	DI49	MH6	1.00	6.93	6.93	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.93	7.08	HGL Too High!
P32	DI23	MH12	1.00	6.98	6.98	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.99	7.11	HGL Too High!
P31	DI9	MH12	1.00	6.98	6.98	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.98	7.13	HGL Too High!
P30	MH12	MH11	1.60	6.96	6.96	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	6.98	7.48	HGL Too High!
P27	MH11	MH10	1.60	6.86	6.86	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	6.96	7.21	HGL Too High!
P25	MH10	MH9	1.60	6.83	6.83	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	6.86	7.54	HGL Too High!
P22	MH9	MH8	1.60	6.76	6.76	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	6.83	7.85	HGL ok
P-80	DI-80	MH-08	1.00	6.76	6.76	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	6.79	7.34	HGL Too High!
P28	DI22	MH11	1.00	6.96	6.96	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.97	6.74	HGL Too High!
P29	DI8	MH11	1.00	6.96	6.96	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.96	6.92	HGL Too High!
P26	DI21	MH10	1.00	6.86	6.86	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.87	7.23	HGL Too High!
P23	DI20	MH9	1.00	6.83	6.83	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	6.83	7.38	HGL Too High!
P24	DI7	MH9	1.00	6.83	6.83	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.83	7.48	HGL Too High!

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RK&K

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Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.55	10.55	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.55	7.41	
P5	MH1	MH2	1.20	10.54	10.54	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.55	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.54	10.54	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.54	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.52	10.52	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	10.54	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.41	10.41	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	10.52	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.30	10.30	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	10.41	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.54	10.54	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.55	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.54	10.54	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.55	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.52	10.52	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.53	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.52	10.52	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.53	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.41	10.41	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.42	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.43	10.43	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.45	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.41	10.41	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	10.43	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.43	10.43	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.43	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.48	10.48	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.49	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.48	10.48	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.48	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.46	10.46	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	10.48	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.36	10.36	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	10.46	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.33	10.33	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	10.36	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.26	10.26	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	10.33	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.26	10.26	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	10.29	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.46	10.46	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.47	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.46	10.46	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.46	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.36	10.36	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.37	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.33	10.33	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.33	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.33	10.33	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.33	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.05	11.05	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.05	7.41	
P5	MH1	MH2	1.20	11.04	11.04	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.05	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.04	11.04	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.04	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.02	11.02	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	11.04	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.91	10.91	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	11.02	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.80	10.80	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	10.91	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.04	11.04	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.05	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.04	11.04	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.05	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.02	11.02	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.03	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.02	11.02	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.03	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.91	10.91	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.92	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.93	10.93	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	10.95	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.91	10.91	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	10.93	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.93	10.93	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.93	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.98	10.98	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.99	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.98	10.98	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.98	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.96	10.96	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	10.98	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.86	10.86	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	10.96	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.83	10.83	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	10.86	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.76	10.76	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	10.83	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.76	10.76	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	10.79	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.96	10.96	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.97	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.96	10.96	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.96	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.86	10.86	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.87	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.83	10.83	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.83	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.83	10.83	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.83	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.45	11.45	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.45	7.41	
P5	MH1	MH2	1.20	11.44	11.44	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.45	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.44	11.44	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.44	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.42	11.42	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	11.44	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.31	11.31	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	11.42	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.20	11.20	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	11.31	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.44	11.44	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.45	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.44	11.44	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.45	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.42	11.42	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.43	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.42	11.42	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.43	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.31	11.31	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.32	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.33	11.33	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.35	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.31	11.31	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	11.33	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.33	11.33	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.33	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.38	11.38	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.39	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.38	11.38	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.38	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.36	11.36	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	11.38	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.26	11.26	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	11.36	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.23	11.23	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	11.26	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.16	11.16	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	11.23	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.16	11.16	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	11.19	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.36	11.36	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.37	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.36	11.36	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.36	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.26	11.26	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.27	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.23	11.23	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.23	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.23	11.23	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.23	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_i + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.95	11.95	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.95	7.41	
P5	MH1	MH2	1.20	11.94	11.94	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.95	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.94	11.94	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.94	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.92	11.92	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	11.94	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.81	11.81	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	11.92	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.70	11.70	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	11.81	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.94	11.94	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.95	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.94	11.94	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.95	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.92	11.92	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.93	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.92	11.92	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.93	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.81	11.81	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.82	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.83	11.83	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	11.85	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.81	11.81	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	11.83	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.83	11.83	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.83	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.88	11.88	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.89	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.88	11.88	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.88	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.86	11.86	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	11.88	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.76	11.76	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	11.86	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.73	11.73	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	11.76	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.66	11.66	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	11.73	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.66	11.66	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	11.69	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.86	11.86	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.87	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.86	11.86	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.86	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.76	11.76	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.77	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.73	11.73	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.73	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.73	11.73	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.73	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_i + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.65	12.65	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.65	7.41	
P5	MH1	MH2	1.20	12.64	12.64	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.65	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.64	12.64	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.64	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.62	12.62	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	12.64	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.51	12.51	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	12.62	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.40	12.40	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	12.51	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.64	12.64	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.65	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.64	12.64	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.65	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.62	12.62	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.63	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.62	12.62	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.63	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.51	12.51	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.52	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.53	12.53	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.55	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.51	12.51	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	12.53	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.53	12.53	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.53	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.58	12.58	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.59	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.58	12.58	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.58	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.56	12.56	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	12.58	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.46	12.46	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	12.56	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.43	12.43	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	12.46	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.36	12.36	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	12.43	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.36	12.36	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	12.39	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.56	12.56	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.57	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.56	12.56	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.56	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.46	12.46	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.47	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.43	12.43	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.43	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.43	12.43	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.43	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.15	13.15	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.15	7.41	
P5	MH1	MH2	1.20	13.14	13.14	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.15	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.14	13.14	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.14	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.12	13.12	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	13.14	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.01	13.01	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	13.12	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.90	12.90	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	13.01	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.14	13.14	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.15	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.14	13.14	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.15	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.12	13.12	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.13	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.12	13.12	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.13	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.01	13.01	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.02	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.03	13.03	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.05	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.01	13.01	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	13.03	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.03	13.03	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.03	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.08	13.08	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.09	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.08	13.08	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.08	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.06	13.06	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	13.08	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.96	12.96	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	13.06	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.93	12.93	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	12.96	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.86	12.86	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	12.93	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.86	12.86	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	12.89	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.06	13.06	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.07	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.06	13.06	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.06	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.96	12.96	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.97	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.93	12.93	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.93	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.93	12.93	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.93	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	14.45	14.45	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.45	7.41	
P5	MH1	MH2	1.20	14.44	14.44	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	14.45	7.93	HGL Too High!
P7	MH2	MH3	1.20	14.44	14.44	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	14.44	7.65	HGL Too High!
P10	MH3	MH4	1.20	14.42	14.42	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	14.44	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.31	14.31	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	14.42	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.20	14.20	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	14.31	7.40	HGL Too High!
P9	DI3	MH3	1.00	14.44	14.44	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.45	6.62	HGL Too High!
P8	DI17	MH3	1.00	14.44	14.44	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.45	6.96	HGL Too High!
P12	DI4	MH4	1.00	14.42	14.42	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.43	6.48	HGL Too High!
P11	DI18	MH4	1.00	14.42	14.42	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.43	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.31	14.31	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.32	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.33	14.33	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	14.35	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.31	14.31	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	14.33	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.33	14.33	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.33	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.38	14.38	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.39	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.38	14.38	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.38	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.36	14.36	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	14.38	7.48	HGL Too High!
P27	MH11	MH10	1.60	14.26	14.26	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	14.36	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.23	14.23	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	14.26	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.16	14.16	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	14.23	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.16	14.16	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	14.19	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.36	14.36	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.37	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.36	14.36	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.36	6.92	HGL Too High!
P26	DI21	MH10	1.00	14.26	14.26	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.27	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.23	14.23	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.23	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.23	14.23	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.23	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.39	9.39	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.39	7.41	
P5	MH1	MH2	1.20	9.38	9.38	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.39	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.38	9.38	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.38	7.65	HGL Too High!
P10	MH3	MH4	1.20	9.36	9.36	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	9.38	7.28	HGL Too High!
P13	MH4	MH5	1.20	9.25	9.25	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	9.36	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.14	9.14	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	9.25	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.38	9.38	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.39	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.38	9.38	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.39	6.96	HGL Too High!
P12	DI4	MH4	1.00	9.36	9.36	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.37	6.48	HGL Too High!
P11	DI18	MH4	1.00	9.36	9.36	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.37	6.56	HGL Too High!
P14	DI5	MH5	1.00	9.25	9.25	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.26	6.61	HGL Too High!
P18	DI6	MH6	1.00	9.27	9.27	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.29	7.13	HGL Too High!
P16	MH6	MH5	1.20	9.25	9.25	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	9.27	7.55	HGL Too High!
P17	DI49	MH6	1.00	9.27	9.27	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.27	7.08	HGL Too High!
P32	DI23	MH12	1.00	9.32	9.32	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.33	7.11	HGL Too High!
P31	DI9	MH12	1.00	9.32	9.32	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.32	7.13	HGL Too High!
P30	MH12	MH11	1.60	9.30	9.30	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	9.32	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.20	9.20	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	9.30	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.17	9.17	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	9.20	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.10	9.10	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	9.17	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.10	9.10	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	9.13	7.34	HGL Too High!
P28	DI22	MH11	1.00	9.30	9.30	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.31	6.74	HGL Too High!
P29	DI8	MH11	1.00	9.30	9.30	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.30	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.20	9.20	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.21	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.17	9.17	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.17	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.17	9.17	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.17	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.59	9.59	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.59	7.41	
P5	MH1	MH2	1.20	9.58	9.58	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.59	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.58	9.58	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.58	7.65	HGL Too High!
P10	MH3	MH4	1.20	9.56	9.56	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	9.58	7.28	HGL Too High!
P13	MH4	MH5	1.20	9.45	9.45	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	9.56	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.34	9.34	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	9.45	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.58	9.58	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.59	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.58	9.58	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.59	6.96	HGL Too High!
P12	DI4	MH4	1.00	9.56	9.56	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.57	6.48	HGL Too High!
P11	DI18	MH4	1.00	9.56	9.56	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.57	6.56	HGL Too High!
P14	DI5	MH5	1.00	9.45	9.45	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.46	6.61	HGL Too High!
P18	DI6	MH6	1.00	9.47	9.47	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	9.49	7.13	HGL Too High!
P16	MH6	MH5	1.20	9.45	9.45	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	9.47	7.55	HGL Too High!
P17	DI49	MH6	1.00	9.47	9.47	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.47	7.08	HGL Too High!
P32	DI23	MH12	1.00	9.52	9.52	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.53	7.11	HGL Too High!
P31	DI9	MH12	1.00	9.52	9.52	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.52	7.13	HGL Too High!
P30	MH12	MH11	1.60	9.50	9.50	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	9.52	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.40	9.40	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	9.50	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.37	9.37	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	9.40	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.30	9.30	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	9.37	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.30	9.30	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	9.33	7.34	HGL Too High!
P28	DI22	MH11	1.00	9.50	9.50	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.51	6.74	HGL Too High!
P29	DI8	MH11	1.00	9.50	9.50	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.50	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.40	9.40	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.41	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.37	9.37	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.37	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.37	9.37	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.37	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.09	13.09	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.09	7.41	
P5	MH1	MH2	1.20	13.08	13.08	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.09	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.08	13.08	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.08	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.06	13.06	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	13.08	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.95	12.95	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	13.06	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.84	12.84	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	12.95	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.08	13.08	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.09	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.08	13.08	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.09	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.06	13.06	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.07	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.06	13.06	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.07	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.95	12.95	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.96	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.97	12.97	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	12.99	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.95	12.95	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	12.97	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.97	12.97	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.97	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.02	13.02	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.03	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.02	13.02	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.02	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.00	13.00	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	13.02	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.90	12.90	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	13.00	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.87	12.87	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	12.90	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.80	12.80	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	12.87	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.80	12.80	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	12.83	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.00	13.00	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.01	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.00	13.00	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.00	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.90	12.90	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.91	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.87	12.87	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.87	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.87	12.87	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.87	7.48	HGL Too High!

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Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.59	13.59	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.59	7.41	
P5	MH1	MH2	1.20	13.58	13.58	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.59	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.58	13.58	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.58	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.56	13.56	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	13.58	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.45	13.45	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	13.56	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.34	13.34	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	13.45	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.58	13.58	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.59	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.58	13.58	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.59	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.56	13.56	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.57	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.56	13.56	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.57	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.45	13.45	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.46	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.47	13.47	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.49	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.45	13.45	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	13.47	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.47	13.47	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.47	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.52	13.52	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.53	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.52	13.52	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.52	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.50	13.50	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	13.52	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.40	13.40	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	13.50	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.37	13.37	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	13.40	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.30	13.30	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	13.37	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.30	13.30	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	13.33	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.50	13.50	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.51	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.50	13.50	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.50	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.40	13.40	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.41	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.37	13.37	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.37	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.37	13.37	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.37	7.48	HGL Too High!

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No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.99	13.99	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.99	7.41	
P5	MH1	MH2	1.20	13.98	13.98	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.99	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.98	13.98	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.98	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.96	13.96	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	13.98	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.85	13.85	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	13.96	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.74	13.74	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	13.85	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.98	13.98	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.99	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.98	13.98	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.99	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.96	13.96	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.97	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.96	13.96	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.97	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.85	13.85	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.86	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.87	13.87	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	13.89	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.85	13.85	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	13.87	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.87	13.87	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.87	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.92	13.92	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.93	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.92	13.92	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.92	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.90	13.90	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	13.92	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.80	13.80	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	13.90	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.77	13.77	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	13.80	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.70	13.70	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	13.77	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.70	13.70	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	13.73	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.90	13.90	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.91	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.90	13.90	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.90	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.80	13.80	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.81	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.77	13.77	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.77	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.77	13.77	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.77	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	14.49	14.49	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.49	7.41	
P5	MH1	MH2	1.20	14.48	14.48	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	14.49	7.93	HGL Too High!
P7	MH2	MH3	1.20	14.48	14.48	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	14.48	7.65	HGL Too High!
P10	MH3	MH4	1.20	14.46	14.46	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	14.48	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.35	14.35	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	14.46	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.24	14.24	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	14.35	7.40	HGL Too High!
P9	DI3	MH3	1.00	14.48	14.48	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.49	6.62	HGL Too High!
P8	DI17	MH3	1.00	14.48	14.48	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.49	6.96	HGL Too High!
P12	DI4	MH4	1.00	14.46	14.46	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.47	6.48	HGL Too High!
P11	DI18	MH4	1.00	14.46	14.46	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.47	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.35	14.35	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.36	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.37	14.37	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	14.39	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.35	14.35	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	14.37	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.37	14.37	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.37	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.42	14.42	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.43	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.42	14.42	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.42	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.40	14.40	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	14.42	7.48	HGL Too High!
P27	MH11	MH10	1.60	14.30	14.30	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	14.40	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.27	14.27	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	14.30	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.20	14.20	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	14.27	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.20	14.20	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	14.23	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.40	14.40	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.41	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.40	14.40	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.40	6.92	HGL Too High!
P26	DI21	MH10	1.00	14.30	14.30	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.31	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.27	14.27	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.27	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.27	14.27	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.27	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	15.19	15.19	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.19	7.41	
P5	MH1	MH2	1.20	15.18	15.18	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	15.19	7.93	HGL Too High!
P7	MH2	MH3	1.20	15.18	15.18	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	15.18	7.65	HGL Too High!
P10	MH3	MH4	1.20	15.16	15.16	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	15.18	7.28	HGL Too High!
P13	MH4	MH5	1.20	15.05	15.05	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	15.16	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.94	14.94	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	15.05	7.40	HGL Too High!
P9	DI3	MH3	1.00	15.18	15.18	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.19	6.62	HGL Too High!
P8	DI17	MH3	1.00	15.18	15.18	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.19	6.96	HGL Too High!
P12	DI4	MH4	1.00	15.16	15.16	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.17	6.48	HGL Too High!
P11	DI18	MH4	1.00	15.16	15.16	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.17	6.56	HGL Too High!
P14	DI5	MH5	1.00	15.05	15.05	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.06	6.61	HGL Too High!
P18	DI6	MH6	1.00	15.07	15.07	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	15.09	7.13	HGL Too High!
P16	MH6	MH5	1.20	15.05	15.05	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	15.07	7.55	HGL Too High!
P17	DI49	MH6	1.00	15.07	15.07	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.07	7.08	HGL Too High!
P32	DI23	MH12	1.00	15.12	15.12	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.13	7.11	HGL Too High!
P31	DI9	MH12	1.00	15.12	15.12	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.12	7.13	HGL Too High!
P30	MH12	MH11	1.60	15.10	15.10	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	15.12	7.48	HGL Too High!
P27	MH11	MH10	1.60	15.00	15.00	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	15.10	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.97	14.97	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	15.00	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.90	14.90	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	14.97	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.90	14.90	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	14.93	7.34	HGL Too High!
P28	DI22	MH11	1.00	15.10	15.10	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.11	6.74	HGL Too High!
P29	DI8	MH11	1.00	15.10	15.10	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.10	6.92	HGL Too High!
P26	DI21	MH10	1.00	15.00	15.00	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.01	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.97	14.97	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.97	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.97	14.97	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.97	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	15.69	15.69	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.69	7.41	
P5	MH1	MH2	1.20	15.68	15.68	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	15.69	7.93	HGL Too High!
P7	MH2	MH3	1.20	15.68	15.68	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	15.68	7.65	HGL Too High!
P10	MH3	MH4	1.20	15.66	15.66	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	15.68	7.28	HGL Too High!
P13	MH4	MH5	1.20	15.55	15.55	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	15.66	7.09	HGL Too High!
P15	MH5	MH41	1.60	15.44	15.44	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	15.55	7.40	HGL Too High!
P9	DI3	MH3	1.00	15.68	15.68	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.69	6.62	HGL Too High!
P8	DI17	MH3	1.00	15.68	15.68	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.69	6.96	HGL Too High!
P12	DI4	MH4	1.00	15.66	15.66	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.67	6.48	HGL Too High!
P11	DI18	MH4	1.00	15.66	15.66	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.67	6.56	HGL Too High!
P14	DI5	MH5	1.00	15.55	15.55	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.56	6.61	HGL Too High!
P18	DI6	MH6	1.00	15.57	15.57	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	15.59	7.13	HGL Too High!
P16	MH6	MH5	1.20	15.55	15.55	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	15.57	7.55	HGL Too High!
P17	DI49	MH6	1.00	15.57	15.57	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.57	7.08	HGL Too High!
P32	DI23	MH12	1.00	15.62	15.62	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.63	7.11	HGL Too High!
P31	DI9	MH12	1.00	15.62	15.62	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.62	7.13	HGL Too High!
P30	MH12	MH11	1.60	15.60	15.60	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	15.62	7.48	HGL Too High!
P27	MH11	MH10	1.60	15.50	15.50	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	15.60	7.21	HGL Too High!
P25	MH10	MH9	1.60	15.47	15.47	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	15.50	7.54	HGL Too High!
P22	MH9	MH8	1.60	15.40	15.40	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	15.47	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	15.40	15.40	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	15.43	7.34	HGL Too High!
P28	DI22	MH11	1.00	15.60	15.60	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.61	6.74	HGL Too High!
P29	DI8	MH11	1.00	15.60	15.60	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.60	6.92	HGL Too High!
P26	DI21	MH10	1.00	15.50	15.50	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.51	7.23	HGL Too High!
P23	DI20	MH9	1.00	15.47	15.47	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	15.47	7.38	HGL Too High!
P24	DI7	MH9	1.00	15.47	15.47	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.47	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 50 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	16.99	16.99	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.99	7.41	
P5	MH1	MH2	1.20	16.98	16.98	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	16.99	7.93	HGL Too High!
P7	MH2	MH3	1.20	16.98	16.98	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	16.98	7.65	HGL Too High!
P10	MH3	MH4	1.20	16.96	16.96	18	2.0	1.1	8	53.7	0.0003	0.02	0	0.00	0.00	0.1	0.7	0.5	0.7	0.0	87	0.01	0.01	1.0	0.5	0.01	0.02	16.98	7.28	HGL Too High!
P13	MH4	MH5	1.20	16.85	16.85	18	4.5	2.6	84	59.3	0.0016	0.09	0	0.00	0.03	2.3	1.5	1.2	1.1	0.0	8	0.00	0.03	1.0	0.5	0.02	0.11	16.96	7.09	HGL Too High!
P15	MH5	MH41	1.60	16.74	16.74	24	7.1	2.3	90	50	0.0008	0.04	0	0.00	0.02	11.7	0.9	1.8	2.6	0.0	84	0.07	0.13	1.0	0.5	0.06	0.10	16.85	7.40	HGL Too High!
P9	DI3	MH3	1.00	16.98	16.98	15	0.9	0.7	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.99	6.62	HGL Too High!
P8	DI17	MH3	1.00	16.98	16.98	15	0.8	0.7	81	31.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.99	6.96	HGL Too High!
P12	DI4	MH4	1.00	16.96	16.96	15	1.3	1.1	99	20.1	0.0004	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.97	6.48	HGL Too High!
P11	DI18	MH4	1.00	16.96	16.96	15	1.2	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.97	6.56	HGL Too High!
P14	DI5	MH5	1.00	16.85	16.85	15	1.0	0.8	21	22.6	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.86	6.61	HGL Too High!
P18	DI6	MH6	1.00	16.87	16.87	15	1.4	1.1	23	38	0.0004	0.02	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.02	16.89	7.13	HGL Too High!
P16	MH6	MH5	1.20	16.85	16.85	18	1.8	1.0	86	40	0.0002	0.01	0	0.00	0.00	1.6	0.1	0.0	1.1	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	16.87	7.55	HGL Too High!
P17	DI49	MH6	1.00	16.87	16.87	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.87	7.08	HGL Too High!
P32	DI23	MH12	1.00	16.92	16.92	15	1.1	0.9	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.93	7.11	HGL Too High!
P31	DI9	MH12	1.00	16.92	16.92	15	0.8	0.7	90	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.92	7.13	HGL Too High!
P30	MH12	MH11	1.60	16.90	16.90	24	1.9	0.6	1	50.1	0.0003	0.01	0	0.00	0.00	0.6	1.0	0.0	0.9	0.0	64	0.01	0.01	1.0	0.5	0.01	0.02	16.92	7.48	HGL Too High!
P27	MH11	MH10	1.60	16.80	16.80	24	4.0	1.3	5	73.2	0.0012	0.09	0	0.00	0.01	1.2	1.0	0.7	0.6	0.0	1	0.00	0.01	1.0	0.5	0.00	0.09	16.90	7.21	HGL Too High!
P25	MH10	MH9	1.60	16.77	16.77	24	4.5	1.4	5	69.7	0.0003	0.02	0	0.00	0.01	5.0	0.3	0.0	1.3	0.0	5	0.00	0.02	1.0	0.5	0.01	0.03	16.80	7.54	HGL Too High!
P22	MH9	MH8	1.60	16.70	16.70	24	5.6	1.8	51	108	0.0005	0.06	0	0.00	0.01	6.3	0.3	0.3	1.4	0.0	5	0.00	0.03	1.0	0.5	0.01	0.07	16.77	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	16.70	16.70	15	1.7	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	16.73	7.34	HGL Too High!
P28	DI22	MH11	1.00	16.90	16.90	15	1.1	0.9	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.91	6.74	HGL Too High!
P29	DI8	MH11	1.00	16.90	16.90	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.90	6.92	HGL Too High!
P26	DI21	MH10	1.00	16.80	16.80	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.81	7.23	HGL Too High!
P23	DI20	MH9	1.00	16.77	16.77	15	0.7	0.5	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	16.77	7.38	HGL Too High!
P24	DI7	MH9	1.00	16.77	16.77	15	0.6	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.77	7.48	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 100 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-41	MH-41	MH-42	1	0	1	0.00	1.00	0.00	1.10	6.0	7.90	7.10	7.78	24	92	0.012	0.001007	0.0033	4.5	14.0	4.5	0.34	8.24	1.50	1.20	Q ok
P-42	MH-42	DI-43	1	0	1	0.00	1.00	0.00	2.15	6.0	8.24	7.00	15.05	**30**	30	0.012	0.001146	0.0030	5.0	24.3	5.2	0.10	8.33	1.10	1.01	Q ok
P-43	DI-43	DI-44	4208	31	4239	0.10	1.00	0.10	2.25	6.0	8.33	6.96	15.65	**30**	25	0.012	0.001241	0.0032	5.1	25.1	5.4	0.08	8.41	0.91	0.83	Q ok
P-44	DI-44	DI-45	4675	523	5198	0.12	1.00	0.12	2.37	6.0	8.41	6.93	16.40	**30**	69	0.012	0.001363	0.0030	5.0	24.5	5.3	0.22	8.63	0.73	0.52	Q ok
P-45	DI-45	MH-46	4490	535	5025	0.12	1.00	0.12	2.48	6.0	8.63	6.86	17.04	30	52	0.012	0.001470	0.0031	5.0	24.6	5.5	0.16	8.78	0.42	0.26	Q ok
P-46	MH-46	DI-47	1	0	1	0.00	1.00	0.00	3.22	6.0	8.78	6.80	21.88	30	42	0.012	0.002424	0.0031	5.0	24.7	5.7	0.12	8.91	0.16	0.03	Q ok
P-47	DI-47	MH-60	4551	287	4838	0.11	1.00	0.11	3.33	6.0	8.91	6.77	22.52	36	23	0.012	0.000971	0.0030	5.6	39.9	5.8	0.07	8.97	-0.07	-0.14	Q ok
P-60	MH-60	MH-61	1	0	1	0.00	1.00	0.00	4.54	6.0	8.97	6.73	30.56	36	75	0.012	0.001789	0.0039	6.4	44.9	6.9	0.18	9.15	-0.24	-0.53	Q ok
P-61	MH-61	DI-62	1	0	1	0.00	1.00	0.00	4.54	6.0	9.15	6.67	30.26	36	76	0.012	0.001754	0.0039	6.4	45.4	6.9	0.18	9.34	-0.63	-0.93	Q ok
P-62	DI-62	DI-63	1435	40	1475	0.03	1.00	0.03	4.57	6.0	9.34	6.63	30.34	36	50	0.012	0.001763	0.0040	6.5	45.7	6.9	0.12	9.46	-1.03	-1.23	Q ok
P-63	DI-63	DI-77	1999	107	2106	0.05	1.00	0.05	5.36	6.0	9.46	6.57	35.21	*36*	25	0.012	0.002374	0.0036	6.1	43.4	6.9	0.06	9.52	-1.33	-1.42	Q ok
P-77	DI-77	DI-85	2311	122	2433	0.06	1.00	0.06	6.64	6.0	9.52	6.57	43.60	**48**	50	0.012	0.000785	0.0030	6.8	85.2	6.7	0.12	9.64	-1.52	-1.67	Q ok
P-85	DI-85	MH-86	5006	304	5310	0.12	1.00	0.12	11.74	6.0	9.64	6.53	76.69	60	186	0.012	0.000739	0.0030	7.9	154.8	7.8	0.40	10.04	-1.77	-2.33	Q ok
P-86	MH-86	MH-87	1	0	1	0.00	1.00	0.00	12.49	6.0	10.04	6.40	79.91	60	45	0.012	0.000802	0.0031	8.0	157.4	7.9	0.09	10.14	-2.43	-2.57	Q ok
P-87	**MH-87**	**OUTFALL**	**1**	**0**	**1**	**0.00**	**1.00**	**0.00**	**13.30**	**6.0**	**10.14**	**6.38**	**84.85**	**60**	**9**	**0.012**	**0.000904**	**0.0033**	**8.3**	**162.9**	**8.2**	**0.02**	**10.15**	**-2.67**	**-2.70**	**Q ok**
P-48	MSS MH-08	MH-49	1	0	1	0.00	1.00	0.00	1.05	6.0	7.24	7.33	7.73	24	64	0.012	0.000994	0.0070	6.5	20.6	6.0	0.18	7.42	1.65	1.20	Q ok
P-50	B7 North	1.00	32048	0	32048	0.74	1.00	0.74	0.74	6.0	0.00	7.73	5.69	18	16	0.012	0.002496	0.0050	4.6	8.0	5.0	0.05	6.05	0.35	0.27	Q ok
P-65	B7 West	MH-64	32234	0	32234	0.74	1.00	0.74	0.74	6.0	0.00	7.73	5.72	18	17	0.012	0.002525	0.0047	4.4	7.8	4.9	0.06	6.06	-0.95	-1.03	Q ok
P-64	MH-64	DI-63	1	0	1	0.00	1.00	0.00	0.74	6.0	6.06	7.69	5.69	18	20	0.012	0.002504	0.0050	4.6	8.0	5.0	0.07	6.12	-1.13	-1.23	Q ok
P-51	DI-51	DI-52	3030	31	3061	0.07	1.00	0.07	0.07	6.0	0.00	7.73	0.54	15	26	0.012	0.000060	0.0050	4.0	4.9	2.4	0.18	6.18	3.70	3.57	Q ok
P-52	DI-52	DI-53	4699	521	5220	0.12	1.00	0.12	0.19	6.0	6.18	7.66	1.46	15	69	0.012	0.000433	0.0049	4.0	4.9	3.4	0.34	6.52	3.37	3.03	Q ok
P-53	DI-53	MH-54	4484	537	5021	0.12	1.00	0.12	0.31	6.0	6.52	7.56	2.31	15	51	0.012	0.001089	0.0051	4.1	5.0	3.9	0.22	6.73	2.83	2.57	Q ok
P-54	MH-54	DI-55	1	0	1	0.00	1.00	0.00	1.07	6.0	6.73	7.50	8.05	24	41	0.012	0.001079	0.0049	5.4	17.1	5.3	0.13	6.86	2.37	2.17	Q ok
P-55	DI-55	MH-60	5685	291	5976	0.14	1.00	0.14	1.21	6.0	6.86	7.43	9.00	**24**	23	0.012	0.001348	0.0052	5.6	17.7	5.6	0.07	6.93	1.97	1.85	Q ok
P-56	B5 South	MH-54	33482	0	33482	0.77	1.00	0.77	0.77	6.0	0.00	7.73	5.94	18	17	0.012	0.002725	0.0053	4.7	8.3	5.1	0.06	6.06	2.56	2.47	Q ok
P-78	DI-78	DI-79	3667	223	3890	0.09	1.00	0.09	0.09	6.0	0.00	7.73	0.69	15	84	0.012	0.000097	0.0200	8.1	9.9	4.0	0.35	6.35	7.12	5.44	Q ok
P-79	DI-79	DI-71	3253	204	3457	0.08	1.00	0.08	0.17	6.0	6.35	7.60	1.28	18	29	0.012	0.000127	0.0200	9.1	16.1	5.5	0.09	6.44	5.24	4.66	Q ok
P-71	DI-71	DI-72	3698	198	3896	0.09	1.00	0.09	0.35	6.0	6.44	7.60	2.67	18	42	0.012	0.000552	0.0200	9.1	16.1	6.4	0.11	6.55	4.46	3.62	Q ok
P-72	DI-72	DI-73	2021	16	2037	0.05	1.00	0.05	0.40	6.0	6.55	7.53	3.00	18	29	0.012	0.000696	0.0200	9.1	16.1	6.8	0.07	6.62	3.42	2.84	Q ok
P-73	DI-73	MH-74	1071	0	1071	0.02	1.00	0.02	0.42	6.0	6.62	7.53	3.19	18	17	0.012	0.000784	0.0200	9.1	16.1	6.8	0.04	6.66	2.64	2.30	Q ok
P-74	MH-74	DI-75	1	0	1	0.00	1.00	0.00	1.13	6.0	6.66	7.50	8.44	18	17	0.012	0.005501	0.0200	9.1	16.1	9.0	0.03	6.70	2.10	1.76	Q ok
P-75	DI-75	DI-76	2135	0	2135	0.05	1.00	0.05	1.18	6.0	6.70	7.50	8.81	18	43	0.012	0.005990	0.0200	9.1	16.1	9.3	0.08	6.77	1.56	0.70	Q ok
P-76	DI-76	DI-77	1993	48	2041	0.05	1.00	0.05	1.22	6.0	6.77	7.46	9.12	18	51	0.012	0.006420	0.0200	9.1	16.1	9.3	0.09	6.86	0.50	-0.52	Q ok
P-70	DI-70	DI-71	3812	274	4086	0.09	1.00	0.09	0.09	6.0	0.00	7.73	0.72	15	86	0.012	0.000107	0.0200	8.1	9.9	4.0	0.36	6.36	6.38	4.66	Q ok
P-80	DI-80	MH-74	22886	15258	38144	0.88	0.80	0.70	0.70	6.0	0.00	7.73	5.43	18	24	0.012	0.002277	0.0050	4.6	8.0	4.9	0.08	6.08	2.42	2.30	Q ok
P-90	DI-90	DI-91	6026	1962	7988	0.18	0.95	0.17	0.17	6.0	0.00	7.73	1.35	15	79	0.012	0.000371	0.0200	8.1	9.9	5.6	0.23	6.23	2.54	0.96	Q ok
P-91	DI-91	MH-87	6475	2667	9142	0.21	0.91	0.19	0.81	6.0	6.23	7.66	6.24	18	81	0.012	0.003003	0.0200	9.1	16.1	8.4	0.16	6.39	-0.04	-1.66	Q ok
P-92	B6 North	DI-91	19569	0	19569	0.45	1.00	0.45	0.45	6.0	0.00	7.73	3.47	18	63	0.012	0.000931	0.0049	4.5	8.0	4.4	0.24	6.24	0.47	0.16	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

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Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 100 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-95	TD-04	MH-86	21353	32030	53383	1.23	0.61	0.75	0.75	6.0	0.00	7.73	5.78	12	16	0.011	0.018825	0.0506	12.1	9.5	12.7	0.02	6.02	8.01	7.20	Q ok
P-38	DI-38	DI-39	1483	0	1483	0.03	1.00	0.03	0.03	6.0	0.00	7.73	0.26	15	99	0.012	0.000014	0.0200	8.1	9.9	4.0	0.42	6.42	2.75	0.77	Q ok
P-39	DI-39	DI-40	3833	220	4053	0.09	1.00	0.09	0.13	6.0	6.42	7.60	0.97	15	70	0.012	0.000190	0.0200	8.1	9.9	4.8	0.24	6.66	0.57	-0.83	Q ok
P-40	DI-40	DI-85	4668	293	4961	0.11	1.00	0.11	0.24	6.0	6.66	7.50	1.81	18	26	0.012	0.000252	0.0208	9.3	16.4	5.6	0.08	6.74	-1.03	-1.57	Q ok
P-35	MH-35	DI-36	1	0	1	0.00	1.00	0.00	4.60	6.0	7.40	7.26	33.40	**36**	94	0.012	0.002137	0.0050	7.2	51.1	7.7	0.20	7.61	-0.16	-0.63	Q ok
P-36	DI-36	DI-37	1851	0	1851	0.04	1.00	0.04	4.64	6.0	7.61	7.20	33.40	**36**	98	0.012	0.002137	0.0050	7.2	51.1	7.7	0.21	7.82	-0.73	-1.22	Q ok
P-37	DI-37	DI-85	3893	195	4088	0.09	1.00	0.09	4.74	6.0	7.82	7.13	33.77	36	70	0.012	0.002184	0.0050	7.2	51.1	7.7	0.15	7.97	-1.32	-1.67	Q ok
P-30	DI-30	MH-35	1403	0	1403	0.03	1.00	0.03	0.03	6.0	0.00	7.73	0.25	18	47	0.012	0.000005	0.0200	9.1	16.1	4.5	0.18	6.18	0.98	0.04	Q ok
P-11	DI-11	DI-12	4746	684	5430	0.12	1.00	0.12	0.12	6.0	0.00	7.73	0.96	15	20	0.012	0.000189	0.0065	4.6	5.6	3.2	0.10	6.10	2.91	2.78	Q ok
P-12	DI-12	DI-13	4957	1287	6244	0.14	0.99	0.14	0.27	6.0	6.10	7.69	2.05	15	92	0.012	0.000858	0.0065	4.6	5.7	4.1	0.37	6.47	2.68	2.08	Q ok
P-13	DI-13	MH-14	4947	1296	6243	0.14	0.99	0.14	0.41	6.0	6.47	7.56	3.09	15	54	0.012	0.001944	0.0065	4.6	5.6	4.7	0.19	6.67	1.98	1.63	Q ok
P-14	MH-14	DI-15	1	0	1	0.00	1.00	0.00	1.14	6.0	6.67	7.50	8.55	24	38	0.012	0.001218	0.0066	6.3	19.9	6.1	0.10	6.77	1.53	1.28	Q ok
P-15	DI-15	DI-16	3998	870	4868	0.11	1.00	0.11	1.25	6.0	6.77	7.46	9.35	24	73	0.012	0.001455	0.0064	6.3	19.7	6.2	0.20	6.97	1.18	0.71	Q ok
P-16	DI-16	MH-17	5113	501	5614	0.13	1.00	0.13	1.38	6.0	6.97	7.40	10.22	24	31	0.012	0.001739	0.0071	6.6	20.6	6.5	0.08	7.04	0.61	0.39	Q ok
P-18	B7 South	MH-14	31929	0	31929	0.73	1.00	0.73	0.73	6.0	0.00	7.73	5.66	18	17	0.012	0.002478	0.0053	4.7	8.3	5.1	0.06	6.06	1.72	1.63	Q ok
P-01	DI-01	DI-02	7520	1261	8781	0.20	1.00	0.20	0.20	6.0	0.00	7.73	1.56	15	77	0.012	0.000496	0.0065	4.6	5.6	3.9	0.33	6.33	2.91	2.41	Q ok
P-02	DI-02	DI-03	2113	487	2600	0.06	1.00	0.06	0.26	6.0	6.33	7.63	1.99	15	38	0.012	0.000811	0.0066	4.6	5.7	4.2	0.15	6.48	2.31	2.06	Q ok
P-03	DI-03	MH-04	4989	1312	6301	0.14	0.99	0.14	0.40	6.0	6.48	7.56	3.06	15	46	0.012	0.001906	0.0065	4.6	5.7	4.7	0.16	6.64	1.96	1.66	Q ok
P-04	MH-04	DI-05	1	0	1	0.00	1.00	0.00	0.88	6.0	6.64	7.53	6.60	18	46	0.012	0.003364	0.0065	5.2	9.2	5.7	0.14	6.78	1.56	1.26	Q ok
P-05	DI-05	DI-06	3831	995	4826	0.11	0.99	0.11	0.99	6.0	6.78	7.46	7.36	24	73	0.012	0.000902	0.0064	6.3	19.7	5.6	0.22	7.00	1.16	0.69	Q ok
P-06	DI-06	MH-17	5161	592	5753	0.13	1.00	0.13	1.65	6.0	7.00	7.40	12.24	24	30	0.012	0.002494	0.0067	6.4	20.0	6.7	0.07	7.07	0.59	0.39	Q ok
P-17	MH-17	MH-35	1	0	1	0.00	1.00	0.00	3.04	6.0	7.07	7.36	22.36	*36*	115	0.012	0.000957	0.0030	5.6	39.9	5.8	0.33	7.40	0.29	-0.06	Q ok
Check P-17 for Sanitary Crossing for Conflict																										Check P-1
P-08	DI-08	MH-07	1526	0	1526	0.04	1.00	0.04	0.04	6.0	0.00	7.73	0.27	15	58	0.012	0.000015	0.0066	4.6	5.7	2.3	0.43	6.43	1.36	0.98	Q ok
P-07	MH-07	DI-06	1	0	1	0.00	1.00	0.00	0.54	6.0	0.00	7.73	4.15	18	14	0.012	0.001328	0.0064	5.2	9.1	5.0	0.05	6.05	0.88	0.79	Q ok
P-09	B9/J	MH-04	20585	0	20585	0.47	1.00	0.47	0.47	6.0	0.00	7.73	3.65	18	17	0.012	0.001030	0.0053	4.7	8.3	4.5	0.06	6.06	1.75	1.66	Q ok
P-10	B9/J	MH-07	21845	0	21845	0.50	1.00	0.50	0.50	6.0	0.00	7.73	3.88	18	17	0.012	0.001160	0.0053	4.7	8.3	4.5	0.06	6.06	1.07	0.98	Q ok
P-20	TD-05	DI-21	5394	0	5394	0.12	1.00	0.12	0.12	6.0	0.00	7.73	0.96	8	39	0.011	0.004490	0.0500	9.1	3.2	7.8	0.08	6.08	8.50	6.55	Q ok
P-21	DI-21	MH-22	6185	3410	9595	0.22	0.85	0.19	0.31	6.0	6.08	7.69	2.39	15	31	0.012	0.001162	0.0200	8.1	9.9	6.6	0.08	6.16	4.54	3.92	Q ok
P-22	MH-22	MH-23	1	0	1	0.00	1.00	0.00	0.51	6.0	6.16	7.66	3.89	18	42	0.012	0.001167	0.0200	9.1	16.1	7.5	0.09	6.26	3.72	2.88	Q ok
P-23	MH-23	MH-24	1	0	1	0.00	1.00	0.00	1.33	6.0	6.26	7.63	10.13	18	66	0.012	0.007932	0.0200	9.1	16.1	9.7	0.11	6.37	2.68	1.36	Q ok
P-24	MH-24	MH-35	1	0	1	0.00	1.00	0.00	1.53	6.0	6.37	7.60	11.62	18	56	0.012	0.010433	0.0200	9.1	16.1	9.9	0.09	6.46	1.16	0.04	Q ok
P-25	DI-25	MH-22	6504	3883	10387	0.24	0.83	0.20	0.20	6.0	0.00	7.73	1.53	15	31	0.012	0.000475	0.0200	8.1	9.9	5.6	0.09	6.09	4.54	3.92	Q ok
P-26	B8/K	MH-23	16317	0	16317	0.37	1.00	0.37	0.37	6.0	0.00	7.73	2.89	18	56	0.012	0.000647	0.0050	4.6	8.0	4.1	0.23	6.23	3.06	2.78	Q ok
P-27	B6 South	MH-23	19451	0	19451	0.45	1.00	0.45	0.45	6.0	0.00	7.73	3.45	18	56	0.012	0.000920	0.0050	4.6	8.0	4.4	0.21	6.21	3.06	2.78	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/2023 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/2023 | Cm. No.: 20077.000
Segment: Central Green Outfall | Storm Frequency: 100 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-28	DI-28	MH-24	3596	533	4129	0.09	1.00	0.09	0.09	6.0	0.00	7.73	0.73	18	34	0.012	0.000041	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok
P-29	DI-29	MH-24	4110	551	4661	0.11	1.00	0.11	0.11	6.0	0.00	7.73	0.83	18	34	0.012	0.000053	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok

KEY

	Upsized from Semi-Final Design to have capacity for 50-yr design storm
	Optional Upsize-50-yr design storm results in >85% Full
	No Change from Semi-Final Design

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	7.01	7.01	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	7.16	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	6.91	6.91	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	7.01	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	6.76	6.76	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	6.91	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	6.56	6.56	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	6.76	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	6.36	6.36	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	6.56	7.59	HGL ok
P-46	MH-46	DI-47	2.00	6.17	6.17	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	6.36	8.54	HGL ok
P-47	DI-47	MH-60	2.40	5.79	5.79	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	6.17	9.09	HGL ok
P-60	MH-60	MH-61	2.40	5.54	5.54	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	5.79	9.84	HGL ok
P-61	MH-61	DI-62	2.40	5.22	5.22	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	5.54	11.03	HGL ok
P-62	DI-62	DI-63	2.40	4.94	4.94	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	5.22	10.34	HGL ok
P-63	DI-63	DI-77	1.93	4.48	4.48	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	4.94	10.08	HGL ok
P-77	DI-77	DI-85	3.20	3.99	3.99	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	4.48	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.42	3.42	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	3.99	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.29	3.29	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	3.42	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.20**	**3.20**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**3.29**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	7.01	7.01	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	7.11	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	6.36	6.36	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	6.44	10.00	HGL ok
P-65	B7 West	MH-64	1.20	5.09	5.09	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	5.15	10.00	HGL ok
P-64	MH-64	DI-63	1.20	4.94	4.94	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	5.09	10.14	HGL ok
P-51	DI-51	DI-52	1.00	6.27	6.27	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.28	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	6.24	6.24	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	6.27	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	6.15	6.15	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	6.24	7.59	HGL ok
P-54	MH-54	DI-55	1.60	6.00	6.00	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	6.15	8.54	HGL ok
P-55	DI-55	MH-60	1.60	5.79	5.79	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	6.00	9.09	HGL ok
P-56	B5 South	MH-54	1.20	6.15	6.15	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	6.22	10.00	HGL ok
P-78	DI-78	DI-79	1.00	5.97	6.44	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.45	11.60	HGL ok
P-79	DI-79	DI-71	1.20	5.95	5.95	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	5.97	11.15	HGL ok
P-71	DI-71	DI-72	1.20	5.91	5.91	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	5.95	11.15	HGL ok
P-72	DI-72	DI-73	1.20	5.86	5.86	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	5.91	10.99	HGL ok
P-73	DI-73	MH-74	1.20	5.81	5.81	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	5.86	10.84	HGL ok
P-74	MH-74	DI-75	1.20	5.60	5.60	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	5.81	11.24	HGL ok
P-75	DI-75	DI-76	1.20	5.09	5.09	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	5.60	10.63	HGL ok
P-76	DI-76	DI-77	1.20	4.48	4.48	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	5.09	10.34	HGL ok
P-70	DI-70	DI-71	1.00	5.95	5.95	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	5.96	11.60	HGL ok
P-80	DI-80	MH-74	1.20	5.81	5.81	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	5.90	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.68	3.68	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	3.71	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.29	3.29	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	3.68	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.68	3.68	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	3.74	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.42	8.00	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	8.41	10.50	HGL ok
P-38	DI-38	DI-39	1.00	4.03	4.03	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.03	10.67	HGL ok
P-39	DI-39	DI-40	1.00	4.02	4.02	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	4.03	10.16	HGL ok
P-40	DI-40	DI-85	1.20	3.99	3.99	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	4.02	9.98	HGL ok
P-35	MH-35	DI-36	2.40	4.81	4.81	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	5.39	11.72	HGL ok
P-36	DI-36	DI-37	2.40	4.39	4.39	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	4.81	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	3.99	3.99	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	4.39	10.16	HGL ok
P-30	DI-30	MH-35	1.20	5.39	5.39	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.39	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.48	6.48	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.48	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	6.38	6.38	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	6.48	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	6.22	6.22	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	6.38	7.91	HGL ok
P-14	MH-14	DI-15	1.60	6.07	6.07	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	6.22	8.68	HGL ok
P-15	DI-15	DI-16	1.60	5.88	5.88	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	6.07	9.01	HGL ok
P-16	DI-16	MH-17	1.60	5.64	5.64	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	5.88	9.77	HGL ok
P-18	B7 South	MH-14	1.20	6.22	6.22	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	6.28	10.00	HGL ok
P-01	DI-01	DI-02	1.00	6.50	6.50	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	6.54	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	6.44	6.44	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	6.50	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	6.29	6.29	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	6.44	7.91	HGL ok
P-04	MH-04	DI-05	1.20	6.09	6.09	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	6.29	8.60	HGL ok
P-05	DI-05	DI-06	1.60	5.87	5.87	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	6.09	9.01	HGL ok
P-06	DI-06	MH-17	1.60	5.64	5.64	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	5.87	9.87	HGL ok
P-17	MH-17	MH-35	1.60	5.39	5.39	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	5.64	10.61	HGL ok
P-08	DI-08	MH-07	1.00	5.93	5.93	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.93	11.39	HGL ok
P-07	MH-07	DI-06	1.20	5.87	5.87	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	5.93	10.19	HGL ok
P-09	B9/J	MH-04	1.20	6.29	6.29	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.32	10.00	HGL ok
P-10	B9/J	MH-07	1.20	5.93	5.93	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	5.96	10.00	HGL ok
P-20	TD-05	DI-21	0.53	7.02	7.08	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	7.29	10.50	HGL ok
P-21	DI-21	MH-22	1.00	6.84	6.84	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	7.02	9.46	HGL ok
P-22	MH-22	MH-23	1.20	6.75	6.75	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	6.84	9.72	HGL ok
P-23	MH-23	MH-24	1.20	6.15	6.15	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	6.75	10.97	HGL ok
P-24	MH-24	MH-35	1.20	5.39	5.39	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	6.15	11.20	HGL ok
P-25	DI-25	MH-22	1.00	6.84	6.84	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	6.86	9.46	HGL ok
P-26	B8/K	MH-23	1.20	6.75	6.75	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	6.79	10.00	HGL ok
P-27	B6 South	MH-23	1.20	6.75	6.75	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	6.81	10.00	HGL ok
P-28	DI-28	MH-24	1.20	6.15	6.15	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.15	10.95	HGL ok
P-29	DI-29	MH-24	1.20	6.15	6.15	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.15	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by: SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by: TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.: 100	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	7.21	7.21	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	7.36	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	7.11	7.11	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	7.21	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	6.96	6.96	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	7.11	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	6.76	6.76	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	6.96	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	6.56	6.56	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	6.76	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	6.37	6.37	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	6.56	8.54	HGL ok
P-47	DI-47	MH-60	2.40	5.99	5.99	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	6.37	9.09	HGL ok
P-60	MH-60	MH-61	2.40	5.74	5.74	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	5.99	9.84	HGL ok
P-61	MH-61	DI-62	2.40	5.42	5.42	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	5.74	11.03	HGL ok
P-62	DI-62	DI-63	2.40	5.14	5.14	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	5.42	10.34	HGL ok
P-63	DI-63	DI-77	1.93	4.68	4.68	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	5.14	10.08	HGL ok
P-77	DI-77	DI-85	3.20	4.19	4.19	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	4.68	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.62	3.62	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	4.19	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.49	3.49	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	3.62	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.40**	**3.40**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	*0.5*	**0.08**	**0.09**	**3.49**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	7.21	7.21	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	7.31	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	6.56	6.56	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	6.64	10.00	HGL ok
P-65	B7 West	MH-64	1.20	5.29	5.29	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	5.35	10.00	HGL ok
P-64	MH-64	DI-63	1.20	5.14	5.14	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	5.29	10.14	HGL ok
P-51	DI-51	DI-52	1.00	6.47	6.47	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.48	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	6.44	6.44	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	6.47	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	6.35	6.35	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	6.44	7.59	HGL ok
P-54	MH-54	DI-55	1.60	6.20	6.20	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	6.35	8.54	HGL ok
P-55	DI-55	MH-60	1.60	5.99	5.99	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	6.20	9.09	HGL ok
P-56	B5 South	MH-54	1.20	6.35	6.35	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	6.42	10.00	HGL ok
P-78	DI-78	DI-79	1.00	6.17	6.44	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.45	11.60	HGL ok
P-79	DI-79	DI-71	1.20	6.15	6.15	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	6.17	11.15	HGL ok
P-71	DI-71	DI-72	1.20	6.11	6.11	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	6.15	11.15	HGL ok
P-72	DI-72	DI-73	1.20	6.06	6.06	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	6.11	10.99	HGL ok
P-73	DI-73	MH-74	1.20	6.01	6.01	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	6.06	10.84	HGL ok
P-74	MH-74	DI-75	1.20	5.80	5.80	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	6.01	11.24	HGL ok
P-75	DI-75	DI-76	1.20	5.29	5.29	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	5.80	10.63	HGL ok
P-76	DI-76	DI-77	1.20	4.68	4.68	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	5.29	10.34	HGL ok
P-70	DI-70	DI-71	1.00	6.15	6.15	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.16	11.60	HGL ok
P-80	DI-80	MH-74	1.20	6.01	6.01	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	6.10	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.88	3.88	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	3.91	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.49	3.49	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	3.88	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.88	3.88	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	3.94	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.62	8.00	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	8.41	10.50	HGL ok
P-38	DI-38	DI-39	1.00	4.23	4.23	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.23	10.67	HGL ok
P-39	DI-39	DI-40	1.00	4.22	4.22	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	4.23	10.16	HGL ok
P-40	DI-40	DI-85	1.20	4.19	4.19	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	4.22	9.98	HGL ok
P-35	MH-35	DI-36	2.40	5.01	5.01	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	5.59	11.72	HGL ok
P-36	DI-36	DI-37	2.40	4.59	4.59	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	5.01	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*Q*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	4.19	4.19	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	4.59	10.16	HGL ok
P-30	DI-30	MH-35	1.20	5.59	5.59	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.59	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.68	6.68	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.68	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	6.58	6.58	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	6.68	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	6.42	6.42	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	6.58	7.91	HGL ok
P-14	MH-14	DI-15	1.60	6.27	6.27	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	6.42	8.68	HGL ok
P-15	DI-15	DI-16	1.60	6.08	6.08	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	6.27	9.01	HGL ok
P-16	DI-16	MH-17	1.60	5.84	5.84	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	6.08	9.77	HGL ok
P-18	B7 South	MH-14	1.20	6.42	6.42	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	6.48	10.00	HGL ok
P-01	DI-01	DI-02	1.00	6.70	6.70	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	6.74	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	6.64	6.64	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	6.70	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	6.49	6.49	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	6.64	7.91	HGL ok
P-04	MH-04	DI-05	1.20	6.29	6.29	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	6.49	8.60	HGL ok
P-05	DI-05	DI-06	1.60	6.07	6.07	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	6.29	9.01	HGL ok
P-06	DI-06	MH-17	1.60	5.84	5.84	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	6.07	9.87	HGL ok
P-17	MH-17	MH-35	1.60	5.59	5.59	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	5.84	10.61	HGL ok
P-08	DI-08	MH-07	1.00	6.13	6.13	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.13	11.39	HGL ok
P-07	MH-07	DI-06	1.20	6.07	6.07	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	6.13	10.19	HGL ok
P-09	B9/J	MH-04	1.20	6.49	6.49	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.52	10.00	HGL ok
P-10	B9/J	MH-07	1.20	6.13	6.13	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.16	10.00	HGL ok
P-20	TD-05	DI-21	0.53	7.22	7.22	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	7.42	10.50	HGL ok
P-21	DI-21	MH-22	1.00	7.04	7.04	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	7.22	9.46	HGL ok
P-22	MH-22	MH-23	1.20	6.95	6.95	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	7.04	9.72	HGL ok
P-23	MH-23	MH-24	1.20	6.35	6.35	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	6.95	10.97	HGL ok
P-24	MH-24	MH-35	1.20	5.59	5.59	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	6.35	11.20	HGL ok
P-25	DI-25	MH-22	1.00	7.04	7.04	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	7.06	9.46	HGL ok
P-26	B8/K	MH-23	1.20	6.95	6.95	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	6.99	10.00	HGL ok
P-27	B6 South	MH-23	1.20	6.95	6.95	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	7.01	10.00	HGL ok
P-28	DI-28	MH-24	1.20	6.35	6.35	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.35	10.95	HGL ok
P-29	DI-29	MH-24	1.20	6.35	6.35	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.35	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	10.71	10.71	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	10.86	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.61	10.61	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	10.71	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.46	10.46	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	10.61	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.26	10.26	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	10.46	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.06	10.06	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	10.26	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.87	9.87	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	10.06	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.49	9.49	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	9.87	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.24	9.24	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	9.49	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	8.92	8.92	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	9.24	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.64	8.64	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	8.92	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.18	8.18	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	8.64	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.69	7.69	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	8.18	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.12	7.12	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	7.69	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.99	6.99	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	7.12	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**6.90**	**6.90**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**6.99**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.71	10.71	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	10.81	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.06	10.06	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	10.14	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	8.79	8.79	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	8.85	10.00	HGL ok
P-64	MH-64	DI-63	1.20	8.64	8.64	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	8.79	10.14	HGL ok
P-51	DI-51	DI-52	1.00	9.97	9.97	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.98	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.94	9.94	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	9.97	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.85	9.85	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	9.94	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.70	9.70	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	9.85	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.49	9.49	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	9.70	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.85	9.85	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.92	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.67	9.67	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.68	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.65	9.65	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	9.67	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.61	9.61	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	9.65	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.56	9.56	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	9.61	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.51	9.51	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	9.56	10.84	HGL ok
P-74	MH-74	DI-75	1.20	9.30	9.30	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	9.51	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.79	8.79	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	9.30	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.18	8.18	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	8.79	10.34	HGL ok
P-70	DI-70	DI-71	1.00	9.65	9.65	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.66	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.51	9.51	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	9.60	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.38	7.38	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	7.41	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.99	6.99	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	7.38	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	7.38	7.38	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	7.44	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.12	8.00	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	8.41	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.73	7.73	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.73	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.72	7.72	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	7.73	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.69	7.69	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	7.72	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.51	8.51	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	9.09	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.09	8.09	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	8.51	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*Q*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.69	7.69	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	8.09	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.09	9.09	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.09	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.18	10.18	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.18	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.08	10.08	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	10.18	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.92	9.92	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	10.08	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.77	9.77	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	9.92	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.58	9.58	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	9.77	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.34	9.34	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	9.58	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.92	9.92	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	9.98	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.20	10.20	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.24	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.14	10.14	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	10.20	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.99	9.99	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	10.14	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.79	9.79	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	9.99	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.57	9.57	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	9.79	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.34	9.34	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	9.57	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.09	9.09	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	9.34	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.63	9.63	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.63	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.57	9.57	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	9.63	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	9.99	9.99	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.02	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.63	9.63	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.66	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	10.72	10.72	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	10.92	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.54	10.54	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	10.72	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.45	10.45	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	10.54	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.85	9.85	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	10.45	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.09	9.09	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	9.85	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.54	10.54	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.56	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.45	10.45	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	10.49	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.45	10.45	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	10.51	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.85	9.85	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.85	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.85	9.85	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.85	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002^*O^*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.21	11.21	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	11.36	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.11	11.11	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	11.21	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.96	10.96	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	11.11	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.76	10.76	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	10.96	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.56	10.56	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	10.76	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.37	10.37	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	10.56	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.99	9.99	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	10.37	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.74	9.74	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	9.99	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.42	9.42	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	9.74	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.14	9.14	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	9.42	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	8.68	8.68	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	9.14	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	8.19	8.19	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	8.68	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.62	7.62	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	8.19	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.49	7.49	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	7.62	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.40**	**7.40**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**7.49**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	11.21	11.21	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	11.31	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.56	10.56	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	10.64	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.29	9.29	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	9.35	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.14	9.14	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	9.29	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.47	10.47	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.48	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.44	10.44	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	*1.3*	1.0	0.01	0.04	10.47	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.35	10.35	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	*1.3*	1.0	0.03	0.09	10.44	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.20	10.20	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	10.35	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.99	9.99	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	*1.3*	1.0	0.18	0.21	10.20	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.35	10.35	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.42	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.17	10.17	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.18	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.15	10.15	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	*1.3*	1.0	0.01	0.01	10.17	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.11	10.11	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	*1.3*	1.0	0.02	0.05	10.15	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.06	10.06	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	*1.3*	1.0	0.03	0.05	10.11	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.01	10.01	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	10.06	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	9.80	9.80	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	10.01	11.24	HGL ok
P-75	DI-75	DI-76	1.20	9.29	9.29	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	9.80	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	8.68	8.68	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	9.29	10.34	HGL ok
P-70	DI-70	DI-71	1.00	10.15	10.15	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.16	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.01	10.01	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	10.10	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	7.88	7.88	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	7.91	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.49	7.49	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	*1.3*	1.0	0.14	0.39	7.88	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	7.88	7.88	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	7.94	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.62	8.00	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	8.41	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.23	8.23	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.23	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.22	8.22	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	*1.3*	1.0	0.00	0.02	8.23	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.19	8.19	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	*1.3*	1.0	0.02	0.02	8.22	9.98	HGL ok
P-35	MH-35	DI-36	2.40	9.01	9.01	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	9.59	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.59	8.59	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	9.01	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.19	8.19	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	8.59	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.59	9.59	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.59	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.68	10.68	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.68	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.58	10.58	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	10.68	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.42	10.42	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	10.58	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.27	10.27	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	10.42	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.08	10.08	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	10.27	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.84	9.84	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	10.08	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.42	10.42	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.48	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.70	10.70	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.74	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.64	10.64	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	10.70	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.49	10.49	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	10.64	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.29	10.29	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	10.49	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.07	10.07	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	10.29	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.84	9.84	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	10.07	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.59	9.59	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	9.84	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.13	10.13	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.13	11.39	HGL ok
P-07	MH-07	DI-06	1.20	10.07	10.07	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	10.13	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.49	10.49	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.52	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.13	10.13	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.16	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.22	11.22	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	11.42	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.04	11.04	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	11.22	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.95	10.95	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	11.04	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.35	10.35	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	10.95	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.59	9.59	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	10.35	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.04	11.04	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.06	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.95	10.95	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	10.99	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.95	10.95	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	11.01	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.35	10.35	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.35	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.35	10.35	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.35	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvatu (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\ adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	11.61	11.61	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	11.76	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.51	11.51	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	11.61	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.36	11.36	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	11.51	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.16	11.16	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	11.36	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.96	10.96	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	11.16	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.77	10.77	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	10.96	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.39	10.39	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	10.77	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.14	10.14	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	10.39	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.82	9.82	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	10.14	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	9.54	9.54	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	9.82	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.08	9.08	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	9.54	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	8.59	8.59	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	9.08	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	8.02	8.02	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	8.59	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.89	7.89	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	8.02	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.80**	**7.80**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**7.89**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	11.61	11.61	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	11.71	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.96	10.96	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	11.04	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.69	9.69	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	9.75	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.54	9.54	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	9.69	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.87	10.87	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.88	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.84	10.84	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	10.87	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.75	10.75	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	10.84	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.60	10.60	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	10.75	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.39	10.39	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	10.60	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.75	10.75	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.82	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.57	10.57	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.58	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.55	10.55	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	10.57	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.51	10.51	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	10.55	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.46	10.46	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	10.51	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.41	10.41	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	10.46	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.20	10.20	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	10.41	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	9.69	9.69	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	10.20	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.08	9.08	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	9.69	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.55	10.55	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.56	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.41	10.41	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	10.50	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	8.28	8.28	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.31	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	7.89	7.89	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	8.28	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.28	8.28	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	8.34	10.00	HGL ok
P-95	TD-04	MH-86	0.80	8.02	8.02	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	8.43	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.63	8.63	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.63	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.62	8.62	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	8.63	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.59	8.59	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	8.62	9.98	HGL ok
P-35	MH-35	DI-36	2.40	9.41	9.41	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	9.99	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.99	8.99	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	9.41	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.59	8.59	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	8.99	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.99	9.99	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.99	11.24	HGL ok
P-11	DI-11	DI-12	1.00	11.08	11.08	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.08	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.98	10.98	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	11.08	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.82	10.82	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	10.98	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.67	10.67	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	10.82	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.48	10.48	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	10.67	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.24	10.24	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	10.48	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.82	10.82	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.88	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.10	11.10	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	11.14	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.04	11.04	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	11.10	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.89	10.89	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	11.04	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.69	10.69	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	10.89	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.47	10.47	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	10.69	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.24	10.24	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	10.47	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.99	9.99	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	10.24	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.53	10.53	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.53	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	10.47	10.47	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	10.53	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.89	10.89	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.92	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.53	10.53	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.56	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.62	11.62	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	11.82	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.44	11.44	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	11.62	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.35	11.35	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	11.44	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.75	10.75	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	11.35	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.99	9.99	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	10.75	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.44	11.44	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.46	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.35	11.35	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	11.39	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.35	11.35	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	11.41	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.75	10.75	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.75	10.75	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.75	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ ft	Tot. H Loss, $H = H_f + H_{t\,adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	12.11	12.11	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	12.26	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.01	12.01	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	12.11	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.86	11.86	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	12.01	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.66	11.66	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	11.86	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.46	11.46	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	11.66	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.27	11.27	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	11.46	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.89	10.89	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	11.27	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.64	10.64	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	10.89	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.32	10.32	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	10.64	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.04	10.04	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	10.32	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.58	9.58	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	10.04	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.09	9.09	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	9.58	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	8.52	8.52	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	9.09	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	8.39	8.39	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	8.52	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**8.30**	**8.30**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**8.39**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	12.11	12.11	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	12.21	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.46	11.46	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	11.54	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.19	10.19	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.25	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.04	10.04	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	10.19	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.37	11.37	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.38	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.34	11.34	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	11.37	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.25	11.25	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	11.34	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.10	11.10	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	11.25	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.89	10.89	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	11.10	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.25	11.25	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	11.32	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.07	11.07	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.08	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.05	11.05	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.07	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.01	11.01	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	11.05	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.96	10.96	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	11.01	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.91	10.91	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	10.96	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.70	10.70	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	10.91	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.19	10.19	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	10.70	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.58	9.58	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	10.19	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.05	11.05	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.06	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	10.91	10.91	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	11.00	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	8.78	8.78	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	8.81	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	8.39	8.39	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	8.78	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.78	8.78	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	8.84	10.00	HGL ok
P-95	TD-04	MH-86	0.80	8.52	8.52	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	8.93	10.50	HGL ok
P-38	DI-38	DI-39	1.00	9.13	9.13	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.13	10.67	HGL ok
P-39	DI-39	DI-40	1.00	9.12	9.12	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	9.13	10.16	HGL ok
P-40	DI-40	DI-85	1.20	9.09	9.09	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	9.12	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	9.91	9.91	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	10.49	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.49	9.49	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	9.91	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.09	9.09	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	9.49	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.49	10.49	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.49	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.58	11.58	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.58	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.48	11.48	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	11.58	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.32	11.32	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	11.48	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.17	11.17	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	11.32	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.98	10.98	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	11.17	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.74	10.74	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	10.98	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.32	11.32	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	11.38	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.60	11.60	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	11.64	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.54	11.54	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	11.60	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.39	11.39	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	11.54	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.19	11.19	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	11.39	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.97	10.97	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	11.19	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.74	10.74	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	10.97	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.49	10.49	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	10.74	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.03	11.03	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.03	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	10.97	10.97	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	11.03	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.39	11.39	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.42	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.03	11.03	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.06	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.12	12.12	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	12.32	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.94	11.94	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	12.12	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.85	11.85	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	11.94	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.25	11.25	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	11.85	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.49	10.49	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	11.25	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.94	11.94	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.96	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.85	11.85	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	11.89	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.85	11.85	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	11.91	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.25	11.25	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.25	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.25	11.25	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.25	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	**HGL Check**
P-41	MH-41	MH-42	1.60	12.81	12.81	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	12.96	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.71	12.71	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	12.81	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.56	12.56	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	12.71	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.36	12.36	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	12.56	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.16	12.16	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	12.36	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.97	11.97	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	12.16	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.59	11.59	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	11.97	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.34	11.34	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	11.59	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.02	11.02	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	11.34	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.74	10.74	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	11.02	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.28	10.28	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	10.74	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.79	9.79	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	10.28	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.22	9.22	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	9.79	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.09	9.09	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	9.22	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.00**	**9.00**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**9.09**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	12.81	12.81	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	12.91	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.16	12.16	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	12.24	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.89	10.89	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	10.95	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.74	10.74	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	10.89	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.07	12.07	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.08	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.04	12.04	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	12.07	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.95	11.95	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	12.04	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.80	11.80	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	11.95	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.59	11.59	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	11.80	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.95	11.95	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.02	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.77	11.77	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.78	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.75	11.75	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.77	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.71	11.71	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	11.75	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.66	11.66	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	11.71	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.61	11.61	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	11.66	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.40	11.40	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	11.61	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.89	10.89	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	11.40	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.28	10.28	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	10.89	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.75	11.75	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.76	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.61	11.61	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	11.70	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.48	9.48	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.51	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.09	9.09	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	9.48	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.48	9.48	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	9.54	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.22	9.22	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	9.63	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	9.83	9.83	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.83	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	9.82	9.82	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	9.83	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.79	9.79	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	9.82	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.61	10.61	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	11.19	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.19	10.19	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	10.61	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.79	9.79	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	10.19	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.19	11.19	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.19	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.28	12.28	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.28	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.18	12.18	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	12.28	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.02	12.02	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	12.18	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.87	11.87	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	12.02	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.68	11.68	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	11.87	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.44	11.44	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	11.68	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.02	12.02	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.08	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.30	12.30	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.34	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.24	12.24	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	12.30	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.09	12.09	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	12.24	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.89	11.89	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	12.09	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.67	11.67	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	11.89	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.44	11.44	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	11.67	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.19	11.19	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	11.44	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.73	11.73	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.73	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.67	11.67	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	11.73	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.09	12.09	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.12	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.73	11.73	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.76	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.82	12.82	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	13.02	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.64	12.64	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	12.82	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.55	12.55	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	12.64	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.95	11.95	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	12.55	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.19	11.19	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	11.95	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.64	12.64	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	12.66	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.55	12.55	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	12.59	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.55	12.55	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	12.61	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.95	11.95	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.95	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.95	11.95	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.95	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	13.31	13.31	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	13.46	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.21	13.21	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	13.31	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.06	13.06	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	13.21	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.86	12.86	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	13.06	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.66	12.66	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	12.86	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.47	12.47	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	12.66	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.09	12.09	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	12.47	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.84	11.84	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	12.09	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.52	11.52	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	11.84	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.24	11.24	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	11.52	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.78	10.78	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	11.24	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.29	10.29	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	10.78	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.72	9.72	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	10.29	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.59	9.59	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	9.72	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.50**	**9.50**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**9.59**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.31	13.31	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	13.41	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.66	12.66	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	12.74	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.39	11.39	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	11.45	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.24	11.24	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	11.39	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.57	12.57	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.58	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.54	12.54	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	12.57	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.45	12.45	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	12.54	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.30	12.30	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	12.45	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.09	12.09	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	12.30	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.45	12.45	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.52	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.27	12.27	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.28	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.25	12.25	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.27	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.21	12.21	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	12.25	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.16	12.16	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	12.21	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.11	12.11	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	12.16	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.90	11.90	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	12.11	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.39	11.39	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	11.90	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.78	10.78	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	11.39	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.25	12.25	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.26	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.11	12.11	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	12.20	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.98	9.98	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.01	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.59	9.59	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	9.98	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.98	9.98	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	10.04	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.72	9.72	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	10.13	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.33	10.33	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.33	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.32	10.32	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	10.33	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.29	10.29	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	10.32	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.11	11.11	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	11.69	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.69	10.69	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	11.11	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.29	10.29	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	10.69	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.69	11.69	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.69	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.78	12.78	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.78	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.68	12.68	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	12.78	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.52	12.52	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	12.68	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.37	12.37	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	12.52	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.18	12.18	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	12.37	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.94	11.94	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	12.18	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.52	12.52	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.58	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.80	12.80	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.84	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.74	12.74	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	12.80	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.59	12.59	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	12.74	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.39	12.39	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	12.59	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.17	12.17	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	12.39	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.94	11.94	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	12.17	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.69	11.69	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	11.94	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.23	12.23	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.23	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.17	12.17	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	12.23	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.59	12.59	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.62	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.23	12.23	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.26	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.32	13.32	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	13.52	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.14	13.14	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	13.32	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.05	13.05	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	13.14	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.45	12.45	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	13.05	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.69	11.69	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	12.45	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.14	13.14	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.16	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.05	13.05	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	13.09	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.05	13.05	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	13.11	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.45	12.45	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.45	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.45	12.45	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.45	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR Date: 2/23/23 Sheet No.: 2 of 5
Checked by: TMC Date: 3/23/23 Cm. No.: 20077
Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add $Hc = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	14.61	14.61	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	14.76	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.51	14.51	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	14.61	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	14.36	14.36	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	14.51	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.16	14.16	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	14.36	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.96	13.96	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	14.16	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.77	13.77	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	13.96	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.39	13.39	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	13.77	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	13.14	13.14	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	13.39	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.82	12.82	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	13.14	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.54	12.54	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	12.82	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.08	12.08	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	12.54	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.59	11.59	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	12.08	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.02	11.02	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	11.59	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.89	10.89	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	11.02	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.80**	**10.80**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	0.5	**0.08**	**0.09**	**10.89**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.61	14.61	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	14.71	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.96	13.96	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	14.04	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.69	12.69	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.75	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.54	12.54	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	12.69	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.87	13.87	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.88	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.84	13.84	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	13.87	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.75	13.75	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	13.84	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.60	13.60	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	13.75	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.39	13.39	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	13.60	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.75	13.75	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	13.82	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.57	13.57	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.58	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.55	13.55	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.57	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.51	13.51	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	13.55	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.46	13.46	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	13.51	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.41	13.41	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	13.46	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	13.20	13.20	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	13.41	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.69	12.69	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	13.20	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.08	12.08	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	12.69	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.55	13.55	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.56	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.41	13.41	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	13.50	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.28	11.28	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.31	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.89	10.89	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	11.28	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.28	11.28	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	11.34	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.02	11.02	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	11.43	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.63	11.63	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.63	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.62	11.62	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	11.63	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.59	11.59	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	11.62	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.41	12.41	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	12.99	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.99	11.99	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	12.41	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.59	11.59	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	11.99	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.99	12.99	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.99	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.08	14.08	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.08	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.98	13.98	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	14.08	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.82	13.82	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	13.98	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.67	13.67	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	13.82	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.48	13.48	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	13.67	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.24	13.24	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	13.48	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.82	13.82	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.88	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.10	14.10	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	14.14	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.04	14.04	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	14.10	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.89	13.89	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	14.04	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.69	13.69	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	13.89	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.47	13.47	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	13.69	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.24	13.24	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	13.47	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.99	12.99	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	13.24	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.53	13.53	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.53	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.47	13.47	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	13.53	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.89	13.89	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.92	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.53	13.53	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.56	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.62	14.62	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	14.82	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.44	14.44	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	14.62	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	14.35	14.35	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	14.44	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.75	13.75	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	14.35	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.99	12.99	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	13.75	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.44	14.44	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.46	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	14.35	14.35	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	14.39	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	14.35	14.35	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	14.41	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.75	13.75	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.75	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.75	13.75	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.75	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D) ft	Tailwater, link to Inlet WSE of downstream pipe (TW) ft	Outlet W. S. Elevation (HGL Dn) ft	Outflow Pipe Diameter (D_o) in	Outflow Pipe Design Flow (Q_o) cfs	Pressure-flow Vel., $V_o=Q_o/A$ (V_o) fps	Skew angle vs. (Δ_o) deg	Outflow Pipe Length (L) ft	Friction Slope (S_{fo}) ft/ft	Friction Loss (H_f) ft	Angle of Curvature (O) deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c) ft	Contraction Loss (H_o) ft	Q*V for determining controlling inflow pipe (Q1V1) ft^4/s^2	Q*V for determining controlling inflow pipe (Q2V2) ft^4/s^2	Q*V for determining controlling inflow pipe (Q3V3) ft^4/s^2	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi) ft	Controlling In-flow skew (Δ_i) deg	Bend Loss (H_Δ) ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t) cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$) ft	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H) ft	Inlet W. S. Elevation (HGL Up) ft	Top of Grate (T/G) ft	HGL Check
P-41	MH-41	MH-42	1.60	9.55	9.55	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	9.70	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	9.45	9.45	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	9.55	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.30	9.30	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	9.45	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.10	9.10	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	9.30	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	8.90	8.90	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	9.10	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	8.71	8.71	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	8.90	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.33	8.33	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	8.71	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.08	8.08	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	8.33	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.76	7.76	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	8.08	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.48	7.48	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	7.76	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.02	7.02	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	7.48	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.53	6.53	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	7.02	10.08	HGL ok
P-85	DI-85	MH-86	4.00	5.96	5.96	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	6.53	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.83	5.83	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	5.96	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.74**	**5.74**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**5.83**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.55	9.55	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	9.65	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	8.90	8.90	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	8.98	10.00	HGL ok
P-65	B7 West	MH-64	1.20	7.63	7.63	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	7.69	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.48	7.48	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	7.63	10.14	HGL ok
P-51	DI-51	DI-52	1.00	8.81	8.81	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.82	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	8.78	8.78	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	8.81	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.69	8.69	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	8.78	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.54	8.54	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	8.69	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.33	8.33	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	8.54	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	8.69	8.69	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.76	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.51	8.51	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.52	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.49	8.49	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	8.51	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.45	8.45	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	8.49	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.40	8.40	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	8.45	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.35	8.35	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	8.40	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.14	8.14	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	8.35	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.63	7.63	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	8.14	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.02	7.02	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	7.63	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.49	8.49	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.50	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.35	8.35	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	8.44	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.22	6.22	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	6.25	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.83	5.83	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	6.22	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.22	6.22	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	6.28	10.00	HGL ok
P-95	TD-04	MH-86	0.80	5.96	8.00	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	8.41	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.57	6.57	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.57	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.56	6.56	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	6.57	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.53	6.53	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	6.56	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.35	7.35	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	7.93	11.72	HGL ok
P-36	DI-36	DI-37	2.40	6.93	6.93	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	7.35	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.53	6.53	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	6.93	10.16	HGL ok
P-30	DI-30	MH-35	1.20	7.93	7.93	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.93	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.02	9.02	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.02	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	8.92	8.92	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	9.02	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	8.76	8.76	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	8.92	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.61	8.61	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	8.76	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.42	8.42	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	8.61	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.18	8.18	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	8.42	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.76	8.76	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	8.82	10.00	HGL ok
P-01	DI-01	DI-02	1.00	9.04	9.04	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	9.08	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	8.98	8.98	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	9.04	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	8.83	8.83	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	8.98	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.63	8.63	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	8.83	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.41	8.41	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	8.63	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.18	8.18	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	8.41	9.87	HGL ok
P-17	MH-17	MH-35	1.60	7.93	7.93	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	8.18	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.47	8.47	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.47	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.41	8.41	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	8.47	10.19	HGL ok
P-09	B9/J	MH-04	1.20	8.83	8.83	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.86	10.00	HGL ok
P-10	B9/J	MH-07	1.20	8.47	8.47	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.50	10.00	HGL ok
P-20	TD-05	DI-21	0.53	9.56	9.56	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	9.76	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	9.38	9.38	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	9.56	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.29	9.29	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	9.38	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	8.69	8.69	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	9.29	10.97	HGL ok
P-24	MH-24	MH-35	1.20	7.93	7.93	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	8.69	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.38	9.38	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.40	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.29	9.29	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	9.33	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.29	9.29	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	9.35	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	8.69	8.69	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.69	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.69	8.69	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.69	10.95	HGL ok

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Project:	South Market Street Infrastructure Improvements	Prepared by: SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by: TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.: 100	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	9.75	9.75	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	9.90	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	9.65	9.65	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	9.75	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.50	9.50	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	9.65	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.30	9.30	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	9.50	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.10	9.10	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	9.30	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	8.91	8.91	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	9.10	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.53	8.53	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	8.91	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.28	8.28	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	8.53	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.96	7.96	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	8.28	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.68	7.68	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	7.96	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.22	7.22	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	7.68	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.73	6.73	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	7.22	10.08	HGL ok
P-85	DI-85	MH-86	4.00	6.16	6.16	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	6.73	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.03	6.03	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	6.16	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.94**	**5.94**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	*0.5*	**0.08**	**0.09**	**6.03**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.75	9.75	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	9.85	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.10	9.10	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	9.18	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	7.83	7.83	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	7.89	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.68	7.68	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	7.83	10.14	HGL ok
P-51	DI-51	DI-52	1.00	9.01	9.01	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.02	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	8.98	8.98	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	9.01	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.89	8.89	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	8.98	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.74	8.74	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	8.89	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.53	8.53	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	8.74	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	8.89	8.89	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.96	10.00	HGL ok
P-78	DI-78	DI-79	1.00	8.71	8.71	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.72	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.69	8.69	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	8.71	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.65	8.65	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	8.69	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.60	8.60	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	8.65	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.55	8.55	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	8.60	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.34	8.34	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	8.55	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.83	7.83	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	8.34	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.22	7.22	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	7.83	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.69	8.69	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.70	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.55	8.55	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	8.64	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.42	6.42	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	6.45	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.03	6.03	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	6.42	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.42	6.42	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	6.48	10.00	HGL ok
P-95	TD-04	MH-86	0.80	6.16	8.00	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	8.41	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.77	6.77	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.77	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.76	6.76	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	6.77	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.73	6.73	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	6.76	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.55	7.55	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	8.13	11.72	HGL ok
P-36	DI-36	DI-37	2.40	[illegible]	7.13	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	7.55	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 100 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.73	6.73	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	7.13	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.13	8.13	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.13	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.22	9.22	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.22	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.12	9.12	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	9.22	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	8.96	8.96	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	9.12	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.81	8.81	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	8.96	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.62	8.62	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	8.81	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.38	8.38	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	8.62	9.77	HGL ok
P-18	B7 South	MH-14	1.20	8.96	8.96	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	9.02	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.24	9.24	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	9.28	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.18	9.18	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	9.24	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.03	9.03	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	9.18	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.83	8.83	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	9.03	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.61	8.61	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	8.83	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.38	8.38	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	8.61	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.13	8.13	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	8.38	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.67	8.67	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.67	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.61	8.61	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	8.67	10.19	HGL ok
P-09	B9/J	MH-04	1.20	9.03	9.03	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.06	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	8.67	8.67	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.70	10.00	HGL ok
P-20	TD-05	DI-21	0.53	9.76	9.76	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	9.96	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	9.58	9.58	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	9.76	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.49	9.49	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	9.58	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	8.89	8.89	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	9.49	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.13	8.13	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	8.89	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.58	9.58	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.60	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.49	9.49	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	9.53	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.49	9.49	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	9.55	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	8.89	8.89	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.89	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.89	8.89	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.89	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvatu (O, deg)	Curved align; add $Hc = 0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\ adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	13.25	13.25	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	13.40	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.15	13.15	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	13.25	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.00	13.00	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	13.15	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.80	12.80	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	13.00	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.60	12.60	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	12.80	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.41	12.41	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	12.60	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.03	12.03	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	12.41	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.78	11.78	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	12.03	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.46	11.46	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	11.78	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.18	11.18	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	11.46	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.72	10.72	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	11.18	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.23	10.23	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	10.72	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.66	9.66	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	10.23	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.53	9.53	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	9.66	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.44**	**9.44**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**9.53**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.25	13.25	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	13.35	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.60	12.60	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	12.68	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.33	11.33	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	11.39	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.18	11.18	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	11.33	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.51	12.51	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.52	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.48	12.48	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	12.51	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.39	12.39	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	12.48	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.24	12.24	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	12.39	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.03	12.03	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	12.24	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.39	12.39	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.46	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.21	12.21	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.22	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.19	12.19	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.21	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.15	12.15	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	12.19	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.10	12.10	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	12.15	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.05	12.05	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	12.10	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.84	11.84	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	12.05	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.33	11.33	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	11.84	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.72	10.72	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	11.33	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.19	12.19	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.20	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.05	12.05	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	12.14	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.92	9.92	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	9.95	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.53	9.53	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	9.92	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.92	9.92	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	9.98	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.66	9.66	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	10.07	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.27	10.27	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.27	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.26	10.26	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	10.27	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.23	10.23	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	10.26	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.05	11.05	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	11.63	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.63	10.63	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	11.05	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.23	10.23	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	10.63	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.63	11.63	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.63	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.72	12.72	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.72	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.62	12.62	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	12.72	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.46	12.46	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	12.62	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.31	12.31	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	12.46	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.12	12.12	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	12.31	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.88	11.88	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	12.12	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.46	12.46	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.52	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.74	12.74	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.78	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.68	12.68	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	12.74	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.53	12.53	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	12.68	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.33	12.33	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	12.53	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.11	12.11	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	12.33	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.88	11.88	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	12.11	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.63	11.63	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	11.88	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.17	12.17	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.17	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.11	12.11	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	12.17	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.53	12.53	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.56	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.17	12.17	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.20	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.26	13.26	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	13.46	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.08	13.08	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	13.26	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.99	12.99	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	13.08	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.39	12.39	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	12.99	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.63	11.63	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	12.39	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.08	13.08	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.10	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.99	12.99	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	13.03	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.99	12.99	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	13.05	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.39	12.39	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.39	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.39	12.39	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.39	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)		

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\ adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	13.75	13.75	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	13.90	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.65	13.65	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	13.75	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.50	13.50	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	13.65	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.30	13.30	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	13.50	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.10	13.10	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	13.30	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.91	12.91	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	13.10	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.53	12.53	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	12.91	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.28	12.28	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	12.53	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.96	11.96	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	12.28	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.68	11.68	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	11.96	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.22	11.22	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	11.68	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.73	10.73	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	11.22	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.16	10.16	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	10.73	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.03	10.03	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	10.16	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.94**	**9.94**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**10.03**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.75	13.75	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	13.85	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.10	13.10	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	13.18	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.83	11.83	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	11.89	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.68	11.68	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	11.83	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.01	13.01	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.02	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.98	12.98	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	13.01	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.89	12.89	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	12.98	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.74	12.74	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	12.89	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.53	12.53	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	12.74	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.89	12.89	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.96	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.71	12.71	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.72	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.69	12.69	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.71	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.65	12.65	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	12.69	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.60	12.60	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	12.65	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.55	12.55	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	12.60	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.34	12.34	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	12.55	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.83	11.83	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	12.34	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.22	11.22	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	11.83	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.69	12.69	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.70	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.55	12.55	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	12.64	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.42	10.42	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.45	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.03	10.03	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	10.42	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.42	10.42	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	10.48	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.16	10.16	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	10.57	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.77	10.77	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.77	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.76	10.76	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	10.77	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.73	10.73	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	10.76	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.55	11.55	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	12.13	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.13	11.13	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	11.55	10.67	HGL Too High!

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Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.73	10.73	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	11.13	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.13	12.13	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.13	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.22	13.22	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.22	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.12	13.12	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	13.22	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.96	12.96	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	13.12	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.81	12.81	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	12.96	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.62	12.62	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	12.81	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.38	12.38	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	12.62	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.96	12.96	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.02	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.24	13.24	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	13.28	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.18	13.18	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	13.24	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.03	13.03	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	13.18	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.83	12.83	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	13.03	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.61	12.61	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	12.83	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.38	12.38	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	12.61	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.13	12.13	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	12.38	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.67	12.67	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.67	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.61	12.61	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	12.67	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.03	13.03	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.06	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.67	12.67	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.70	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.76	13.76	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	13.96	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.58	13.58	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	13.76	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.49	13.49	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	13.58	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.89	12.89	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	13.49	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.13	12.13	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	12.89	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.58	13.58	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.60	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.49	13.49	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	13.53	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.49	13.49	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	13.55	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.89	12.89	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.89	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.89	12.89	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.89	10.95	HGL Too High!

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR | Checked by: TMC | Design Freq.: 100 -year (50-year for sumps)

Date: 2/23/23 | Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D (ft)	Tailwater, link to Inlet WSE of downstream pipe TW (ft)	Outlet W. S. Elevation HGL Dn (ft)	Outflow Pipe Diameter D_o (in)	Outflow Pipe Design Flow Q_o (cfs)	Pressure-flow Vel., $V_o=Q_o/A$ V_o (fps)	Skew angle vs. Δ_o (deg)	Outflow Pipe Length L (ft)	Friction Slope S_{fo} (ft/ft)	Friction Loss H_f (ft)	Angle of Curvature O (deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c (ft)	Contraction Loss H_o (ft)	Q*V for determining controlling inflow pipe Q1V1 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q2V2 (ft^4/s^2)	Q*V for determining controlling inflow pipe Q3V3 (ft^4/s^2)	Controlling Inflow Velocity Vi	Expansion Loss Hi (ft)	Controlling In-flow skew Δ_i (deg)	Bend Loss H_Δ (ft)	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$ H_t (cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\,adj}$ (ft)	Tot. H Loss, $H=H_f+H_{t\,adj}$ H (ft)	Inlet W. S. Elevation HGL Up (ft)	Top of Grate T/G (ft)	HGL Check
P-41	MH-41	MH-42	1.60	14.15	14.15	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	14.30	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.05	14.05	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	14.15	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.90	13.90	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	14.05	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.70	13.70	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	13.90	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.50	13.50	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	13.70	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.31	13.31	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	13.50	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.93	12.93	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	13.31	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.68	12.68	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	12.93	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.36	12.36	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	12.68	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.08	12.08	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	12.36	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.62	11.62	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	12.08	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.13	11.13	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	11.62	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.56	10.56	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	11.13	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.43	10.43	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	10.56	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.34**	**10.34**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**10.43**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.15	14.15	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	14.25	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.50	13.50	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	13.58	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.23	12.23	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.29	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.08	12.08	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	12.23	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.41	13.41	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.42	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.38	13.38	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	13.41	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.29	13.29	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	13.38	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.14	13.14	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	13.29	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.93	12.93	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	13.14	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.29	13.29	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	13.36	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.11	13.11	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.12	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.09	13.09	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.11	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.05	13.05	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	13.09	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.00	13.00	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	13.05	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.95	12.95	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	13.00	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.74	12.74	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	12.95	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.23	12.23	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	12.74	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.62	11.62	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	12.23	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.09	13.09	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.10	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.95	12.95	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	13.04	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.82	10.82	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	10.85	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.43	10.43	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	10.82	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.82	10.82	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	10.88	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.56	10.56	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	10.97	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.17	11.17	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.17	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.16	11.16	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	11.17	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.13	11.13	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	11.16	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.95	11.95	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	12.53	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.53	11.53	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	11.95	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.13	11.13	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	11.53	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.53	12.53	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.53	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.62	13.62	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.62	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.52	13.52	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	13.62	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.36	13.36	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	13.52	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.21	13.21	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	13.36	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.02	13.02	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	13.21	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.78	12.78	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	13.02	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.36	13.36	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.42	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.64	13.64	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	13.68	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.58	13.58	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	13.64	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.43	13.43	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	13.58	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.23	13.23	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	13.43	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.01	13.01	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	13.23	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.78	12.78	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	13.01	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.53	12.53	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	12.78	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.07	13.07	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.07	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.01	13.01	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	13.07	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.43	13.43	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.46	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.07	13.07	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.10	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.16	14.16	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	14.36	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.98	13.98	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	14.16	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.89	13.89	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	13.98	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.29	13.29	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	13.89	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.53	12.53	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	13.29	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.98	13.98	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.00	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.89	13.89	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	13.93	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.89	13.89	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	13.95	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.29	13.29	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.29	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.29	13.29	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.29	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR — Date: 2/23/23
Checked by: TMC — Date: 3/23/23
Design Freq.: 100 -year (50-year for sumps)

Cm. No.: 20077

Location: No.	Location: From	Location: To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
			0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	14.65	14.65	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	14.80	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.55	14.55	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	14.65	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	14.40	14.40	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	14.55	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.20	14.20	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	14.40	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	14.00	14.00	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	14.20	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.81	13.81	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	14.00	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.43	13.43	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	13.81	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	13.18	13.18	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	13.43	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.86	12.86	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	13.18	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.58	12.58	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	12.86	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.12	12.12	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	12.58	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.63	11.63	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	12.12	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.06	11.06	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	11.63	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.93	10.93	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	11.06	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.84**	**10.84**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**10.93**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.65	14.65	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	14.75	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	14.00	14.00	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	14.08	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.73	12.73	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	12.79	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.58	12.58	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	12.73	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.91	13.91	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.92	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.88	13.88	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	13.91	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.79	13.79	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	13.88	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.64	13.64	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	13.79	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.43	13.43	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	13.64	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.79	13.79	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	13.86	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.61	13.61	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.62	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.59	13.59	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.61	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.55	13.55	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	13.59	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.50	13.50	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	13.55	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.45	13.45	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	13.50	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	13.24	13.24	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	13.45	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.73	12.73	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	13.24	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.12	12.12	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	12.73	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.59	13.59	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.60	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.45	13.45	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	13.54	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.32	11.32	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	11.35	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.93	10.93	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	11.32	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.32	11.32	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	11.38	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.06	11.06	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	11.47	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.67	11.67	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.67	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.66	11.66	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	11.67	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.63	11.63	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	11.66	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.45	12.45	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	13.03	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.03	12.03	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	12.45	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.63	11.63	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	12.03	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.03	13.03	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.03	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.12	14.12	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.12	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	14.02	14.02	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	14.12	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.86	13.86	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	14.02	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.71	13.71	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	13.86	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.52	13.52	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	13.71	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.28	13.28	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	13.52	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.86	13.86	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.92	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.14	14.14	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	14.18	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.08	14.08	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	14.14	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.93	13.93	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	14.08	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.73	13.73	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	13.93	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.51	13.51	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	13.73	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.28	13.28	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	13.51	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.03	13.03	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	13.28	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.57	13.57	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.57	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.51	13.51	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	13.57	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.93	13.93	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.96	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.57	13.57	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.60	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.66	14.66	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	14.86	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.48	14.48	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	14.66	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	14.39	14.39	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	14.48	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.79	13.79	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	14.39	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.03	13.03	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	13.79	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.48	14.48	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.50	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	14.39	14.39	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	14.43	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	14.39	14.39	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	14.45	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.79	13.79	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.79	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.79	13.79	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.79	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR   Date: 2/23/23   Sheet No.: 2 of 5
Checked by: TMC   Date: 3/23/23   Cm. No.: 20077
Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	15.35	15.35	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	15.50	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	15.25	15.25	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	15.35	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	15.10	15.10	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	15.25	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.90	14.90	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	15.10	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	14.70	14.70	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	14.90	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	14.51	14.51	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	14.70	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	14.13	14.13	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	14.51	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	13.88	13.88	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	14.13	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	13.56	13.56	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	13.88	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	13.28	13.28	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	13.56	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.82	12.82	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	13.28	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.33	12.33	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	12.82	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.76	11.76	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	12.33	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	11.63	11.63	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	11.76	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**11.54**	**11.54**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	**0.5**	**0.08**	**0.09**	**11.63**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	15.35	15.35	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	15.45	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	14.70	14.70	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	14.78	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	13.43	13.43	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.49	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	13.28	13.28	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	13.43	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	14.61	14.61	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.62	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	14.58	14.58	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	14.61	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.49	14.49	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	14.58	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	14.34	14.34	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	14.49	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	14.13	14.13	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	14.34	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.49	14.49	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	14.56	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	14.31	14.31	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.32	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	14.29	14.29	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	14.31	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	14.25	14.25	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	14.29	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	14.20	14.20	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	14.25	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	14.15	14.15	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	14.20	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	13.94	13.94	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	14.15	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	13.43	13.43	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	13.94	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.82	12.82	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	13.43	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	14.29	14.29	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.30	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	14.15	14.15	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	14.24	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	12.02	12.02	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.05	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	11.63	11.63	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	12.02	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	12.02	12.02	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	12.08	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.76	11.76	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	12.17	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.37	12.37	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.37	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.36	12.36	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	12.37	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.33	12.33	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	12.36	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	13.15	13.15	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	13.73	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.73	12.73	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	13.15	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.33	12.33	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	12.73	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.73	13.73	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.73	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.82	14.82	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.82	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	14.72	14.72	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	14.82	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	14.56	14.56	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	14.72	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	14.41	14.41	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	14.56	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	14.22	14.22	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	14.41	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.98	13.98	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	14.22	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	14.56	14.56	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	14.62	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.84	14.84	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	14.88	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.78	14.78	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	14.84	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	14.63	14.63	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	14.78	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	14.43	14.43	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	14.63	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	14.21	14.21	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	14.43	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.98	13.98	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	14.21	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.73	13.73	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	13.98	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	14.27	14.27	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.27	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	14.21	14.21	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	14.27	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	14.63	14.63	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	14.66	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	14.27	14.27	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	14.30	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	15.36	15.36	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	15.56	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	15.18	15.18	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	15.36	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	15.09	15.09	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	15.18	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.49	14.49	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	15.09	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.73	13.73	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	14.49	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	15.18	15.18	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	15.20	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	15.09	15.09	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	15.13	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	15.09	15.09	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	15.15	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.49	14.49	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.49	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.49	14.49	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.49	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inle WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvatu O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	15.85	15.85	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	16.00	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	15.75	15.75	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	15.85	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	15.60	15.60	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	15.75	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	15.40	15.40	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	15.60	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	15.20	15.20	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	15.40	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	15.01	15.01	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	15.20	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	14.63	14.63	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	15.01	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	14.38	14.38	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	14.63	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	14.06	14.06	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	14.38	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	13.78	13.78	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	14.06	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	13.32	13.32	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	13.78	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.83	12.83	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	13.32	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	12.26	12.26	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	12.83	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	12.13	12.13	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	12.26	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**12.04**	**12.04**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	0.5	**0.08**	**0.09**	**12.13**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	15.85	15.85	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	15.95	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	15.20	15.20	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	15.28	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	13.93	13.93	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	13.99	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	13.78	13.78	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	13.93	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	15.11	15.11	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.12	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	15.08	15.08	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	15.11	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.99	14.99	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	15.08	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	14.84	14.84	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	14.99	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	14.63	14.63	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	14.84	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.99	14.99	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	15.06	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	14.81	14.81	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.82	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	14.79	14.79	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	14.81	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	14.75	14.75	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	14.79	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	14.70	14.70	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	14.75	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	14.65	14.65	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	14.70	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	14.44	14.44	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	14.65	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	13.93	13.93	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	14.44	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	13.32	13.32	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	13.93	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	14.79	14.79	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.80	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	14.65	14.65	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	14.74	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	12.52	12.52	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	12.55	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	12.13	12.13	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	12.52	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	12.52	12.52	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	12.58	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	12.26	12.26	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	12.67	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.87	12.87	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.87	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.86	12.86	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	12.87	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.83	12.83	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	12.86	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	13.65	13.65	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	14.23	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	13.23	13.23	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	13.65	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.83	12.83	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	13.23	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	14.23	14.23	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.23	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	15.32	15.32	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.32	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	15.22	15.22	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	15.32	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	15.06	15.06	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	15.22	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	14.91	14.91	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	15.06	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	14.72	14.72	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	14.91	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	14.48	14.48	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	14.72	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	15.06	15.06	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	15.12	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	15.34	15.34	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	15.38	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	15.28	15.28	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	15.34	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	15.13	15.13	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	15.28	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	14.93	14.93	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	15.13	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	14.71	14.71	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	14.93	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	14.48	14.48	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	14.71	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	14.23	14.23	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	14.48	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	14.77	14.77	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.77	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	14.71	14.71	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	14.77	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	15.13	15.13	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	15.16	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	14.77	14.77	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	14.80	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	15.86	15.86	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	16.06	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	15.68	15.68	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	15.86	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	15.59	15.59	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	15.68	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.99	14.99	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	15.59	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	14.23	14.23	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	14.99	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	15.68	15.68	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	15.70	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	15.59	15.59	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	15.63	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	15.59	15.59	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	15.65	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.99	14.99	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.99	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.99	14.99	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.99	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)		

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add $Hc = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	17.15	17.15	24	7.8	2.5	69	92	0.0010	0.09	0	0.00	0.02	19.4	0.0	0.0	2.5	0.0	90	0.07	0.12	1.0	0.5	0.06	0.15	17.30	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	17.05	17.05	30	15.0	3.1	13	30	0.0011	0.03	0	0.00	0.04	19.3	19.0	0.0	2.5	0.0	69	0.06	0.13	1.0	0.5	0.06	0.10	17.15	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	16.90	16.90	30	15.7	3.2	0	25	0.0012	0.03	0	0.00	0.04	46.1	0.0	0.0	3.1	0.1	13	0.03	0.12	1.0	1.0	0.12	0.15	17.05	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	16.70	16.70	30	16.4	3.3	6	69	0.0014	0.09	0	0.00	0.04	49.9	0.0	0.0	3.2	0.1	0	0.00	0.10	1.0	1.0	0.10	0.19	16.90	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	16.50	16.50	30	17.0	3.5	13	52	0.0015	0.08	0	0.00	0.05	54.8	0.0	0.0	3.3	0.1	6	0.02	0.12	1.0	1.0	0.12	0.20	16.70	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	16.31	16.31	30	21.9	4.5	83	42	0.0024	0.10	0	0.00	0.08	59.1	18.3	0.0	3.5	0.1	13	0.04	0.18	1.0	0.5	0.09	0.19	16.50	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	15.93	15.93	36	22.5	3.2	90	23	0.0010	0.02	0	0.00	0.04	97.5	0.0	0.0	4.5	0.1	83	0.21	0.36	1.0	1.0	0.36	0.38	16.31	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	15.68	15.68	36	30.6	4.3	82	75	0.0018	0.13	0	0.00	0.07	71.8	25.8	0.0	3.2	0.1	90	0.11	0.24	1.0	0.5	0.12	0.25	15.93	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	15.36	15.36	36	30.3	4.3	7	76	0.0018	0.13	0	0.00	0.07	132.2	0.0	0.0	4.3	0.1	82	0.19	0.36	1.0	0.5	0.18	0.32	15.68	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	15.08	15.08	36	30.3	4.3	89	50	0.0018	0.09	0	0.00	0.07	129.6	0.0	0.0	4.3	0.1	7	0.03	0.20	1.0	1.0	0.20	0.29	15.36	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	14.62	14.62	36	35.2	5.0	92	25	0.0024	0.06	0	0.00	0.10	130.2	18.3	0.0	4.3	0.1	89	0.20	0.40	1.0	1.0	0.40	0.46	15.08	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	14.13	14.13	48	43.6	3.5	91	50	0.0008	0.04	0	0.00	0.05	175.4	47.0	0.0	5.0	0.1	92	0.27	0.45	1.0	1.0	0.45	0.49	14.62	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	13.56	13.56	60	76.7	3.9	17	186	0.0007	0.14	0	0.00	0.06	151.3	1.8	161.3	4.8	0.1	90	0.25	0.43	1.0	1.0	0.43	0.57	14.13	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	13.43	13.43	60	79.9	4.1	0	45	0.0008	0.04	0	0.00	0.06	299.5	42.5	0.0	3.9	0.1	17	0.05	0.19	1.0	0.5	0.10	0.13	13.56	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**13.34**	**13.34**	**60**	**84.9**	**4.3**	**0**	**9**	**0.0009**	**0.01**	**0**	**0.00**	**0.07**	**325.2**	**22.0**	**0.0**	**4.1**	**0.1**	**0**	**0.00**	**0.16**	**1.0**	*0.5*	**0.08**	**0.09**	**13.43**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	17.15	17.15	24	7.7	2.5	51.7	64	0.0010	0.06	0	0.00	0.02	12.0	2.5	0.0	2.0	0.0	51	0.03	0.07	1.0	0.5	0.04	0.10	17.25	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	16.50	16.50	18	5.7	3.2	83	16	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.08	16.58	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	15.23	15.23	18	5.7	3.2	75	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	15.29	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	15.08	15.08	18	5.7	3.2	74	20	0.0025	0.05	0	0.00	0.04	18.5	0.0	0.0	3.2	0.1	75	0.10	0.20	1.0	0.5	0.10	0.15	15.23	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	16.41	16.41	15	0.5	0.4	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.42	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	16.38	16.38	15	1.5	1.2	7	69	0.0004	0.03	0	0.00	0.01	0.2	0.0	0.0	0.4	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	16.41	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	16.29	16.29	15	2.3	1.9	13	51	0.0011	0.06	0	0.00	0.01	1.7	0.0	0.0	1.2	0.0	7	0.00	0.02	1.3	1.0	0.03	0.09	16.38	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	16.14	16.14	24	8.1	2.6	83	41	0.0011	0.04	0	0.00	0.03	4.3	20.0	0.0	3.4	0.1	83	0.12	0.21	1.0	0.5	0.10	0.15	16.29	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	15.93	15.93	24	9.0	2.9	90	23	0.0013	0.03	0	0.00	0.03	20.6	0.0	0.0	2.6	0.0	83	0.07	0.14	1.3	1.0	0.18	0.21	16.14	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	16.29	16.29	18	5.9	3.4	83	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	16.36	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	16.11	16.11	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.12	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	16.09	16.09	18	1.3	0.7	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	16.11	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	16.05	16.05	18	2.7	1.5	2	42	0.0006	0.02	0	0.00	0.01	0.9	0.4	0.0	0.7	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	16.09	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	16.00	16.00	18	3.0	1.7	8	29	0.0007	0.02	0	0.00	0.01	4.0	0.0	0.0	1.5	0.0	2	0.00	0.02	1.3	1.0	0.03	0.05	16.05	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	15.95	15.95	18	3.2	1.8	8	17	0.0008	0.01	0	0.00	0.01	5.1	0.0	0.0	1.7	0.0	8	0.00	0.03	1.0	1.0	0.03	0.05	16.00	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	15.74	15.74	18	8.4	4.8	5	17	0.0055	0.09	0	0.00	0.09	5.7	16.7	0.0	3.1	0.1	82	0.10	0.24	1.0	0.5	0.12	0.21	15.95	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	15.23	15.23	18	8.8	5.0	9	43	0.0060	0.26	0	0.00	0.10	40.3	0.0	0.0	4.8	0.1	5	0.04	0.26	1.0	1.0	0.26	0.51	15.74	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	14.62	14.62	18	9.1	5.2	2	51	0.0064	0.33	0	0.00	0.10	43.9	0.0	0.0	5.0	0.1	9	0.04	0.28	1.0	1.0	0.28	0.60	15.23	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	16.09	16.09	15	0.7	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.10	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	15.95	15.95	18	5.4	3.1	82	24	0.0023	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	16.04	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	13.82	13.82	15	1.3	1.1	0	79	0.0004	0.03	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.03	13.85	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	13.43	13.43	18	6.2	3.5	86	81	0.0030	0.24	0	0.00	0.05	1.5	6.8	0.0	2.0	0.0	90	0.04	0.11	1.3	1.0	0.14	0.39	13.82	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	13.82	13.82	18	3.5	2.0	90	63	0.0009	0.06	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.07	13.88	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	13.56	13.56	12	5.8	7.4	90	16	0.0188	0.30	0	0.00	0.21	0.0	0.0	0.0	0.0	0.0	0	0.00	0.21	1.0	0.5	0.11	0.41	13.97	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	14.17	14.17	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.17	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	14.16	14.16	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	14.17	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	14.13	14.13	18	1.8	1.0	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.01	1.3	1.0	0.02	0.02	14.16	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	14.95	14.95	36	33.4	4.7	2	94	0.0021	0.20	0	0.00	0.09	0.0	70.7	76.5	6.6	0.2	78	0.44	0.77	1.0	0.5	0.38	0.58	15.53	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	14.53	14.53	36	33.4	4.7	3	98	0.0021	0.21	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	2	0.00	0.21	1.0	1.0	0.21	0.42	14.95	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	100	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	14.13	14.13	36	33.8	4.8	90	70	0.0022	0.15	0	0.00	0.09	157.9	0.0	0.0	4.7	0.1	3	0.03	0.24	1.0	1.0	0.24	0.40	14.53	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	15.53	15.53	18	0.2	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.53	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	16.62	16.62	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.62	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	16.52	16.52	15	2.1	1.7	6	92	0.0009	0.08	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.10	16.62	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	16.36	16.36	15	3.1	2.5	14	54	0.0019	0.10	0	0.00	0.02	3.4	0.0	0.0	1.7	0.0	6	0.00	0.04	1.3	1.0	0.06	0.16	16.52	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	16.21	16.21	24	8.6	2.7	9	38	0.0012	0.05	0	0.00	0.03	7.8	18.2	0.0	3.2	0.1	82	0.11	0.19	1.0	0.5	0.09	0.14	16.36	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	16.02	16.02	24	9.3	3.0	91	73	0.0015	0.11	0	0.00	0.03	23.3	0.0	0.0	2.7	0.0	9	0.01	0.09	1.0	1.0	0.09	0.19	16.21	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	15.78	15.78	24	10.2	3.3	90	31	0.0017	0.05	0	0.00	0.04	27.8	0.0	0.0	3.0	0.0	91	0.10	0.19	1.0	1.0	0.19	0.24	16.02	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	16.36	16.36	18	5.7	3.2	82	17	0.0025	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.06	16.42	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	16.64	16.64	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	16.68	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	16.58	16.58	15	2.0	1.6	11	38	0.0008	0.03	0	0.00	0.01	2.0	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	16.64	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	16.43	16.43	15	3.1	2.5	14	46	0.0019	0.09	0	0.00	0.02	3.2	0.0	0.0	1.6	0.0	11	0.00	0.04	1.3	1.0	0.06	0.14	16.58	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	16.23	16.23	18	6.6	3.7	7	46	0.0034	0.15	0	0.00	0.05	7.6	7.5	0.0	2.5	0.0	14	0.02	0.11	1.0	0.5	0.05	0.21	16.43	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	16.01	16.01	24	7.4	2.3	90	73	0.0009	0.07	0	0.00	0.02	24.7	0.0	0.0	3.7	0.1	7	0.02	0.12	1.3	1.0	0.15	0.22	16.23	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	15.78	15.78	24	12.2	3.9	90	30	0.0025	0.07	0	0.00	0.06	17.2	9.7	0.0	2.3	0.0	90	0.06	0.15	1.0	1.0	0.15	0.22	16.01	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	15.53	15.53	36	22.4	3.2	102	115	0.0010	0.11	0	0.00	0.04	47.7	33.2	0.0	3.9	0.1	90	0.16	0.29	1.0	0.5	0.14	0.25	15.78	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	16.07	16.07	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.07	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	16.01	16.01	18	4.1	2.3	67	14	0.0013	0.02	0	0.00	0.02	0.1	8.5	0.0	2.2	0.0	67	0.04	0.09	1.0	0.5	0.05	0.06	16.07	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	16.43	16.43	18	3.7	2.1	83	17	0.0010	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	16.46	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	16.07	16.07	18	3.9	2.2	67	17	0.0012	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	16.10	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	17.16	17.16	8	1.0	2.7	47	39	0.0045	0.18	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.20	17.36	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	16.98	16.98	15	2.4	1.9	90	31	0.0012	0.04	0	0.00	0.01	2.6	0.0	0.0	2.7	0.0	47	0.05	0.11	1.3	1.0	0.14	0.18	17.16	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	16.89	16.89	18	3.9	2.2	0	42	0.0012	0.05	0	0.00	0.02	4.6	1.9	0.0	1.9	0.0	90	0.04	0.08	1.0	0.5	0.04	0.09	16.98	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	16.29	16.29	18	10.1	5.7	0	66	0.0079	0.52	0	0.00	0.13	8.6	4.7	6.7	2.2	0.0	0	0.00	0.15	1.0	0.5	0.08	0.60	16.89	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	15.53	15.53	18	11.6	6.6	78	56	0.0104	0.58	0	0.00	0.17	58.1	0.3	0.4	5.7	0.2	0	0.00	0.35	1.0	0.5	0.17	0.76	16.29	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	16.98	16.98	15	1.5	1.2	90	31	0.0005	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	17.00	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	16.89	16.89	18	2.9	1.6	90	56	0.0006	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.04	16.93	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	16.89	16.89	18	3.5	2.0	90	56	0.0009	0.05	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.06	16.95	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	16.29	16.29	18	0.7	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.29	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	16.29	16.29	18	0.8	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.29	10.95	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) Storm Frequency: 100 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
RELOCATED INLET IN SMR																										
P4	**DI19**	**MH1**	CP-1	2405	0	2405	0.06	1.00	0.06	0.06	6.0	0.00	7.73	0.4	15	27.3	0.012	0.000037	0.005	4.1	5.0	2.5	0.19	6.19	4.49	4.35	Q ok
P5	MH1	MH2	CP-1	1	0	1	0.00	1.00	0.00	0.06	6.0	6.19	7.66	0.4	18	82.7	0.012	0.000014	0.005	4.5	8.0	2.2	0.62	6.81	4.25	3.84	Q ok
P7	MH2	MH3	CP-1	1	0	1	0.00	1.00	0.00	0.06	6.0	6.81	7.46	0.4	18	73.8	0.012	0.000013	0.005	4.6	8.1	2.2	0.55	7.36	3.81	3.44	Q ok
P10	MH3	MH4	CP-2	1	0	1	0.00	1.00	0.00	0.30	6.0	7.36	7.26	2.2	18	53.7	0.012	0.000368	0.005	4.6	8.1	3.7	0.24	7.60	3.34	3.07	Q ok
P13	MH4	MH5	CP-2	1	0	1	0.00	1.00	0.00	0.69	6.0	7.60	7.20	5.0	18	59.3	0.012	0.001930	0.005	4.3	7.7	4.6	0.21	7.81	2.97	2.70	Q ok
P15	MH5	MH41	CP-2	1	0	1	0.00	1.00	0.00	1.10	6.0	7.81	7.13	7.8	*24*	**50.0**	0.012	0.001017	0.020	11.0	34.7	9.0	0.09	7.90	2.60	1.60	Q ok
P9	DI3	MH3	CP-1	4110	3259	7369	0.17	0.76	0.13	0.13	6.0	0.00	7.73	1.0	15	18.3	0.012	0.000203	0.005	4.0	4.9	3.0	0.10	6.10	3.68	3.59	Q ok
P8	DI17	MH3	CP-1	3878	2100	5978	0.14	0.85	0.12	0.12	6.0	0.00	7.73	0.9	15	31.3	0.012	0.000166	0.005	4.2	5.2	2.9	0.18	6.18	3.71	3.54	Q ok
P12	DI4	MH4	CP-1	7109	2561	9670	0.22	0.93	0.21	0.21	6.0	0.00	6.73	1.4	15	20.1	0.012	0.000396	0.005	4.0	4.9	3.4	0.10	6.10	3.48	3.38	Q ok
P11	DI18	MH4	CP-1	6435	2210	8645	0.20	0.94	0.19	0.19	6.0	0.00	6.70	1.3	15	28.4	0.012	0.000320	0.005	4.1	5.1	3.4	0.14	6.14	3.48	3.33	Q ok
P14	DI5	MH5	CP-1	4974	2549	7523	0.17	0.86	0.15	0.15	6.0	0.00	7.73	1.1	15	22.6	0.012	0.000270	0.005	4.0	4.9	3.3	0.11	6.11	3.68	3.57	Q ok
P18	DI6	MH6	CP-1	6937	1863	8800	0.20	0.98	0.20	0.20	6.0	0.00	7.73	1.5	15	38.0	0.012	0.000482	0.005	4.0	4.9	3.4	0.18	6.18	4.57	4.38	Q ok
P16	MH6	MH5	CP-2	1	0	1	0.00	1.00	0.00	0.25	6.0	6.18	7.66	1.9	18	40.0	0.012	0.000289	0.011	6.8	12.1	4.8	0.14	6.32	3.77	3.32	Q ok
RELOCATED INLET IN SMR																											
P17	**DI49**	**MH6**	CP-2	2236	105	2341	0.05	1.00	0.05	0.05	6.0	0.00	7.73	0.4	15	33.0	0.012	0.000035	0.005	4.0	4.9	2.4	0.23	6.23	4.19	4.02	Q ok
P32	DI23	MH12	CP-2	5495	1914	7409	0.17	0.94	0.16	0.16	6.0	0.00	7.73	1.2	15	33.31	0.012	0.0003	0.005	4.1	5.0	3.3	0.17	6.17	3.98	3.81	Q ok
P31	DI9	MH12	CP-2	4483	551	5034	0.12	1.00	0.12	0.12	6.0	0.00	7.73	0.9	15	18.3	0.012	0.0002	0.005	4.0	4.9	3.0	0.10	6.10	3.86	3.77	Q ok
P30	MH12	MH11	CP-2	1	0	1	0.00	1.00	0.00	0.28	6.0	6.17	7.66	2.1	18	50.1	0.012	0.0003	0.005	4.5	8.0	3.7	0.22	6.39	3.67	3.42	Q ok
P27	MH11	MH10	CP-2	1	0	1	0.00	1.00	0.00	0.57	6.0	6.39	7.60	4.3	18	73.2	0.012	0.0014	0.005	4.6	8.1	4.7	0.26	6.65	3.39	3.02	Q ok
P25	MH10	MH9	CP-2	1	0	1	0.00	1.00	0.00	0.65	6.0	6.65	7.50	4.9	24	69.68	0.012	0.0004	0.006	6.3	19.7	5.1	0.23	6.88	2.92	2.47	Q ok
P22	MH9	MH8	CP-2	1	0	1	0.00	1.00	0.00	0.83	6.0	6.88	7.43	6.1	24	108.3	0.012	0.0006	0.005	5.5	17.3	5.0	0.36	7.24	2.47	1.93	Q ok
P-80	DI-80	MH-08		9967	0	9967	0.23	1.00	0.23	0.23	6.0	0.00	7.73	1.8	15	49	0.012	0.0006	0.009	5.5	6.8	4.5	0.18	6.18	4.53	4.07	Q ok
P28	DI22	MH11	CP-1	5555	1955	7510	0.17	0.94	0.16	0.16	6.0	0.00	7.73	1.2	15	30.3	0.012	0.0003	0.005	4.0	4.9	3.3	0.15	6.15	3.64	3.49	Q ok
P29	DI8	MH11	CP-1	5120	570	5690	0.13	1.00	0.13	0.13	6.0	0.00	7.73	1.0	15	18.3	0.012	0.0002	0.005	4.0	4.9	3.0	0.10	6.10	3.64	3.55	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: ____ of ____

County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077

Segment: Market Street (to Central Green Outfall) Storm Frequency: 100 -year (50-year for sumps)

Location			Plan Sheet	Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To		A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
				ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P26	DI21	MH10	CP-1	2755	930	3685	0.08	0.94	0.08	0.08	6.0	0.00	7.73	0.6	15	18.3	0.012	0.0001	0.005	4.0	4.9	2.8	0.11	6.11	4.02	3.93	Q ok
P23	DI20	MH9	CP-2	3213	1102	4315	0.10	0.94	0.09	0.09	6.0	0.00	7.73	0.7	15	29.3	0.012	0.0001	0.005	4.0	4.9	2.8	0.17	6.17	4.53	4.38	Q ok
P24	DI7	MH9	CP-2	3164	527	3691	0.08	1.00	0.08	0.08	6.0	0.00	7.73	0.7	15	28.02	0.012	0.0001	0.005	4.0	4.9	2.8	0.17	6.17	4.38	4.24	Q ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	7.45	7.45	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.46	7.41	
P5	MH1	MH2	1.20	7.45	7.45	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	7.45	7.93	HGL Too High!
P7	MH2	MH3	1.20	7.45	7.45	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.45	7.65	HGL Too High!
P10	MH3	MH4	1.20	7.42	7.42	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	7.45	7.28	HGL Too High!
P13	MH4	MH5	1.20	7.29	7.29	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	7.42	7.09	HGL Too High!
P15	MH5	MH41	1.60	7.16	7.16	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	7.29	7.40	HGL Too High!
P9	DI3	MH3	1.00	7.45	7.45	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.46	6.62	HGL Too High!
P8	DI17	MH3	1.00	7.45	7.45	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.46	6.96	HGL Too High!
P12	DI4	MH4	1.00	7.42	7.42	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	7.44	6.48	HGL Too High!
P11	DI18	MH4	1.00	7.42	7.42	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.44	6.56	HGL Too High!
P14	DI5	MH5	1.00	7.29	7.29	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.30	6.61	HGL Too High!
P18	DI6	MH6	1.00	7.31	7.31	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	7.33	7.13	HGL Too High!
P16	MH6	MH5	1.20	7.29	7.29	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	7.31	7.55	HGL Too High!
P17	DI49	MH6	1.00	7.31	7.31	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.31	7.08	HGL Too High!
P32	DI23	MH12	1.00	7.36	7.36	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.38	7.11	HGL Too High!
P31	DI9	MH12	1.00	7.36	7.36	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.37	7.13	HGL Too High!
P30	MH12	MH11	1.60	7.34	7.34	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	7.36	7.48	HGL Too High!
P27	MH11	MH10	1.60	7.23	7.23	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	7.34	7.21	HGL Too High!
P25	MH10	MH9	1.60	7.19	7.19	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	7.23	7.54	HGL Too High!
P22	MH9	MH8	1.60	7.11	7.11	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	7.19	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	7.11	7.11	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	7.14	7.34	HGL Too High!
P28	DI22	MH11	1.00	7.34	7.34	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.35	6.74	HGL Too High!
P29	DI8	MH11	1.00	7.34	7.34	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.34	6.92	HGL Too High!
P26	DI21	MH10	1.00	7.23	7.23	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.23	7.23	HGL Too High!
P23	DI20	MH9	1.00	7.19	7.19	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	7.19	7.38	HGL Too High!
P24	DI7	MH9	1.00	7.19	7.19	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.19	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	7.65	7.65	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.66	7.41	
P5	MH1	MH2	1.20	7.65	7.65	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	7.65	7.93	HGL Too High!
P7	MH2	MH3	1.20	7.65	7.65	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	7.65	7.65	HGL Too High!
P10	MH3	MH4	1.20	7.62	7.62	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	7.65	7.28	HGL Too High!
P13	MH4	MH5	1.20	7.49	7.49	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	7.62	7.09	HGL Too High!
P15	MH5	MH41	1.60	7.36	7.36	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	7.49	7.40	HGL Too High!
P9	DI3	MH3	1.00	7.65	7.65	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.66	6.62	HGL Too High!
P8	DI17	MH3	1.00	7.65	7.65	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.66	6.96	HGL Too High!
P12	DI4	MH4	1.00	7.62	7.62	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	7.64	6.48	HGL Too High!
P11	DI18	MH4	1.00	7.62	7.62	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.64	6.56	HGL Too High!
P14	DI5	MH5	1.00	7.49	7.49	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.50	6.61	HGL Too High!
P18	DI6	MH6	1.00	7.51	7.51	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	7.53	7.13	HGL Too High!
P16	MH6	MH5	1.20	7.49	7.49	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	7.51	7.55	HGL Too High!
P17	DI49	MH6	1.00	7.51	7.51	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.51	7.08	HGL Too High!
P32	DI23	MH12	1.00	7.56	7.56	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.58	7.11	HGL Too High!
P31	DI9	MH12	1.00	7.56	7.56	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.57	7.13	HGL Too High!
P30	MH12	MH11	1.60	7.54	7.54	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	7.56	7.48	HGL Too High!
P27	MH11	MH10	1.60	7.43	7.43	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	7.54	7.21	HGL Too High!
P25	MH10	MH9	1.60	7.39	7.39	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	7.43	7.54	HGL Too High!
P22	MH9	MH8	1.60	7.31	7.31	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	7.39	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	7.31	7.31	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	7.34	7.34	HGL Too High!
P28	DI22	MH11	1.00	7.54	7.54	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.55	6.74	HGL Too High!
P29	DI8	MH11	1.00	7.54	7.54	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	7.54	6.92	HGL Too High!
P26	DI21	MH10	1.00	7.43	7.43	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.43	7.23	HGL Too High!
P23	DI20	MH9	1.00	7.39	7.39	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	7.39	7.38	HGL Too High!
P24	DI7	MH9	1.00	7.39	7.39	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.39	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.15	11.15	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.16	7.41	
P5	MH1	MH2	1.20	11.15	11.15	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.15	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.15	11.15	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.15	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.12	11.12	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	11.15	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.99	10.99	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	11.12	7.09	HGL Too High!
P15	MH5	MH41	1.60	10.86	10.86	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	10.99	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.15	11.15	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.16	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.15	11.15	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.16	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.12	11.12	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.14	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.12	11.12	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.14	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.99	10.99	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.00	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.01	11.01	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.03	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.99	10.99	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	11.01	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.01	11.01	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.01	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.06	11.06	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.08	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.06	11.06	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.07	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.04	11.04	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	11.06	7.48	HGL Too High!
P27	MH11	MH10	1.60	10.93	10.93	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	11.04	7.21	HGL Too High!
P25	MH10	MH9	1.60	10.89	10.89	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	10.93	7.54	HGL Too High!
P22	MH9	MH8	1.60	10.81	10.81	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	10.89	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	10.81	10.81	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	10.84	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.04	11.04	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.05	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.04	11.04	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.04	6.92	HGL Too High!
P26	DI21	MH10	1.00	10.93	10.93	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.93	7.23	HGL Too High!
P23	DI20	MH9	1.00	10.89	10.89	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	10.89	7.38	HGL Too High!
P24	DI7	MH9	1.00	10.89	10.89	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.89	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	11.65	11.65	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.66	7.41	
P5	MH1	MH2	1.20	11.65	11.65	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	11.65	7.93	HGL Too High!
P7	MH2	MH3	1.20	11.65	11.65	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	11.65	7.65	HGL Too High!
P10	MH3	MH4	1.20	11.62	11.62	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	11.65	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.49	11.49	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	11.62	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.36	11.36	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	11.49	7.40	HGL Too High!
P9	DI3	MH3	1.00	11.65	11.65	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.66	6.62	HGL Too High!
P8	DI17	MH3	1.00	11.65	11.65	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.66	6.96	HGL Too High!
P12	DI4	MH4	1.00	11.62	11.62	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	11.64	6.48	HGL Too High!
P11	DI18	MH4	1.00	11.62	11.62	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.64	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.49	11.49	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.50	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.51	11.51	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.53	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.49	11.49	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	11.51	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.51	11.51	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.51	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.56	11.56	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.58	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.56	11.56	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.57	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.54	11.54	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	11.56	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.43	11.43	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	11.54	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.39	11.39	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	11.43	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.31	11.31	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	11.39	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.31	11.31	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	11.34	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.54	11.54	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.55	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.54	11.54	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.54	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.43	11.43	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.43	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.39	11.39	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.39	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.39	11.39	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.39	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.05	12.05	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.06	7.41	
P5	MH1	MH2	1.20	12.05	12.05	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.05	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.05	12.05	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.05	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.02	12.02	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	12.05	7.28	HGL Too High!
P13	MH4	MH5	1.20	11.89	11.89	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	12.02	7.09	HGL Too High!
P15	MH5	MH41	1.60	11.76	11.76	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	11.89	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.05	12.05	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.06	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.05	12.05	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.06	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.02	12.02	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.04	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.02	12.02	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.04	6.56	HGL Too High!
P14	DI5	MH5	1.00	11.89	11.89	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.90	6.61	HGL Too High!
P18	DI6	MH6	1.00	11.91	11.91	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.93	7.13	HGL Too High!
P16	MH6	MH5	1.20	11.89	11.89	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	11.91	7.55	HGL Too High!
P17	DI49	MH6	1.00	11.91	11.91	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.91	7.08	HGL Too High!
P32	DI23	MH12	1.00	11.96	11.96	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.98	7.11	HGL Too High!
P31	DI9	MH12	1.00	11.96	11.96	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.97	7.13	HGL Too High!
P30	MH12	MH11	1.60	11.94	11.94	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	11.96	7.48	HGL Too High!
P27	MH11	MH10	1.60	11.83	11.83	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	11.94	7.21	HGL Too High!
P25	MH10	MH9	1.60	11.79	11.79	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	11.83	7.54	HGL Too High!
P22	MH9	MH8	1.60	11.71	11.71	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	11.79	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	11.71	11.71	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	11.74	7.34	HGL Too High!
P28	DI22	MH11	1.00	11.94	11.94	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.95	6.74	HGL Too High!
P29	DI8	MH11	1.00	11.94	11.94	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.94	6.92	HGL Too High!
P26	DI21	MH10	1.00	11.83	11.83	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.83	7.23	HGL Too High!
P23	DI20	MH9	1.00	11.79	11.79	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	11.79	7.38	HGL Too High!
P24	DI7	MH9	1.00	11.79	11.79	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.79	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	12.55	12.55	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.56	7.41	
P5	MH1	MH2	1.20	12.55	12.55	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	12.55	7.93	HGL Too High!
P7	MH2	MH3	1.20	12.55	12.55	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	12.55	7.65	HGL Too High!
P10	MH3	MH4	1.20	12.52	12.52	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	12.55	7.28	HGL Too High!
P13	MH4	MH5	1.20	12.39	12.39	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	12.52	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.26	12.26	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	12.39	7.40	HGL Too High!
P9	DI3	MH3	1.00	12.55	12.55	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.56	6.62	HGL Too High!
P8	DI17	MH3	1.00	12.55	12.55	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.56	6.96	HGL Too High!
P12	DI4	MH4	1.00	12.52	12.52	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	12.54	6.48	HGL Too High!
P11	DI18	MH4	1.00	12.52	12.52	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.54	6.56	HGL Too High!
P14	DI5	MH5	1.00	12.39	12.39	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.40	6.61	HGL Too High!
P18	DI6	MH6	1.00	12.41	12.41	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	12.43	7.13	HGL Too High!
P16	MH6	MH5	1.20	12.39	12.39	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	12.41	7.55	HGL Too High!
P17	DI49	MH6	1.00	12.41	12.41	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.41	7.08	HGL Too High!
P32	DI23	MH12	1.00	12.46	12.46	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.48	7.11	HGL Too High!
P31	DI9	MH12	1.00	12.46	12.46	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.47	7.13	HGL Too High!
P30	MH12	MH11	1.60	12.44	12.44	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	12.46	7.48	HGL Too High!
P27	MH11	MH10	1.60	12.33	12.33	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	12.44	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.29	12.29	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	12.33	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.21	12.21	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	12.29	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.21	12.21	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	12.24	7.34	HGL Too High!
P28	DI22	MH11	1.00	12.44	12.44	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.45	6.74	HGL Too High!
P29	DI8	MH11	1.00	12.44	12.44	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.44	6.92	HGL Too High!
P26	DI21	MH10	1.00	12.33	12.33	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.33	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.29	12.29	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.29	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.29	12.29	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.29	7.48	HGL Too High!

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Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.25	13.25	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.26	7.41	
P5	MH1	MH2	1.20	13.25	13.25	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.25	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.25	13.25	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.25	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.22	13.22	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	13.25	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.09	13.09	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	13.22	7.09	HGL Too High!
P15	MH5	MH41	1.60	12.96	12.96	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	13.09	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.25	13.25	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.26	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.25	13.25	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.26	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.22	13.22	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	13.24	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.22	13.22	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.24	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.09	13.09	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.10	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.11	13.11	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.13	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.09	13.09	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	13.11	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.11	13.11	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.11	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.16	13.16	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.18	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.16	13.16	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.17	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.14	13.14	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	13.16	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.03	13.03	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	13.14	7.21	HGL Too High!
P25	MH10	MH9	1.60	12.99	12.99	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	13.03	7.54	HGL Too High!
P22	MH9	MH8	1.60	12.91	12.91	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	12.99	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	12.91	12.91	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	12.94	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.14	13.14	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.15	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.14	13.14	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.14	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.03	13.03	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.03	7.23	HGL Too High!
P23	DI20	MH9	1.00	12.99	12.99	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	12.99	7.38	HGL Too High!
P24	DI7	MH9	1.00	12.99	12.99	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.99	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.75	13.75	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.76	7.41	
P5	MH1	MH2	1.20	13.75	13.75	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.75	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.75	13.75	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.75	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.72	13.72	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	13.75	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.59	13.59	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	13.72	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.46	13.46	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	13.59	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.75	13.75	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.76	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.75	13.75	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.76	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.72	13.72	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	13.74	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.72	13.72	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.74	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.59	13.59	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.60	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.61	13.61	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.63	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.59	13.59	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	13.61	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.61	13.61	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.61	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.66	13.66	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.68	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.66	13.66	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.67	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.64	13.64	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	13.66	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.53	13.53	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	13.64	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.49	13.49	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	13.53	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.41	13.41	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	13.49	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.41	13.41	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	13.44	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.64	13.64	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.65	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.64	13.64	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.64	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.53	13.53	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.53	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.49	13.49	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.49	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.49	13.49	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.49	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	15.05	15.05	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.06	7.41	
P5	MH1	MH2	1.20	15.05	15.05	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	15.05	7.93	HGL Too High!
P7	MH2	MH3	1.20	15.05	15.05	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	15.05	7.65	HGL Too High!
P10	MH3	MH4	1.20	15.02	15.02	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	15.05	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.89	14.89	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	15.02	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.76	14.76	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	14.89	7.40	HGL Too High!
P9	DI3	MH3	1.00	15.05	15.05	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.06	6.62	HGL Too High!
P8	DI17	MH3	1.00	15.05	15.05	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.06	6.96	HGL Too High!
P12	DI4	MH4	1.00	15.02	15.02	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	15.04	6.48	HGL Too High!
P11	DI18	MH4	1.00	15.02	15.02	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.04	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.89	14.89	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.90	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.91	14.91	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.93	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.89	14.89	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	14.91	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.91	14.91	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.91	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.96	14.96	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.98	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.96	14.96	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.97	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.94	14.94	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	14.96	7.48	HGL Too High!
P27	MH11	MH10	1.60	14.83	14.83	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	14.94	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.79	14.79	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	14.83	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.71	14.71	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	14.79	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.71	14.71	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	14.74	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.94	14.94	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.95	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.94	14.94	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.94	6.92	HGL Too High!
P26	DI21	MH10	1.00	14.83	14.83	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.83	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.79	14.79	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.79	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.79	14.79	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.79	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	9.99	9.99	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.00	7.41	
P5	MH1	MH2	1.20	9.99	9.99	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	9.99	7.93	HGL Too High!
P7	MH2	MH3	1.20	9.99	9.99	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	9.99	7.65	HGL Too High!
P10	MH3	MH4	1.20	9.96	9.96	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	9.99	7.28	HGL Too High!
P13	MH4	MH5	1.20	9.83	9.83	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	9.96	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.70	9.70	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	9.83	7.40	HGL Too High!
P9	DI3	MH3	1.00	9.99	9.99	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.00	6.62	HGL Too High!
P8	DI17	MH3	1.00	9.99	9.99	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.00	6.96	HGL Too High!
P12	DI4	MH4	1.00	9.96	9.96	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	9.98	6.48	HGL Too High!
P11	DI18	MH4	1.00	9.96	9.96	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.98	6.56	HGL Too High!
P14	DI5	MH5	1.00	9.83	9.83	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.84	6.61	HGL Too High!
P18	DI6	MH6	1.00	9.85	9.85	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.87	7.13	HGL Too High!
P16	MH6	MH5	1.20	9.83	9.83	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	9.85	7.55	HGL Too High!
P17	DI49	MH6	1.00	9.85	9.85	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.85	7.08	HGL Too High!
P32	DI23	MH12	1.00	9.90	9.90	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.92	7.11	HGL Too High!
P31	DI9	MH12	1.00	9.90	9.90	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.91	7.13	HGL Too High!
P30	MH12	MH11	1.60	9.88	9.88	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	9.90	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.77	9.77	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	9.88	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.73	9.73	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	9.77	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.65	9.65	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	9.73	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.65	9.65	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	9.68	7.34	HGL Too High!
P28	DI22	MH11	1.00	9.88	9.88	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.89	6.74	HGL Too High!
P29	DI8	MH11	1.00	9.88	9.88	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.88	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.77	9.77	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.77	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.73	9.73	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.73	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.73	9.73	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.73	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	10.19	10.19	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.20	7.41	
P5	MH1	MH2	1.20	10.19	10.19	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	10.19	7.93	HGL Too High!
P7	MH2	MH3	1.20	10.19	10.19	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	10.19	7.65	HGL Too High!
P10	MH3	MH4	1.20	10.16	10.16	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	10.19	7.28	HGL Too High!
P13	MH4	MH5	1.20	10.03	10.03	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	10.16	7.09	HGL Too High!
P15	MH5	MH41	1.60	9.90	9.90	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	10.03	7.40	HGL Too High!
P9	DI3	MH3	1.00	10.19	10.19	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.20	6.62	HGL Too High!
P8	DI17	MH3	1.00	10.19	10.19	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.20	6.96	HGL Too High!
P12	DI4	MH4	1.00	10.16	10.16	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	10.18	6.48	HGL Too High!
P11	DI18	MH4	1.00	10.16	10.16	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.18	6.56	HGL Too High!
P14	DI5	MH5	1.00	10.03	10.03	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.04	6.61	HGL Too High!
P18	DI6	MH6	1.00	10.05	10.05	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.07	7.13	HGL Too High!
P16	MH6	MH5	1.20	10.03	10.03	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	10.05	7.55	HGL Too High!
P17	DI49	MH6	1.00	10.05	10.05	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.05	7.08	HGL Too High!
P32	DI23	MH12	1.00	10.10	10.10	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.12	7.11	HGL Too High!
P31	DI9	MH12	1.00	10.10	10.10	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.11	7.13	HGL Too High!
P30	MH12	MH11	1.60	10.08	10.08	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	10.10	7.48	HGL Too High!
P27	MH11	MH10	1.60	9.97	9.97	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	10.08	7.21	HGL Too High!
P25	MH10	MH9	1.60	9.93	9.93	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	9.97	7.54	HGL Too High!
P22	MH9	MH8	1.60	9.85	9.85	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	9.93	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	9.85	9.85	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	9.88	7.34	HGL Too High!
P28	DI22	MH11	1.00	10.08	10.08	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.09	6.74	HGL Too High!
P29	DI8	MH11	1.00	10.08	10.08	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.08	6.92	HGL Too High!
P26	DI21	MH10	1.00	9.97	9.97	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.97	7.23	HGL Too High!
P23	DI20	MH9	1.00	9.93	9.93	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	9.93	7.38	HGL Too High!
P24	DI7	MH9	1.00	9.93	9.93	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.93	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	13.69	13.69	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.70	7.41	
P5	MH1	MH2	1.20	13.69	13.69	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	13.69	7.93	HGL Too High!
P7	MH2	MH3	1.20	13.69	13.69	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	13.69	7.65	HGL Too High!
P10	MH3	MH4	1.20	13.66	13.66	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	13.69	7.28	HGL Too High!
P13	MH4	MH5	1.20	13.53	13.53	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	13.66	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.40	13.40	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	13.53	7.40	HGL Too High!
P9	DI3	MH3	1.00	13.69	13.69	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.70	6.62	HGL Too High!
P8	DI17	MH3	1.00	13.69	13.69	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.70	6.96	HGL Too High!
P12	DI4	MH4	1.00	13.66	13.66	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	13.68	6.48	HGL Too High!
P11	DI18	MH4	1.00	13.66	13.66	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.68	6.56	HGL Too High!
P14	DI5	MH5	1.00	13.53	13.53	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.54	6.61	HGL Too High!
P18	DI6	MH6	1.00	13.55	13.55	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.57	7.13	HGL Too High!
P16	MH6	MH5	1.20	13.53	13.53	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	13.55	7.55	HGL Too High!
P17	DI49	MH6	1.00	13.55	13.55	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.55	7.08	HGL Too High!
P32	DI23	MH12	1.00	13.60	13.60	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.62	7.11	HGL Too High!
P31	DI9	MH12	1.00	13.60	13.60	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.61	7.13	HGL Too High!
P30	MH12	MH11	1.60	13.58	13.58	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	13.60	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.47	13.47	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	13.58	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.43	13.43	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	13.47	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.35	13.35	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	13.43	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.35	13.35	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	13.38	7.34	HGL Too High!
P28	DI22	MH11	1.00	13.58	13.58	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.59	6.74	HGL Too High!
P29	DI8	MH11	1.00	13.58	13.58	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.58	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.47	13.47	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.47	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.43	13.43	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.43	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.43	13.43	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.43	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	14.19	14.19	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.20	7.41	
P5	MH1	MH2	1.20	14.19	14.19	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	14.19	7.93	HGL Too High!
P7	MH2	MH3	1.20	14.19	14.19	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	14.19	7.65	HGL Too High!
P10	MH3	MH4	1.20	14.16	14.16	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	14.19	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.03	14.03	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	14.16	7.09	HGL Too High!
P15	MH5	MH41	1.60	13.90	13.90	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	14.03	7.40	HGL Too High!
P9	DI3	MH3	1.00	14.19	14.19	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.20	6.62	HGL Too High!
P8	DI17	MH3	1.00	14.19	14.19	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.20	6.96	HGL Too High!
P12	DI4	MH4	1.00	14.16	14.16	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	14.18	6.48	HGL Too High!
P11	DI18	MH4	1.00	14.16	14.16	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.18	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.03	14.03	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.04	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.05	14.05	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.07	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.03	14.03	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	14.05	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.05	14.05	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.05	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.10	14.10	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.12	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.10	14.10	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.11	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.08	14.08	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	14.10	7.48	HGL Too High!
P27	MH11	MH10	1.60	13.97	13.97	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	14.08	7.21	HGL Too High!
P25	MH10	MH9	1.60	13.93	13.93	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	13.97	7.54	HGL Too High!
P22	MH9	MH8	1.60	13.85	13.85	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	13.93	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	13.85	13.85	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	13.88	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.08	14.08	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.09	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.08	14.08	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.08	6.92	HGL Too High!
P26	DI21	MH10	1.00	13.97	13.97	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.97	7.23	HGL Too High!
P23	DI20	MH9	1.00	13.93	13.93	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	13.93	7.38	HGL Too High!
P24	DI7	MH9	1.00	13.93	13.93	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.93	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	14.59	14.59	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.60	7.41	
P5	MH1	MH2	1.20	14.59	14.59	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	14.59	7.93	HGL Too High!
P7	MH2	MH3	1.20	14.59	14.59	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	14.59	7.65	HGL Too High!
P10	MH3	MH4	1.20	14.56	14.56	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	14.59	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.43	14.43	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	14.56	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.30	14.30	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	14.43	7.40	HGL Too High!
P9	DI3	MH3	1.00	14.59	14.59	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.60	6.62	HGL Too High!
P8	DI17	MH3	1.00	14.59	14.59	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.60	6.96	HGL Too High!
P12	DI4	MH4	1.00	14.56	14.56	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	14.58	6.48	HGL Too High!
P11	DI18	MH4	1.00	14.56	14.56	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.58	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.43	14.43	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.44	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.45	14.45	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.47	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.43	14.43	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	14.45	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.45	14.45	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.45	7.08	HGL Too High!
P32	DI23	MH12	1.00	14.50	14.50	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.52	7.11	HGL Too High!
P31	DI9	MH12	1.00	14.50	14.50	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.51	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.48	14.48	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	14.50	7.48	HGL Too High!
P27	MH11	MH10	1.60	14.37	14.37	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	14.48	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.33	14.33	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	14.37	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.25	14.25	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	14.33	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.25	14.25	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	14.28	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.48	14.48	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.49	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.48	14.48	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.48	6.92	HGL Too High!
P26	DI21	MH10	1.00	14.37	14.37	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.37	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.33	14.33	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.33	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.33	14.33	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.33	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	15.09	15.09	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.10	7.41	
P5	MH1	MH2	1.20	15.09	15.09	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	15.09	7.93	HGL Too High!
P7	MH2	MH3	1.20	15.09	15.09	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	15.09	7.65	HGL Too High!
P10	MH3	MH4	1.20	15.06	15.06	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	15.09	7.28	HGL Too High!
P13	MH4	MH5	1.20	14.93	14.93	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	15.06	7.09	HGL Too High!
P15	MH5	MH41	1.60	14.80	14.80	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	14.93	7.40	HGL Too High!
P9	DI3	MH3	1.00	15.09	15.09	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.10	6.62	HGL Too High!
P8	DI17	MH3	1.00	15.09	15.09	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.10	6.96	HGL Too High!
P12	DI4	MH4	1.00	15.06	15.06	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	15.08	6.48	HGL Too High!
P11	DI18	MH4	1.00	15.06	15.06	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.08	6.56	HGL Too High!
P14	DI5	MH5	1.00	14.93	14.93	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.94	6.61	HGL Too High!
P18	DI6	MH6	1.00	14.95	14.95	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.97	7.13	HGL Too High!
P16	MH6	MH5	1.20	14.93	14.93	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	14.95	7.55	HGL Too High!
P17	DI49	MH6	1.00	14.95	14.95	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.95	7.08	HGL Too High!
P32	DI23	MH12	1.00	15.00	15.00	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.02	7.11	HGL Too High!
P31	DI9	MH12	1.00	15.00	15.00	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.01	7.13	HGL Too High!
P30	MH12	MH11	1.60	14.98	14.98	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	15.00	7.48	HGL Too High!
P27	MH11	MH10	1.60	14.87	14.87	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	14.98	7.21	HGL Too High!
P25	MH10	MH9	1.60	14.83	14.83	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	14.87	7.54	HGL Too High!
P22	MH9	MH8	1.60	14.75	14.75	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	14.83	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	14.75	14.75	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	14.78	7.34	HGL Too High!
P28	DI22	MH11	1.00	14.98	14.98	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.99	6.74	HGL Too High!
P29	DI8	MH11	1.00	14.98	14.98	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.98	6.92	HGL Too High!
P26	DI21	MH10	1.00	14.87	14.87	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.87	7.23	HGL Too High!
P23	DI20	MH9	1.00	14.83	14.83	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	14.83	7.38	HGL Too High!
P24	DI7	MH9	1.00	14.83	14.83	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.83	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: ___ of ___
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) | Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	15.79	15.79	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.80	7.41	
P5	MH1	MH2	1.20	15.79	15.79	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	15.79	7.93	HGL Too High!
P7	MH2	MH3	1.20	15.79	15.79	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	15.79	7.65	HGL Too High!
P10	MH3	MH4	1.20	15.76	15.76	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	15.79	7.28	HGL Too High!
P13	MH4	MH5	1.20	15.63	15.63	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	15.76	7.09	HGL Too High!
P15	MH5	MH41	1.60	15.50	15.50	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	15.63	7.40	HGL Too High!
P9	DI3	MH3	1.00	15.79	15.79	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.80	6.62	HGL Too High!
P8	DI17	MH3	1.00	15.79	15.79	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.80	6.96	HGL Too High!
P12	DI4	MH4	1.00	15.76	15.76	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	15.78	6.48	HGL Too High!
P11	DI18	MH4	1.00	15.76	15.76	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.78	6.56	HGL Too High!
P14	DI5	MH5	1.00	15.63	15.63	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.64	6.61	HGL Too High!
P18	DI6	MH6	1.00	15.65	15.65	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	15.67	7.13	HGL Too High!
P16	MH6	MH5	1.20	15.63	15.63	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	15.65	7.55	HGL Too High!
P17	DI49	MH6	1.00	15.65	15.65	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.65	7.08	HGL Too High!
P32	DI23	MH12	1.00	15.70	15.70	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.72	7.11	HGL Too High!
P31	DI9	MH12	1.00	15.70	15.70	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.71	7.13	HGL Too High!
P30	MH12	MH11	1.60	15.68	15.68	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	15.70	7.48	HGL Too High!
P27	MH11	MH10	1.60	15.57	15.57	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	15.68	7.21	HGL Too High!
P25	MH10	MH9	1.60	15.53	15.53	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	15.57	7.54	HGL Too High!
P22	MH9	MH8	1.60	15.45	15.45	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	15.53	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	15.45	15.45	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	15.48	7.34	HGL Too High!
P28	DI22	MH11	1.00	15.68	15.68	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.69	6.74	HGL Too High!
P29	DI8	MH11	1.00	15.68	15.68	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.68	6.92	HGL Too High!
P26	DI21	MH10	1.00	15.57	15.57	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.57	7.23	HGL Too High!
P23	DI20	MH9	1.00	15.53	15.53	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	15.53	7.38	HGL Too High!
P24	DI7	MH9	1.00	15.53	15.53	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.53	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	16.29	16.29	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.30	7.41	
P5	MH1	MH2	1.20	16.29	16.29	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	16.29	7.93	HGL Too High!
P7	MH2	MH3	1.20	16.29	16.29	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	16.29	7.65	HGL Too High!
P10	MH3	MH4	1.20	16.26	16.26	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	16.29	7.28	HGL Too High!
P13	MH4	MH5	1.20	16.13	16.13	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	16.26	7.09	HGL Too High!
P15	MH5	MH41	1.60	16.00	16.00	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	16.13	7.40	HGL Too High!
P9	DI3	MH3	1.00	16.29	16.29	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.30	6.62	HGL Too High!
P8	DI17	MH3	1.00	16.29	16.29	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.30	6.96	HGL Too High!
P12	DI4	MH4	1.00	16.26	16.26	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	16.28	6.48	HGL Too High!
P11	DI18	MH4	1.00	16.26	16.26	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.28	6.56	HGL Too High!
P14	DI5	MH5	1.00	16.13	16.13	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.14	6.61	HGL Too High!
P18	DI6	MH6	1.00	16.15	16.15	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	16.17	7.13	HGL Too High!
P16	MH6	MH5	1.20	16.13	16.13	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	16.15	7.55	HGL Too High!
P17	DI49	MH6	1.00	16.15	16.15	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.15	7.08	HGL Too High!
P32	DI23	MH12	1.00	16.20	16.20	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.22	7.11	HGL Too High!
P31	DI9	MH12	1.00	16.20	16.20	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.21	7.13	HGL Too High!
P30	MH12	MH11	1.60	16.18	16.18	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	16.20	7.48	HGL Too High!
P27	MH11	MH10	1.60	16.07	16.07	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	16.18	7.21	HGL Too High!
P25	MH10	MH9	1.60	16.03	16.03	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	16.07	7.54	HGL Too High!
P22	MH9	MH8	1.60	15.95	15.95	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	16.03	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	15.95	15.95	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	15.98	7.34	HGL Too High!
P28	DI22	MH11	1.00	16.18	16.18	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.19	6.74	HGL Too High!
P29	DI8	MH11	1.00	16.18	16.18	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.18	6.92	HGL Too High!
P26	DI21	MH10	1.00	16.07	16.07	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.07	7.23	HGL Too High!
P23	DI20	MH9	1.00	16.03	16.03	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	16.03	7.38	HGL Too High!
P24	DI7	MH9	1.00	16.03	16.03	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.03	7.48	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements — Prepared by: SNR — Date: 2/23/23 — Sheet No.: ___ of ___
County: New Castle — Checked by: TMC — Date: 3/23/23 — Cm. No.: 20077
Segment: Market Street (to Central Green Outfall) — Design Freq.: 100 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel. $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc =	Contraction Loss	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Q V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P4	DI19	MH1	1.00	17.59	17.59	15	0.4	0.3	90	27.3	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	17.60	7.41	
P5	MH1	MH2	1.20	17.59	17.59	18	0.4	0.2	0	82.7	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.3	0.0	90	0.00	0.00	1.0	0.5	0.00	0.00	17.59	7.93	HGL Too High!
P7	MH2	MH3	1.20	17.59	17.59	18	0.4	0.2	1	73.8	0.0000	0.00	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	0	0.00	0.00	1.0	0.5	0.00	0.00	17.59	7.65	HGL Too High!
P10	MH3	MH4	1.20	17.56	17.56	18	2.2	1.2	8	53.7	0.0004	0.02	0	0.00	0.01	0.1	0.8	0.7	0.8	0.0	87	0.01	0.02	1.0	0.5	0.01	0.03	17.59	7.28	HGL Too High!
P13	MH4	MH5	1.20	17.43	17.43	18	5.0	2.8	84	59.3	0.0019	0.11	0	0.00	0.03	2.7	1.6	1.3	1.2	0.0	8	0.00	0.04	1.0	0.5	0.02	0.14	17.56	7.09	HGL Too High!
P15	MH5	MH41	1.60	17.30	17.30	24	7.8	2.5	90	50	0.0010	0.05	0	0.00	0.02	14.1	1.1	2.1	2.8	0.0	84	0.08	0.15	1.0	0.5	0.08	0.13	17.43	7.40	HGL Too High!
P9	DI3	MH3	1.00	17.59	17.59	15	1.0	0.8	87	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	17.60	6.62	HGL Too High!
P8	DI17	MH3	1.00	17.59	17.59	15	0.9	0.7	81	31.3	0.0002	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	17.60	6.96	HGL Too High!
P12	DI4	MH4	1.00	17.56	17.56	15	1.4	1.1	99	20.1	0.0004	0.01	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.01	17.58	6.48	HGL Too High!
P11	DI18	MH4	1.00	17.56	17.56	15	1.3	1.0	86	28.4	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	17.58	6.56	HGL Too High!
P14	DI5	MH5	1.00	17.43	17.43	15	1.1	0.9	21	22.6	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	17.44	6.61	HGL Too High!
P18	DI6	MH6	1.00	17.45	17.45	15	1.5	1.3	23	38	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	17.47	7.13	HGL Too High!
P16	MH6	MH5	1.20	17.43	17.43	18	1.9	1.1	86	40	0.0003	0.01	0	0.00	0.00	1.9	0.1	0.0	1.3	0.0	23	0.01	0.02	1.0	0.5	0.01	0.02	17.45	7.55	HGL Too High!
P17	DI49	MH6	1.00	17.45	17.45	15	0.4	0.3	94	33	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	17.45	7.08	HGL Too High!
P32	DI23	MH12	1.00	17.50	17.50	15	1.2	1.0	64	33.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	17.52	7.11	HGL Too High!
P31	DI9	MH12	1.00	17.50	17.50	15	0.9	0.7	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	17.51	7.13	HGL Too High!
P30	MH12	MH11	1.60	17.48	17.48	24	2.1	0.7	1	50.1	0.0003	0.02	0	0.00	0.00	0.6	1.2	0.0	1.0	0.0	64	0.01	0.02	1.0	0.5	0.01	0.03	17.50	7.48	HGL Too High!
P27	MH11	MH10	1.60	17.37	17.37	24	4.3	1.4	5	73.2	0.0014	0.10	0	0.00	0.01	1.4	1.3	0.8	0.7	0.0	1	0.00	0.01	1.0	0.5	0.00	0.11	17.48	7.21	HGL Too High!
P25	MH10	MH9	1.60	17.33	17.33	24	4.9	1.5	5	69.7	0.0004	0.03	0	0.00	0.01	5.9	0.3	0.0	1.4	0.0	5	0.00	0.02	1.0	0.5	0.01	0.04	17.37	7.54	HGL Too High!
P22	MH9	MH8	1.60	17.25	17.25	24	6.1	2.0	51	108	0.0006	0.07	0	0.00	0.01	7.5	0.4	0.3	1.5	0.0	5	0.00	0.03	1.0	0.5	0.02	0.08	17.33	7.85	HGL Too High!
P-80	DI-80	MH-08	1.00	17.25	17.25	15	1.8	1.4	35	49	0.0006	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	26	0.00	0.01	1.0	1.0	0.01	0.04	17.28	7.34	HGL Too High!
P28	DI22	MH11	1.00	17.48	17.48	15	1.2	1.0	90	30.3	0.0003	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	17.49	6.74	HGL Too High!
P29	DI8	MH11	1.00	17.48	17.48	15	1.0	0.8	90	18.3	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	17.48	6.92	HGL Too High!
P26	DI21	MH10	1.00	17.37	17.37	15	0.6	0.5	93	18.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	17.37	7.23	HGL Too High!
P23	DI20	MH9	1.00	17.33	17.33	15	0.7	0.6	85	29.3	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	85	0.00	0.00	1.0	1.0	0.00	0.00	17.33	7.38	HGL Too High!
P24	DI7	MH9	1.00	17.33	17.33	15	0.7	0.5	47	28	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	17.33	7.48	HGL Too High!

Delaware Department of Transportation
Storm Drainage Design Computations

RK&K

Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 200 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-41	MH-41	MH-42	1	0	1	0.00	1.00	0.00	1.10	6.0	7.89	7.43	8.14	24	92	0.012	0.001102	0.0033	4.5	14.0	4.7	0.33	8.22	1.50	1.20	Q ok
P-42	MH-42	DI-43	1	0	1	0.00	1.00	0.00	2.15	6.0	8.22	7.32	15.74	30	30	0.012	0.001255	0.0030	5.0	24.3	5.3	0.09	8.31	1.10	1.01	Q ok
P-43	DI-43	DI-44	4208	31	4239	0.10	1.00	0.10	2.25	6.0	8.31	7.29	16.37	30	25	0.012	0.001358	0.0032	5.1	25.1	5.5	0.08	8.39	0.91	0.83	Q ok
P-44	DI-44	DI-45	4675	523	5198	0.12	1.00	0.12	2.37	6.0	8.39	7.25	17.16	30	69	0.012	0.001491	0.0030	5.0	24.5	5.4	0.21	8.60	0.73	0.52	Q ok
P-45	DI-45	MH-46	4490	535	5025	0.12	1.00	0.12	2.48	6.0	8.60	7.18	17.82	30	52	0.012	0.001609	0.0031	5.0	24.6	5.5	0.16	8.76	0.42	0.26	Q ok
P-46	MH-46	DI-47	1	0	1	0.00	1.00	0.00	3.22	6.0	8.76	7.11	22.88	30	42	0.012	0.002651	0.0031	5.0	24.7	5.8	0.12	8.88	0.16	0.03	Q ok
P-47	DI-47	MH-60	4551	287	4838	0.11	1.00	0.11	3.33	6.0	8.88	7.08	23.55	36	23	0.012	0.001062	0.0030	5.6	39.9	5.9	0.06	8.94	-0.07	-0.14	Q ok
P-60	MH-60	MH-61	1	0	1	0.00	1.00	0.00	4.54	6.0	8.94	7.08	32.12	36	75	0.012	0.001976	0.0039	6.4	44.9	6.9	0.18	9.12	-0.24	-0.53	Q ok
P-61	MH-61	DI-62	1	0	1	0.00	1.00	0.00	4.54	6.0	9.12	7.01	31.80	36	76	0.012	0.001937	0.0039	6.4	45.4	7.0	0.18	9.30	-0.63	-0.93	Q ok
P-62	DI-62	DI-63	1435	40	1475	0.03	1.00	0.03	4.57	6.0	9.30	6.94	31.72	36	50	0.012	0.001927	0.0040	6.5	45.7	7.0	0.12	9.42	-1.03	-1.23	Q ok
P-63	DI-63	DI-77	1999	107	2106	0.05	1.00	0.05	5.36	6.0	9.42	6.90	37.00	36	25	0.012	0.002622	0.0036	6.1	43.4	6.9	0.06	9.48	-1.33	-1.42	Q ok
P-77	DI-77	DI-85	2311	122	2433	0.06	1.00	0.06	6.64	6.0	9.48	6.87	45.58	48	50	0.012	0.000858	0.0030	6.8	85.2	6.9	0.12	9.60	-1.52	-1.67	Q ok
P-85	DI-85	MH-86	5006	304	5310	0.12	1.00	0.12	11.74	6.0	9.60	6.83	80.17	60	186	0.012	0.000807	0.0030	7.9	154.8	7.8	0.40	10.00	-1.77	-2.33	Q ok
P-86	MH-86	MH-87	1	0	1	0.00	1.00	0.00	12.49	6.0	10.00	6.69	83.53	60	45	0.012	0.000877	0.0031	8.0	157.4	8.2	0.09	10.09	-2.43	-2.57	Q ok
P-87	**MH-87**	**OUTFALL**	**1**	**0**	**1**	**0.00**	**1.00**	**0.00**	**13.30**	**6.0**	**10.09**	**6.67**	**88.70**	**60**	**9**	**0.012**	**0.000988**	**0.0033**	**8.3**	**162.9**	**8.5**	**0.02**	**10.11**	**-2.67**	**-2.70**	**Q ok**
P-48	MSS MH-08	MH-49	1	0	1	0.00	1.00	0.00	1.05	6.0	7.24	7.67	8.09	24	64	0.012	0.001089	0.0070	6.5	20.6	6.0	0.18	7.42	1.65	1.20	Q ok
P-50	B7 North	1.00	32048	0	32048	0.74	1.00	0.74	0.74	6.0	0.00	8.09	5.95	18	16	0.012	0.002736	0.0050	4.6	8.0	5.1	0.05	6.05	0.35	0.27	Q ok
P-65	B7 West	MH-64	32234	0	32234	0.74	1.00	0.74	0.74	6.0	0.00	8.09	5.99	18	17	0.012	0.002768	0.0047	4.4	7.8	4.9	0.06	6.06	-0.95	-1.03	Q ok
P-64	MH-64	DI-63	1	0	1	0.00	1.00	0.00	0.74	6.0	6.06	8.06	5.96	18	20	0.012	0.002744	0.0050	4.6	8.0	5.1	0.07	6.12	-1.13	-1.23	Q ok
P-51	DI-51	DI-52	3030	31	3061	0.07	1.00	0.07	0.07	6.0	0.00	8.09	0.57	15	26	0.012	0.000066	0.0050	4.0	4.9	2.4	0.18	6.18	3.70	3.57	Q ok
P-52	DI-52	DI-53	4699	521	5220	0.12	1.00	0.12	0.19	6.0	6.18	8.02	1.52	15	69	0.012	0.000475	0.0049	4.0	4.9	3.4	0.34	6.52	3.37	3.03	Q ok
P-53	DI-53	MH-54	4484	537	5021	0.12	1.00	0.12	0.31	6.0	6.52	7.92	2.42	15	51	0.012	0.001193	0.0051	4.1	5.0	4.0	0.21	6.73	2.83	2.57	Q ok
P-54	MH-54	DI-55	1	0	1	0.00	1.00	0.00	1.07	6.0	6.73	7.85	8.43	24	41	0.012	0.001182	0.0049	5.4	17.1	5.4	0.13	6.85	2.37	2.17	Q ok
P-55	DI-55	MH-60	5685	291	5976	0.14	1.00	0.14	1.21	6.0	6.85	7.78	9.42	24	23	0.012	0.001477	0.0052	5.6	17.7	5.7	0.07	6.92	1.97	1.85	Q ok
P-56	B5 South	MH-54	33482	0	33482	0.77	1.00	0.77	0.77	6.0	0.00	8.09	6.22	18	17	0.012	0.002986	0.0053	4.7	8.3	5.2	0.05	6.05	2.56	2.47	Q ok
P-78	DI-78	DI-79	3667	223	3890	0.09	1.00	0.09	0.09	6.0	0.00	8.09	0.72	15	84	0.012	0.000107	0.0200	8.1	9.9	4.0	0.35	6.35	7.12	5.44	Q ok
P-79	DI-79	DI-71	3253	204	3457	0.08	1.00	0.08	0.17	6.0	6.35	7.95	1.34	18	29	0.012	0.000139	0.0200	9.1	16.1	5.5	0.09	6.44	5.24	4.66	Q ok
P-71	DI-71	DI-72	3698	198	3896	0.09	1.00	0.09	0.35	6.0	6.44	7.95	2.80	18	42	0.012	0.000604	0.0200	9.1	16.1	6.4	0.11	6.55	4.46	3.62	Q ok
P-72	DI-72	DI-73	2021	16	2037	0.05	1.00	0.05	0.40	6.0	6.55	7.88	3.14	18	29	0.012	0.000762	0.0200	9.1	16.1	6.8	0.07	6.62	3.42	2.84	Q ok
P-73	DI-73	MH-74	1071	0	1071	0.02	1.00	0.02	0.42	6.0	6.62	7.88	3.34	18	17	0.012	0.000859	0.0200	9.1	16.1	6.8	0.04	6.66	2.64	2.30	Q ok
P-74	MH-74	DI-75	1	0	1	0.00	1.00	0.00	1.13	6.0	6.66	7.85	8.83	18	17	0.012	0.006026	0.0200	9.1	16.1	9.3	0.03	6.70	2.10	1.76	Q ok
P-75	DI-75	DI-76	2135	0	2135	0.05	1.00	0.05	1.18	6.0	6.70	7.85	9.22	18	43	0.012	0.006561	0.0200	9.1	16.1	9.3	0.08	6.77	1.56	0.70	Q ok
P-76	DI-76	DI-77	1993	48	2041	0.05	1.00	0.05	1.22	6.0	6.77	7.81	9.54	18	51	0.012	0.007032	0.0200	9.1	16.1	9.6	0.09	6.86	0.50	-0.52	Q ok
P-70	DI-70	DI-71	3812	274	4086	0.09	1.00	0.09	0.09	6.0	0.00	8.09	0.76	15	86	0.012	0.000118	0.0200	8.1	9.9	4.8	0.30	6.30	6.38	4.66	Q ok
P-80	DI-80	MH-74	22886	15258	38144	0.88	0.80	0.70	0.70	6.0	0.00	8.09	5.68	18	24	0.012	0.002496	0.0050	4.6	8.0	5.0	0.08	6.08	2.42	2.30	Q ok
P-90	DI-90	DI-91	6026	1962	7988	0.18	0.95	0.17	0.17	6.0	0.00	8.09	1.41	15	79	0.012	0.000407	0.0200	8.1	9.9	5.6	0.23	6.23	2.54	0.96	Q ok
P-91	DI-91	MH-87	6475	2667	9142	0.21	0.91	0.19	0.81	6.0	6.23	8.02	6.53	18	81	0.012	0.003291	0.0200	9.1	16.1	8.4	0.16	6.39	-0.04	-1.66	Q ok
P-92	B6 North	DI-91	19569	0	19569	0.45	1.00	0.45	0.45	6.0	0.00	8.09	3.63	18	63	0.012	0.001020	0.0049	4.5	8.0	4.4	0.24	6.24	0.47	0.16	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

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Project: South Market Street Infrastructure Improvements Prepared by: SNR Date: 2/23/2023 Sheet No.: 2 of 5
County: New Castle Checked by: TMC Date: 3/23/2023 Cm. No.: 20077.000
Segment: Central Green Outfall Storm Frequency: 200 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-95	TD-04	MH-86	21353	32030	53383	1.23	0.61	0.75	0.75	6.0	0.00	8.09	6.05	12	16	0.011	0.020630	0.0506	12.1	9.5	12.9	0.02	6.02	8.01	7.20	Q ok
P-38	DI-38	DI-39	1483	0	1483	0.03	1.00	0.03	0.03	6.0	0.00	8.09	0.28	15	99	0.012	0.000015	0.0200	8.1	9.9	4.0	0.42	6.42	2.75	0.77	Q ok
P-39	DI-39	DI-40	3833	220	4053	0.09	1.00	0.09	0.13	6.0	6.42	7.95	1.01	15	70	0.012	0.000208	0.0200	8.1	9.9	4.8	0.24	6.66	0.57	-0.83	Q ok
P-40	DI-40	DI-85	4668	293	4961	0.11	1.00	0.11	0.24	6.0	6.66	7.85	1.89	18	26	0.012	0.000276	0.0208	9.3	16.4	5.6	0.08	6.74	-1.03	-1.57	Q ok
P-35	MH-35	DI-36	1	0	1	0.00	1.00	0.00	4.60	6.0	7.39	7.60	34.95	**36**	94	0.012	0.002340	0.0050	7.2	51.1	7.9	0.20	7.58	-0.16	-0.63	Q ok
P-36	DI-36	DI-37	1851	0	1851	0.04	1.00	0.04	4.64	6.0	7.58	7.53	34.95	**36**	98	0.012	0.002340	0.0050	7.2	51.1	7.9	0.21	7.79	-0.73	-1.22	Q ok
P-37	DI-37	DI-85	3893	195	4088	0.09	1.00	0.09	4.74	6.0	7.79	7.46	35.33	36	70	0.012	0.002390	0.0050	7.2	51.1	7.9	0.15	7.94	-1.32	-1.67	Q ok
P-30	DI-30	MH-35	1403	0	1403	0.03	1.00	0.03	0.03	6.0	0.00	8.09	0.26	18	47	0.012	0.000005	0.0200	9.1	16.1	4.5	0.18	6.18	0.98	0.04	Q ok
P-11	DI-11	DI-12	4746	684	5430	0.12	1.00	0.12	0.12	6.0	0.00	8.09	1.01	15	20	0.012	0.000208	0.0065	4.6	5.6	3.4	0.10	6.10	2.91	2.78	Q ok
P-12	DI-12	DI-13	4957	1287	6244	0.14	0.99	0.14	0.27	6.0	6.10	8.06	2.15	15	92	0.012	0.000941	0.0065	4.6	5.7	4.2	0.36	6.46	2.68	2.08	Q ok
P-13	DI-13	MH-14	4947	1296	6243	0.14	0.99	0.14	0.41	6.0	6.46	7.92	3.23	15	54	0.012	0.002129	0.0065	4.6	5.6	4.7	0.19	6.65	1.98	1.63	Q ok
P-14	MH-14	DI-15	1	0	1	0.00	1.00	0.00	1.14	6.0	6.65	7.85	8.95	24	38	0.012	0.001334	0.0066	6.3	19.9	6.1	0.10	6.75	1.53	1.28	Q ok
P-15	DI-15	DI-16	3998	870	4868	0.11	1.00	0.11	1.25	6.0	6.75	7.81	9.78	24	73	0.012	0.001594	0.0064	6.3	19.7	6.2	0.20	6.95	1.18	0.71	Q ok
P-16	DI-16	MH-17	5113	501	5614	0.13	1.00	0.13	1.38	6.0	6.95	7.74	10.69	24	31	0.012	0.001904	0.0071	6.6	20.6	6.5	0.08	7.03	0.61	0.39	Q ok
P-18	B7 South	MH-14	31929	0	31929	0.73	1.00	0.73	0.73	6.0	0.00	8.09	5.93	18	17	0.012	0.002715	0.0053	4.7	8.3	5.1	0.06	6.06	1.72	1.63	Q ok
P-01	DI-01	DI-02	7520	1261	8781	0.20	1.00	0.20	0.20	6.0	0.00	8.09	1.63	15	77	0.012	0.000543	0.0065	4.6	5.6	3.9	0.33	6.33	2.91	2.41	Q ok
P-02	DI-02	DI-03	2113	487	2600	0.06	1.00	0.06	0.26	6.0	6.33	7.99	2.09	15	38	0.012	0.000889	0.0066	4.6	5.7	4.2	0.15	6.48	2.31	2.06	Q ok
P-03	DI-03	MH-04	4989	1312	6301	0.14	0.99	0.14	0.40	6.0	6.48	7.92	3.20	15	46	0.012	0.002088	0.0065	4.6	5.7	4.7	0.16	6.64	1.96	1.66	Q ok
P-04	MH-04	DI-05	1	0	1	0.00	1.00	0.00	0.88	6.0	6.64	7.88	6.91	18	46	0.012	0.003685	0.0065	5.2	9.2	5.8	0.13	6.78	1.56	1.26	Q ok
P-05	DI-05	DI-06	3831	995	4826	0.11	0.99	0.11	0.99	6.0	6.78	7.81	7.70	24	73	0.012	0.000988	0.0064	6.3	19.7	5.8	0.21	6.99	1.16	0.69	Q ok
P-06	DI-06	MH-17	5161	592	5753	0.13	1.00	0.13	1.65	6.0	6.99	7.74	12.81	24	30	0.012	0.002731	0.0067	6.4	20.0	6.8	0.07	7.06	0.59	0.39	Q ok
P-17	MH-17	MH-35	1	0	1	0.00	1.00	0.00	3.04	6.0	7.06	7.71	23.40	*36*	115	0.012	0.001048	0.0030	5.6	39.9	5.9	0.32	7.39	0.29	-0.06	Q ok
Check P-17 for Sanitary Crossing for Conflict																									Check P-1	
P-08	DI-08	MH-07	1526	0	1526	0.04	1.00	0.04	0.04	6.0	0.00	8.09	0.28	15	58	0.012	0.000016	0.0066	4.6	5.7	2.3	0.43	6.43	1.36	0.98	Q ok
P-07	MH-07	DI-06	1	0	1	0.00	1.00	0.00	0.54	6.0	0.00	8.09	4.34	18	14	0.012	0.001455	0.0064	5.2	9.1	5.1	0.05	6.05	0.88	0.79	Q ok
P-09	B9/J	MH-04	20585	0	20585	0.47	1.00	0.47	0.47	6.0	0.00	8.09	3.82	18	17	0.012	0.001129	0.0053	4.7	8.3	4.5	0.06	6.06	1.75	1.66	Q ok
P-10	B9/J	MH-07	21845	0	21845	0.50	1.00	0.50	0.50	6.0	0.00	8.09	4.06	18	17	0.012	0.001271	0.0053	4.7	8.3	4.6	0.06	6.06	1.07	0.98	Q ok
P-20	TD-05	DI-21	5394	0	5394	0.12	1.00	0.12	0.12	6.0	0.00	8.09	1.00	8	39	0.011	0.004921	0.0500	9.1	3.2	7.8	0.08	6.08	8.50	6.55	Q ok
P-21	DI-21	MH-22	6185	3410	9595	0.22	0.85	0.19	0.31	6.0	6.08	8.06	2.50	15	31	0.012	0.001274	0.0200	8.1	9.9	6.6	0.08	6.16	4.54	3.92	Q ok
P-22	MH-22	MH-23	1	0	1	0.00	1.00	0.00	0.51	6.0	6.16	8.02	4.07	18	42	0.012	0.001279	0.0200	9.1	16.1	7.5	0.09	6.26	3.72	2.88	Q ok
P-23	MH-23	MH-24	1	0	1	0.00	1.00	0.00	1.33	6.0	6.26	7.99	10.61	18	66	0.012	0.008691	0.0200	9.1	16.1	9.7	0.11	6.37	2.68	1.36	Q ok
P-24	MH-24	MH-35	1	0	1	0.00	1.00	0.00	1.53	6.0	6.37	7.95	12.17	18	56	0.012	0.011431	0.0200	9.1	16.1	10.1	0.09	6.46	1.16	0.04	Q ok
P-25	DI-25	MH-22	6504	3883	10387	0.24	0.83	0.20	0.20	6.0	0.00	8.09	1.60	15	31	0.012	0.000521	0.0200	8.1	9.9	5.6	0.09	6.09	4.54	3.92	Q ok
P-26	B8/K	MH-23	16317	0	16317	0.37	1.00	0.37	0.37	6.0	0.00	8.09	3.03	18	56	0.012	0.000709	0.0050	4.6	8.0	4.2	0.22	6.22	3.06	2.78	Q ok
P-27	B6 South	MH-23	19451	0	19451	0.45	1.00	0.45	0.45	6.0	0.00	8.09	3.61	18	56	0.012	0.001008	0.0050	4.6	8.0	4.4	0.21	6.21	3.06	2.78	Q ok

Delaware Department of Transportation
Storm Drainage Design Computations

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/2023 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/2023 | Cm. No.: 20077.000
Segment: Central Green Outfall | Storm Frequency: 200 -year (50-year for sumps)

Location			Impervious Area, C = 0.95 to Inlet	Pervious Area, C = 0.18 to Inlet	Total Area	Incremental Area	Runoff Coefficient	C x Δ A	Σ (C x Δ A)	Inlet Time	Time to Upper End	Rainfall Intensity	Design Discharge	Pipe Diameter	Length of Pipe	Roughness Coefficient	Friction Slope	Pipe Slope	Full Velocity	Full Capacity	Actual Velocity	Flow Time In Pipe	Time to Lower End	Invert at Upper End	Invert at Lower End	Capacity Check
No.	From	To	A_{imp}	A_{perv}	A_{total}	Δ A	C	CxΔA	Σ CA	T_c	T_c	I	Q	D	L	n	S_f	S_o	V_{full}	Q_{full}	V_{act}	T_t	T_t	Inv Up	Inv Dn	
			ft^2	ft^2	ft^2	Acres		Acres	Acres	min	min	in/hr	cfs	in	ft		ft/ft	ft/ft	fps	cfs	fps	min	min	ft	ft	
P-28	DI-28	MH-24	3596	533	4129	0.09	1.00	0.09	0.09	6.0	0.00	8.09	0.77	18	34	0.012	0.000045	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok
P-29	DI-29	MH-24	4110	551	4661	0.11	1.00	0.11	0.11	6.0	0.00	8.09	0.87	18	34	0.012	0.000058	0.0200	9.1	16.1	4.5	0.13	6.13	2.04	1.36	Q ok

KEY

	Upsized from Semi-Final Design to have capacity for 50-yr design storm
	Optional Upsize-50-yr design storm results in >85% Full
	No Change from Semi-Final Design

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements | Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
County: New Castle | Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Segment: Central Green Outfall | Design Freq.: 200 -year (50-year for sumps)

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	7.37	7.37	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	7.54	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	7.27	7.27	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	7.37	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	7.10	7.10	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	7.27	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	6.89	6.89	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	7.10	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	6.67	6.67	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	6.89	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	6.46	6.46	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	6.67	8.54	HGL ok
P-47	DI-47	MH-60	2.40	6.05	6.05	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	6.46	9.09	HGL ok
P-60	MH-60	MH-61	2.40	5.77	5.77	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	6.05	9.84	HGL ok
P-61	MH-61	DI-62	2.40	5.42	5.42	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	5.77	11.03	HGL ok
P-62	DI-62	DI-63	2.40	5.11	5.11	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	5.42	10.34	HGL ok
P-63	DI-63	DI-77	1.93	4.61	4.61	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	5.11	10.08	HGL ok
P-77	DI-77	DI-85	3.20	4.06	4.06	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	4.61	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.44	3.44	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	4.06	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.30	3.30	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	3.44	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.20**	**3.20**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	*0.5*	**0.09**	**0.10**	**3.30**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	7.37	7.37	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	7.48	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	6.67	6.67	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	6.76	10.00	HGL ok
P-65	B7 West	MH-64	1.20	5.27	5.27	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	5.34	10.00	HGL ok
P-64	MH-64	DI-63	1.20	5.11	5.11	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	5.27	10.14	HGL ok
P-51	DI-51	DI-52	1.00	6.58	6.58	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.58	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	6.53	6.53	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	6.58	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	6.44	6.44	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	6.53	7.59	HGL ok
P-54	MH-54	DI-55	1.60	6.28	6.28	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	6.44	8.54	HGL ok
P-55	DI-55	MH-60	1.60	6.05	6.05	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	6.28	9.09	HGL ok
P-56	B5 South	MH-54	1.20	6.44	6.44	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	6.51	10.00	HGL ok
P-78	DI-78	DI-79	1.00	6.23	6.44	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.45	11.60	HGL ok
P-79	DI-79	DI-71	1.20	6.22	6.22	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	6.23	11.15	HGL ok
P-71	DI-71	DI-72	1.20	6.17	6.17	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	6.22	11.15	HGL ok
P-72	DI-72	DI-73	1.20	6.11	6.11	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	6.17	10.99	HGL ok
P-73	DI-73	MH-74	1.20	6.06	6.06	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	6.11	10.84	HGL ok
P-74	MH-74	DI-75	1.20	5.83	5.83	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	6.06	11.24	HGL ok
P-75	DI-75	DI-76	1.20	5.27	5.27	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	5.83	10.63	HGL ok
P-76	DI-76	DI-77	1.20	4.61	4.61	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	5.27	10.34	HGL ok
P-70	DI-70	DI-71	1.00	6.22	6.22	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.23	11.60	HGL ok
P-80	DI-80	MH-74	1.20	6.06	6.06	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	6.16	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.72	3.72	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	3.76	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.30	3.30	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	3.72	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.72	3.72	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	3.80	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.44	8.00	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	8.45	10.50	HGL ok
P-38	DI-38	DI-39	1.00	4.11	4.11	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.11	10.67	HGL ok
P-39	DI-39	DI-40	1.00	4.09	4.09	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	4.11	10.16	HGL ok
P-40	DI-40	DI-85	1.20	4.06	4.06	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	4.09	9.98	HGL ok
P-35	MH-35	DI-36	2.40	4.96	4.96	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	5.60	11.72	HGL ok
P-36	DI-36	DI-37	2.40	4.50	4.50	36	35.9	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	4.96	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	4.06	4.06	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	4.50	10.16	HGL ok
P-30	DI-30	MH-35	1.20	5.60	5.60	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.60	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.79	6.79	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.79	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	6.68	6.68	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	6.79	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	6.50	6.50	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	6.68	7.91	HGL ok
P-14	MH-14	DI-15	1.60	6.35	6.35	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	6.50	8.68	HGL ok
P-15	DI-15	DI-16	1.60	6.14	6.14	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	6.35	9.01	HGL ok
P-16	DI-16	MH-17	1.60	5.87	5.87	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	6.14	9.77	HGL ok
P-18	B7 South	MH-14	1.20	6.50	6.50	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	6.57	10.00	HGL ok
P-01	DI-01	DI-02	1.00	6.81	6.81	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	6.86	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	6.74	6.74	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	6.81	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	6.59	6.59	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	6.74	7.91	HGL ok
P-04	MH-04	DI-05	1.20	6.36	6.36	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	8.3	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	6.59	8.60	HGL ok
P-05	DI-05	DI-06	1.60	6.12	6.12	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	6.36	9.01	HGL ok
P-06	DI-06	MH-17	1.60	5.87	5.87	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	6.12	9.87	HGL ok
P-17	MH-17	MH-35	1.60	5.60	5.60	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	5.87	10.61	HGL ok
P-08	DI-08	MH-07	1.00	6.19	6.19	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.19	11.39	HGL ok
P-07	MH-07	DI-06	1.20	6.12	6.12	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	6.19	10.19	HGL ok
P-09	B9/J	MH-04	1.20	6.59	6.59	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.61	10.00	HGL ok
P-10	B9/J	MH-07	1.20	6.19	6.19	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.22	10.00	HGL ok
P-20	TD-05	DI-21	0.53	7.38	7.38	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	7.60	10.50	HGL ok
P-21	DI-21	MH-22	1.00	7.18	7.18	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	7.38	9.46	HGL ok
P-22	MH-22	MH-23	1.20	7.08	7.08	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	7.18	9.72	HGL ok
P-23	MH-23	MH-24	1.20	6.43	6.43	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	7.08	10.97	HGL ok
P-24	MH-24	MH-35	1.20	5.60	5.60	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	6.43	11.20	HGL ok
P-25	DI-25	MH-22	1.00	7.18	7.18	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	7.20	9.46	HGL ok
P-26	B8/K	MH-23	1.20	7.08	7.08	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	7.13	10.00	HGL ok
P-27	B6 South	MH-23	1.20	7.08	7.08	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	7.15	10.00	HGL ok
P-28	DI-28	MH-24	1.20	6.43	6.43	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.43	10.95	HGL ok
P-29	DI-29	MH-24	1.20	6.43	6.43	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.43	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t=H_o+H_i+H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H=H_f+H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	7.57	7.57	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	7.74	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	7.47	7.47	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	7.57	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	7.30	7.30	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	7.47	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	7.09	7.09	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	7.30	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	6.87	6.87	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	7.09	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	6.66	6.66	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	6.87	8.54	HGL ok
P-47	DI-47	MH-60	2.40	6.25	6.25	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	6.66	9.09	HGL ok
P-60	MH-60	MH-61	2.40	5.97	5.97	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	6.25	9.84	HGL ok
P-61	MH-61	DI-62	2.40	5.62	5.62	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	5.97	11.03	HGL ok
P-62	DI-62	DI-63	2.40	5.31	5.31	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	5.62	10.34	HGL ok
P-63	DI-63	DI-77	1.93	4.81	4.81	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	5.31	10.08	HGL ok
P-77	DI-77	DI-85	3.20	4.26	4.26	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	4.81	10.08	HGL ok
P-85	DI-85	MH-86	4.00	3.64	3.64	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	4.26	9.98	HGL ok
P-86	MH-86	MH-87	4.00	3.50	3.50	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	3.64	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**3.40**	**3.40**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**3.50**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	7.57	7.57	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	7.68	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	6.87	6.87	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	6.96	10.00	HGL ok
P-65	B7 West	MH-64	1.20	5.47	5.47	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	5.54	10.00	HGL ok
P-64	MH-64	DI-63	1.20	5.31	5.31	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	5.47	10.14	HGL ok
P-51	DI-51	DI-52	1.00	6.78	6.78	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.78	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	6.73	6.73	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	6.78	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	6.64	6.64	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	6.73	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	6.48	6.48	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	6.64	8.54	HGL ok
P-55	DI-55	MH-60	1.60	6.25	6.25	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	6.48	9.09	HGL ok
P-56	B5 South	MH-54	1.20	6.64	6.64	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	6.71	10.00	HGL ok
P-78	DI-78	DI-79	1.00	6.43	6.44	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.45	11.60	HGL ok
P-79	DI-79	DI-71	1.20	6.42	6.42	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	6.43	11.15	HGL ok
P-71	DI-71	DI-72	1.20	6.37	6.37	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	6.42	11.15	HGL ok
P-72	DI-72	DI-73	1.20	6.31	6.31	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	6.37	10.99	HGL ok
P-73	DI-73	MH-74	1.20	6.26	6.26	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	6.31	10.84	HGL ok
P-74	MH-74	DI-75	1.20	6.03	6.03	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	6.26	11.24	HGL ok
P-75	DI-75	DI-76	1.20	5.47	5.47	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	6.03	10.63	HGL ok
P-76	DI-76	DI-77	1.20	4.81	4.81	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	5.47	10.34	HGL ok
P-70	DI-70	DI-71	1.00	6.42	6.42	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.43	11.60	HGL ok
P-80	DI-80	MH-74	1.20	6.26	6.26	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	6.36	11.00	HGL ok
P-90	DI-90	DI-91	1.00	3.92	3.92	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	3.96	9.20	HGL ok
P-91	DI-91	MH-87	1.20	3.50	3.50	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	3.92	8.33	HGL ok
P-92	B6 North	DI-91	1.20	3.92	3.92	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	4.00	10.00	HGL ok
P-95	TD-04	MH-86	0.80	3.64	8.00	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	8.45	10.50	HGL ok
P-38	DI-38	DI-39	1.00	4.31	4.31	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	4.31	10.67	HGL ok
P-39	DI-39	DI-40	1.00	4.29	4.29	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	4.31	10.16	HGL ok
P-40	DI-40	DI-85	1.20	4.26	4.26	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	4.29	9.98	HGL ok
P-35	MH-35	DI-36	2.40	5.16	5.16	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	5.80	11.72	HGL ok
P-36	DI-36	DI-37	2.40	4.70	4.70	36	35.9	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	5.16	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	4.26	4.26	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	4.70	10.16	HGL ok
P-30	DI-30	MH-35	1.20	5.80	5.80	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	5.80	11.24	HGL ok
P-11	DI-11	DI-12	1.00	6.99	6.99	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	6.99	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	6.88	6.88	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	6.99	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	6.70	6.70	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	6.88	7.91	HGL ok
P-14	MH-14	DI-15	1.60	6.55	6.55	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	6.70	8.68	HGL ok
P-15	DI-15	DI-16	1.60	6.34	6.34	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	6.55	9.01	HGL ok
P-16	DI-16	MH-17	1.60	6.07	6.07	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	6.34	9.77	HGL ok
P-18	B7 South	MH-14	1.20	6.70	6.70	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	6.77	10.00	HGL ok
P-01	DI-01	DI-02	1.00	7.01	7.01	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	7.06	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	6.94	6.94	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	7.01	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	6.79	6.79	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	6.94	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	6.56	6.56	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	8.3	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	6.79	8.60	HGL ok
P-05	DI-05	DI-06	1.60	6.32	6.32	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	6.56	9.01	HGL ok
P-06	DI-06	MH-17	1.60	6.07	6.07	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	6.32	9.87	HGL ok
P-17	MH-17	MH-35	1.60	5.80	5.80	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	6.07	10.61	HGL ok
P-08	DI-08	MH-07	1.00	6.39	6.39	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.39	11.39	HGL ok
P-07	MH-07	DI-06	1.20	6.32	6.32	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	6.39	10.19	HGL ok
P-09	B9/J	MH-04	1.20	6.79	6.79	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.81	10.00	HGL ok
P-10	B9/J	MH-07	1.20	6.39	6.39	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	6.42	10.00	HGL ok
P-20	TD-05	DI-21	0.53	7.58	7.58	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	7.80	10.50	HGL ok
P-21	DI-21	MH-22	1.00	7.38	7.38	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	7.58	9.46	HGL ok
P-22	MH-22	MH-23	1.20	7.28	7.28	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	7.38	9.72	HGL ok
P-23	MH-23	MH-24	1.20	6.63	6.63	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	7.28	10.97	HGL ok
P-24	MH-24	MH-35	1.20	5.80	5.80	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	6.63	11.20	HGL ok
P-25	DI-25	MH-22	1.00	7.38	7.38	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	7.40	9.46	HGL ok
P-26	B8/K	MH-23	1.20	7.28	7.28	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	7.33	10.00	HGL ok
P-27	B6 South	MH-23	1.20	7.28	7.28	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	7.35	10.00	HGL ok
P-28	DI-28	MH-24	1.20	6.63	6.63	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.63	10.95	HGL ok
P-29	DI-29	MH-24	1.20	6.63	6.63	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.63	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)			

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add $Hc = 0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	11.07	11.07	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	11.24	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.97	10.97	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	11.07	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	10.80	10.80	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	10.97	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	10.59	10.59	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	10.80	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.37	10.37	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	10.59	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.16	10.16	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	10.37	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	9.75	9.75	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	10.16	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.47	9.47	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	9.75	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.12	9.12	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	9.47	11.03	HGL ok
P-62	DI-62	DI-63	2.40	8.81	8.81	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	9.12	10.34	HGL ok
P-63	DI-63	DI-77	1.93	8.31	8.31	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	8.81	10.08	HGL ok
P-77	DI-77	DI-85	3.20	7.76	7.76	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	8.31	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.14	7.14	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	7.76	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.00	7.00	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	7.14	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**6.90**	**6.90**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**7.00**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	11.07	11.07	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	11.18	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.37	10.37	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	10.46	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	8.97	8.97	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.04	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	8.81	8.81	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	8.97	10.14	HGL ok
P-51	DI-51	DI-52	1.00	10.28	10.28	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.28	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.23	10.23	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	10.28	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.14	10.14	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	10.23	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.98	9.98	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	10.14	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	9.75	9.75	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	9.98	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.14	10.14	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	10.21	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	9.93	9.93	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.94	11.60	HGL ok
P-79	DI-79	DI-71	1.20	9.92	9.92	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	9.93	11.15	HGL ok
P-71	DI-71	DI-72	1.20	9.87	9.87	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	9.92	11.15	HGL ok
P-72	DI-72	DI-73	1.20	9.81	9.81	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	9.87	10.99	HGL ok
P-73	DI-73	MH-74	1.20	9.76	9.76	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	9.81	10.84	HGL ok
P-74	MH-74	DI-75	1.20	9.53	9.53	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	9.76	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.97	8.97	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	9.53	10.63	HGL ok
P-76	DI-76	DI-77	1.20	8.31	8.31	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	8.97	10.34	HGL ok
P-70	DI-70	DI-71	1.00	9.92	9.92	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.93	11.60	HGL ok
P-80	DI-80	MH-74	1.20	9.76	9.76	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	9.86	11.00	HGL ok
P-90	DI-90	DI-91	1.00	7.42	7.42	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	7.46	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.00	7.00	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	7.42	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	7.42	7.42	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	7.50	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.14	8.00	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	8.45	10.50	HGL ok
P-38	DI-38	DI-39	1.00	7.81	7.81	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	7.81	10.67	HGL ok
P-39	DI-39	DI-40	1.00	7.79	7.79	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	7.81	10.16	HGL ok
P-40	DI-40	DI-85	1.20	7.76	7.76	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	7.79	9.98	HGL ok
P-35	MH-35	DI-36	2.40	8.66	8.66	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	9.30	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.20	8.20	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	8.66	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	7.76	7.76	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	8.20	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.30	9.30	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.30	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.49	10.49	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.49	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.38	10.38	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	10.49	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.20	10.20	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	10.38	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.05	10.05	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	10.20	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	9.84	9.84	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	10.05	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	9.57	9.57	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	9.84	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.20	10.20	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.27	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	10.51	10.51	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	10.56	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.44	10.44	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	10.51	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.29	10.29	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	10.44	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.06	10.06	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	10.29	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	9.82	9.82	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	10.06	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	9.57	9.57	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	9.82	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.30	9.30	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	9.57	10.61	HGL ok
P-08	DI-08	MH-07	1.00	9.89	9.89	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.89	11.39	HGL ok
P-07	MH-07	DI-06	1.20	9.82	9.82	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	9.89	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.29	10.29	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.31	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	9.89	9.89	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.92	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.08	11.08	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	11.30	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	10.88	10.88	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	11.08	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	10.78	10.78	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	10.88	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.13	10.13	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	10.78	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.30	9.30	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	10.13	11.20	HGL ok
P-25	DI-25	MH-22	1.00	10.88	10.88	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	10.90	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	10.78	10.78	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	10.83	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	10.78	10.78	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	10.85	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.13	10.13	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.13	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.13	10.13	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.13	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)			

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add $Hc = 0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.57	11.57	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	11.74	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.47	11.47	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	11.57	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.30	11.30	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	11.47	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.09	11.09	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	11.30	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	10.87	10.87	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	11.09	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	10.66	10.66	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	10.87	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.25	10.25	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	10.66	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	9.97	9.97	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	10.25	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	9.62	9.62	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	9.97	11.03	HGL ok
P-62	DI-62	DI-63	2.40	9.31	9.31	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	9.62	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	8.81	8.81	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	9.31	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	8.26	8.26	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	8.81	10.08	HGL ok
P-85	DI-85	MH-86	4.00	7.64	7.64	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	8.26	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.50	7.50	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	7.64	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.40**	**7.40**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**7.50**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	11.57	11.57	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	11.68	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	10.87	10.87	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	10.96	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.47	9.47	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.54	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.31	9.31	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	9.47	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	10.78	10.78	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.78	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	10.73	10.73	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	10.78	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	10.64	10.64	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	10.73	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.48	10.48	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	10.64	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.25	10.25	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	10.48	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	10.64	10.64	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	10.71	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.43	10.43	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.44	11.60	HGL ok
P-79	DI-79	DI-71	1.20	10.42	10.42	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	10.43	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.37	10.37	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	10.42	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.31	10.31	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	10.37	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.26	10.26	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	10.31	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.03	10.03	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	10.26	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	9.47	9.47	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	10.03	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	8.81	8.81	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	9.47	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.42	10.42	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.43	11.60	HGL ok
P-80	DI-80	MH-74	1.20	10.26	10.26	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	10.36	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	7.92	7.92	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	7.96	9.20	HGL ok
P-91	DI-91	MH-87	1.20	7.50	7.50	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	7.92	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	7.92	7.92	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	8.00	10.00	HGL ok
P-95	TD-04	MH-86	0.80	7.64	8.00	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	8.45	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.31	8.31	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.31	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.29	8.29	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	8.31	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.26	8.26	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	8.29	9.98	HGL ok
P-35	MH-35	DI-36	2.40	9.16	9.16	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	9.80	11.72	HGL ok
P-36	DI-36	DI-37	2.40	8.70	8.70	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	9.16	10.67	HGL ok

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.26	8.26	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	8.70	10.16	HGL ok
P-30	DI-30	MH-35	1.20	9.80	9.80	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.80	11.24	HGL ok
P-11	DI-11	DI-12	1.00	10.99	10.99	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.99	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	10.88	10.88	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	10.99	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	10.70	10.70	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	10.88	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.55	10.55	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	10.70	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.34	10.34	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	10.55	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.07	10.07	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	10.34	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	10.70	10.70	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.77	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.01	11.01	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	11.06	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	10.94	10.94	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	11.01	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	10.79	10.79	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	10.94	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.56	10.56	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	10.79	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.32	10.32	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	10.56	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.07	10.07	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	10.32	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	9.80	9.80	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	10.07	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.39	10.39	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.39	11.39	HGL ok
P-07	MH-07	DI-06	1.20	10.32	10.32	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	10.39	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	10.79	10.79	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.81	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.39	10.39	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.42	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.58	11.58	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	11.80	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.38	11.38	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	11.58	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.28	11.28	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	11.38	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	10.63	10.63	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	11.28	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	9.80	9.80	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	10.63	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.38	11.38	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.40	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.28	11.28	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	11.33	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.28	11.28	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	11.35	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	10.63	10.63	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.63	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	10.63	10.63	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.63	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inle WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	11.97	11.97	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	12.14	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	11.87	11.87	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	11.97	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	11.70	11.70	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	11.87	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.49	11.49	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	11.70	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.27	11.27	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	11.49	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.06	11.06	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	11.27	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	10.65	10.65	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	11.06	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.37	10.37	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	10.65	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.02	10.02	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	10.37	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	9.71	9.71	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	10.02	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.21	9.21	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	9.71	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	8.66	8.66	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	9.21	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	8.04	8.04	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	8.66	9.98	HGL ok
P-86	MH-86	MH-87	4.00	7.90	7.90	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	8.04	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**7.80**	**7.80**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**7.90**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	11.97	11.97	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	12.08	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.27	11.27	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	11.36	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	9.87	9.87	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.94	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	9.71	9.71	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	9.87	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.18	11.18	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.18	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.13	11.13	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	11.18	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.04	11.04	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	11.13	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	10.88	10.88	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	11.04	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	10.65	10.65	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	10.88	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.04	11.04	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	11.11	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	10.83	10.83	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.84	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	10.82	10.82	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	10.83	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	10.77	10.77	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	10.82	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	10.71	10.71	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	10.77	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	10.66	10.66	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	10.71	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.43	10.43	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	10.66	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	9.87	9.87	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	10.43	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.21	9.21	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	9.87	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	10.82	10.82	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	10.83	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	10.66	10.66	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	10.76	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	8.32	8.32	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	8.36	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	7.90	7.90	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	8.32	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.32	8.32	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	8.40	10.00	HGL ok
P-95	TD-04	MH-86	0.80	8.04	8.04	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	8.49	10.50	HGL ok
P-38	DI-38	DI-39	1.00	8.71	8.71	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.71	10.67	HGL ok
P-39	DI-39	DI-40	1.00	8.69	8.69	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	8.71	10.16	HGL ok
P-40	DI-40	DI-85	1.20	8.66	8.66	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	8.69	9.98	HGL ok
P-35	MH-35	DI-36	2.40	9.56	9.56	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	10.20	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.10	9.10	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	9.56	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	8.66	8.66	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	9.10	10.16	HGL ok
P-30	DI-30	MH-35	1.20	10.20	10.20	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.20	11.24	HGL ok
P-11	DI-11	DI-12	1.00	11.39	11.39	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.39	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.28	11.28	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	11.39	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.10	11.10	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	11.28	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	10.95	10.95	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	11.10	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	10.74	10.74	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	10.95	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.47	10.47	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	10.74	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.10	11.10	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	11.17	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.41	11.41	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	11.46	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.34	11.34	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	11.41	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.19	11.19	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	11.34	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	10.96	10.96	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	11.19	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	10.72	10.72	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	10.96	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.47	10.47	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	10.72	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.20	10.20	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	10.47	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	10.79	10.79	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.79	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	10.72	10.72	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	10.79	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.19	11.19	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	11.21	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	10.79	10.79	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	10.82	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	11.98	11.98	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	12.20	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	11.78	11.78	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	11.98	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	11.68	11.68	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	11.78	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.03	11.03	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	11.68	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.20	10.20	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	11.03	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	11.78	11.78	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	11.80	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	11.68	11.68	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	11.73	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	11.68	11.68	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	11.75	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.03	11.03	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.03	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.03	11.03	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.03	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add $Hc = 0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	12.47	12.47	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	12.64	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	12.37	12.37	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	12.47	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.20	12.20	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	12.37	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	11.99	11.99	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	12.20	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	11.77	11.77	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	11.99	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	11.56	11.56	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	11.77	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.15	11.15	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	11.56	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	10.87	10.87	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	11.15	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	10.52	10.52	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	10.87	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.21	10.21	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	10.52	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	9.71	9.71	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	10.21	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.16	9.16	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	9.71	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	8.54	8.54	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	9.16	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	8.40	8.40	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	8.54	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**8.30**	**8.30**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**8.40**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	12.47	12.47	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	12.58	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	11.77	11.77	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	11.86	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	10.37	10.37	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	10.44	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.21	10.21	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	10.37	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	11.68	11.68	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.68	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	11.63	11.63	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	11.68	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	11.54	11.54	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	11.63	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	11.38	11.38	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	11.54	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.15	11.15	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	11.38	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	11.54	11.54	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	11.61	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	11.33	11.33	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.34	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	11.32	11.32	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	11.33	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.27	11.27	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	11.32	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.21	11.21	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	11.27	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.16	11.16	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	11.21	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	10.93	10.93	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	11.16	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	10.37	10.37	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	10.93	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	9.71	9.71	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	10.37	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	11.32	11.32	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.33	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.16	11.16	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	11.26	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	8.82	8.82	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	8.86	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	8.40	8.40	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	8.82	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	8.82	8.82	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	8.90	10.00	HGL ok
P-95	TD-04	MH-86	0.80	8.54	8.54	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	8.99	10.50	HGL ok
P-38	DI-38	DI-39	1.00	9.21	9.21	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.21	10.67	HGL ok
P-39	DI-39	DI-40	1.00	9.19	9.19	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	9.21	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.16	9.16	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	9.19	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.06	10.06	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	10.70	11.72	HGL ok
P-36	DI-36	DI-37	2.40	9.60	9.60	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	10.06	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.16	9.16	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	9.60	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	10.70	10.70	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.70	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	11.89	11.89	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	11.89	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	11.78	11.78	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	*1.3*	1.0	0.02	0.11	11.89	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	11.60	11.60	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	*1.3*	1.0	0.06	0.18	11.78	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	11.45	11.45	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	*0.5*	0.10	0.15	11.60	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.24	11.24	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	11.45	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	10.97	10.97	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	11.24	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	11.60	11.60	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	*0.5*	0.02	0.07	11.67	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	11.91	11.91	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	11.96	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	11.84	11.84	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	*1.3*	1.0	0.03	0.06	11.91	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	11.69	11.69	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	*1.3*	1.0	0.06	0.16	11.84	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	11.46	11.46	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	*0.5*	0.06	0.23	11.69	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.22	11.22	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	*1.3*	1.0	0.17	0.24	11.46	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	10.97	10.97	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	11.22	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	10.70	10.70	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	*0.5*	0.16	0.28	10.97	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.29	11.29	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.29	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.22	11.22	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	*0.5*	0.05	0.07	11.29	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	11.69	11.69	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.03	11.71	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.29	11.29	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.03	11.32	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	12.48	12.48	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	12.70	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.28	12.28	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	*1.3*	1.0	0.16	0.20	12.48	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.18	12.18	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	*0.5*	0.04	0.10	12.28	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	11.53	11.53	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	*0.5*	0.08	0.66	12.18	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	10.70	10.70	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	*0.5*	0.19	0.83	11.53	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.28	12.28	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	12.30	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.18	12.18	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.01	0.05	12.23	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.18	12.18	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.06	12.25	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	11.53	11.53	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.53	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	11.53	11.53	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.53	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvatu (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	13.17	13.17	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	13.34	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.07	13.07	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	13.17	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	12.90	12.90	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	13.07	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	12.69	12.69	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	12.90	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.47	12.47	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	12.69	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.26	12.26	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	12.47	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	11.85	11.85	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	12.26	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	11.57	11.57	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	11.85	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.22	11.22	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	11.57	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	10.91	10.91	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	11.22	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.41	10.41	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	10.91	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	9.86	9.86	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	10.41	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.24	9.24	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	9.86	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.10	9.10	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	9.24	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.00**	**9.00**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**9.10**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	13.17	13.17	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	13.28	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.47	12.47	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	12.56	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.07	11.07	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	11.14	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	10.91	10.91	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	11.07	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.38	12.38	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.38	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.33	12.33	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	12.38	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.24	12.24	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	12.33	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.08	12.08	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	12.24	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	11.85	11.85	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	12.08	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.24	12.24	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	12.31	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.03	12.03	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.04	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.02	12.02	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.03	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	11.97	11.97	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	12.02	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	11.91	11.91	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	11.97	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	11.86	11.86	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	11.91	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	11.63	11.63	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	11.86	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.07	11.07	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	11.63	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.41	10.41	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	11.07	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.02	12.02	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.03	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	11.86	11.86	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	11.96	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.52	9.52	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	9.56	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.10	9.10	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	9.52	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.52	9.52	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	9.60	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.24	9.24	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	9.69	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	9.91	9.91	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.91	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	9.89	9.89	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	9.91	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	9.86	9.86	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	9.89	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	10.76	10.76	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	11.40	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.30	10.30	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	10.76	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	9.86	9.86	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	10.30	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.40	11.40	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.40	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	12.59	12.59	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.59	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.48	12.48	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	12.59	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.30	12.30	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	12.48	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.15	12.15	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	12.30	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	11.94	11.94	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	12.15	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	11.67	11.67	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	11.94	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.30	12.30	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.37	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	12.61	12.61	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	12.66	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.54	12.54	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	12.61	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.39	12.39	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	12.54	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.16	12.16	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	12.39	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	11.92	11.92	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	12.16	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	11.67	11.67	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	11.92	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.40	11.40	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	11.67	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	11.99	11.99	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.99	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	11.92	11.92	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	11.99	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.39	12.39	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.41	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	11.99	11.99	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.02	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.18	13.18	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	13.40	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	12.98	12.98	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	13.18	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	12.88	12.88	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	12.98	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.23	12.23	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	12.88	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.40	11.40	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	12.23	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	12.98	12.98	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.00	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	12.88	12.88	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	12.93	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	12.88	12.88	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	12.95	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.23	12.23	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.23	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.23	12.23	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.23	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvatu	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	13.67	13.67	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	13.84	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.57	13.57	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	13.67	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.40	13.40	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	13.57	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.19	13.19	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	13.40	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.97	12.97	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	13.19	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.76	12.76	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	12.97	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.35	12.35	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	12.76	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.07	12.07	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	12.35	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.72	11.72	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	12.07	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.41	11.41	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	11.72	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.91	10.91	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	11.41	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.36	10.36	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	10.91	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.74	9.74	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	10.36	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.60	9.60	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	9.74	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.50**	**9.50**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	*0.5*	**0.09**	**0.10**	**9.60**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.67	13.67	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	13.78	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.97	12.97	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	13.06	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.57	11.57	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	11.64	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.41	11.41	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	11.57	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.88	12.88	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.88	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.83	12.83	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	12.88	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.74	12.74	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	12.83	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.58	12.58	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	12.74	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.35	12.35	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	12.58	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.74	12.74	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	12.81	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.53	12.53	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.54	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.52	12.52	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.53	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.47	12.47	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	12.52	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.41	12.41	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	12.47	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.36	12.36	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	12.41	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.13	12.13	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	12.36	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.57	11.57	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	12.13	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.91	10.91	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	11.57	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.52	12.52	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.53	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.36	12.36	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	12.46	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.02	10.02	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.06	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.60	9.60	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	10.02	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.02	10.02	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	10.10	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.74	9.74	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	10.19	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.41	10.41	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.41	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.39	10.39	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	10.41	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.36	10.36	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	10.39	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.26	11.26	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	11.90	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.80	10.80	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	11.26	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.36	10.36	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	10.80	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.90	11.90	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.90	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.09	13.09	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.09	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.98	12.98	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	*1.3*	1.0	0.02	0.11	13.09	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.80	12.80	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	*1.3*	1.0	0.06	0.18	12.98	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.65	12.65	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	*0.5*	0.10	0.15	12.80	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.44	12.44	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	12.65	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.17	12.17	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	12.44	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.80	12.80	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	*0.5*	0.02	0.07	12.87	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.11	13.11	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	13.16	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.04	13.04	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	*1.3*	1.0	0.03	0.06	13.11	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.89	12.89	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	*1.3*	1.0	0.06	0.16	13.04	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.66	12.66	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	*0.5*	0.06	0.23	12.89	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.42	12.42	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	*1.3*	1.0	0.17	0.24	12.66	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.17	12.17	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	12.42	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.90	11.90	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	*0.5*	0.16	0.28	12.17	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.49	12.49	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.49	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.42	12.42	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	*0.5*	0.05	0.07	12.49	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.89	12.89	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.03	12.91	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.49	12.49	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.03	12.52	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.68	13.68	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	13.90	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.48	13.48	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	*1.3*	1.0	0.16	0.20	13.68	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.38	13.38	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	*0.5*	0.04	0.10	13.48	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.73	12.73	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	*0.5*	0.08	0.66	13.38	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.90	11.90	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	*0.5*	0.19	0.83	12.73	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.48	13.48	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.50	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.38	13.38	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.01	0.05	13.43	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.38	13.38	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.06	13.45	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.73	12.73	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.73	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.73	12.73	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.73	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	14.97	14.97	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	15.14	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.87	14.87	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	14.97	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	14.70	14.70	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	14.87	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.49	14.49	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	14.70	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	14.27	14.27	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	14.49	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	14.06	14.06	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	14.27	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.65	13.65	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	14.06	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	13.37	13.37	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	13.65	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	13.02	13.02	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	13.37	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.71	12.71	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	13.02	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.21	12.21	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	12.71	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.66	11.66	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	12.21	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.04	11.04	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	11.66	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.90	10.90	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	11.04	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.80**	**10.80**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**10.90**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.97	14.97	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	15.08	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	14.27	14.27	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	14.36	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.87	12.87	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.94	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.71	12.71	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	12.87	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	14.18	14.18	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.18	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	14.13	14.13	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	14.18	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.04	14.04	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	14.13	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.88	13.88	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	14.04	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.65	13.65	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	13.88	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.04	14.04	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	14.11	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.83	13.83	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.84	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.82	13.82	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.83	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.77	13.77	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	13.82	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.71	13.71	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	13.77	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.66	13.66	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	13.71	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	13.43	13.43	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	13.66	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.87	12.87	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	13.43	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.21	12.21	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	12.87	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.82	13.82	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.83	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.66	13.66	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	13.76	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.32	11.32	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	11.36	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.90	10.90	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	11.32	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.32	11.32	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	11.40	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.04	11.04	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	11.49	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.71	11.71	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.71	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.69	11.69	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	11.71	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.66	11.66	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	11.69	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.56	12.56	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	13.20	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.10	12.10	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	12.56	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.66	11.66	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	12.10	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.20	13.20	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.20	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.39	14.39	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.39	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	14.28	14.28	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	14.39	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	14.10	14.10	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	14.28	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.95	13.95	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	14.10	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.74	13.74	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	13.95	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.47	13.47	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	13.74	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	14.10	14.10	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	14.17	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.41	14.41	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	14.46	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.34	14.34	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	14.41	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	14.19	14.19	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	14.34	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.96	13.96	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	8.3	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	14.19	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.72	13.72	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	13.96	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.47	13.47	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	13.72	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.20	13.20	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	13.47	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.79	13.79	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.79	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.72	13.72	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	13.79	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	14.19	14.19	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	14.21	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.79	13.79	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.82	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.98	14.98	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	15.20	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.78	14.78	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	14.98	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	14.68	14.68	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	14.78	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.03	14.03	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	14.68	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.20	13.20	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	14.03	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.78	14.78	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.80	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	14.68	14.68	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	14.73	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	14.68	14.68	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	14.75	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.03	14.03	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.03	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.03	14.03	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.03	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add $Hc = 0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	9.91	9.91	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	10.08	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	9.81	9.81	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	9.91	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.64	9.64	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	9.81	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.43	9.43	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	9.64	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.21	9.21	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	9.43	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.00	9.00	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	9.21	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.59	8.59	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	9.00	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.31	8.31	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	8.59	9.84	HGL ok
P-61	MH-61	DI-62	2.40	7.96	7.96	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	8.31	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.65	7.65	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	7.96	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.15	7.15	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	7.65	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.60	6.60	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	7.15	10.08	HGL ok
P-85	DI-85	MH-86	4.00	5.98	5.98	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	6.60	9.98	HGL ok
P-86	MH-86	MH-87	4.00	5.84	5.84	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	5.98	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.74**	**5.74**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**5.84**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	9.91	9.91	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	10.02	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.21	9.21	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	9.30	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	7.81	7.81	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	7.88	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.65	7.65	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	7.81	10.14	HGL ok
P-51	DI-51	DI-52	1.00	9.12	9.12	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.12	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.07	9.07	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	9.12	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	8.98	8.98	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	9.07	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	8.82	8.82	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	8.98	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.59	8.59	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	8.82	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	8.98	8.98	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	9.05	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	8.77	8.77	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.78	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.76	8.76	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	8.77	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.71	8.71	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	8.76	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.65	8.65	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	8.71	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.60	8.60	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	8.65	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.37	8.37	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	8.60	11.24	HGL ok
P-75	DI-75	DI-76	1.20	7.81	7.81	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	8.37	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.15	7.15	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	7.81	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.76	8.76	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.77	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.60	8.60	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	8.70	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.26	6.26	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	6.30	9.20	HGL ok
P-91	DI-91	MH-87	1.20	5.84	5.84	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	6.26	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.26	6.26	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	6.34	10.00	HGL ok
P-95	TD-04	MH-86	0.80	5.98	8.00	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	8.45	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.65	6.65	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.65	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.63	6.63	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	6.65	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.60	6.60	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	6.63	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.50	7.50	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	8.14	11.72	HGL ok
P-36	DI-36	DI-37	2.40	7.04	7.04	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	7.50	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.60	6.60	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	7.04	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.14	8.14	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.14	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.33	9.33	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.33	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.22	9.22	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	9.33	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.04	9.04	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	9.22	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	8.89	8.89	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	9.04	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.68	8.68	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	8.89	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.41	8.41	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	8.68	9.77	HGL ok
P-18	B7 South	MH-14	1.20	9.04	9.04	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.11	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.35	9.35	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	9.40	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.28	9.28	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	9.35	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.13	9.13	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	9.28	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	8.90	8.90	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	9.13	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.66	8.66	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	8.90	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.41	8.41	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	8.66	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.14	8.14	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	8.41	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.73	8.73	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.73	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.66	8.66	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	8.73	10.19	HGL ok
P-09	B9/J	MH-04	1.20	9.13	9.13	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.15	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	8.73	8.73	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.76	10.00	HGL ok
P-20	TD-05	DI-21	0.53	9.92	9.92	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	10.14	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	9.72	9.72	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	9.92	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.62	9.62	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	9.72	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	8.97	8.97	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	9.62	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.14	8.14	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	8.97	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.72	9.72	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.74	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.62	9.62	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	9.67	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.62	9.62	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	9.69	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	8.97	8.97	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.97	10.95	HGL ok
P-29	DI-29	MH-24	1.20	8.97	8.97	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.97	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	10.11	10.11	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	10.28	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	10.01	10.01	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	10.11	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	9.84	9.84	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	10.01	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	9.63	9.63	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	9.84	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	9.41	9.41	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	9.63	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	9.20	9.20	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	9.41	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	8.79	8.79	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	9.20	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	8.51	8.51	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	8.79	9.84	HGL ok
P-61	MH-61	DI-62	2.40	8.16	8.16	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	8.51	11.03	HGL ok
P-62	DI-62	DI-63	2.40	7.85	7.85	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	8.16	10.34	HGL ok
P-63	DI-63	DI-77	1.93	7.35	7.35	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	7.85	10.08	HGL ok
P-77	DI-77	DI-85	3.20	6.80	6.80	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	7.35	10.08	HGL ok
P-85	DI-85	MH-86	4.00	6.18	6.18	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	6.80	9.98	HGL ok
P-86	MH-86	MH-87	4.00	6.04	6.04	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	6.18	10.50	HGL ok
P-87	**MH-87**	**OUTFALL**	**4.00**	**5.94**	**5.94**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**6.04**	**10.50**	**HGL ok**
P-48	MSS MH-08	MH-49	1.60	10.11	10.11	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	10.22	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	9.41	9.41	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	9.50	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	8.01	8.01	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	8.08	10.00	HGL ok
P-64	MH-64	DI-63	1.20	7.85	7.85	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	8.01	10.14	HGL ok
P-51	DI-51	DI-52	1.00	9.32	9.32	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.32	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	9.27	9.27	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	9.32	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	9.18	9.18	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	9.27	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	9.02	9.02	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	9.18	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	8.79	8.79	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	9.02	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	9.18	9.18	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	9.25	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	8.97	8.97	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.98	11.60	HGL ok
P-79	DI-79	DI-71	1.20	8.96	8.96	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	8.97	11.15	HGL ok
P-71	DI-71	DI-72	1.20	8.91	8.91	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	8.96	11.15	HGL ok
P-72	DI-72	DI-73	1.20	8.85	8.85	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	8.91	10.99	HGL ok
P-73	DI-73	MH-74	1.20	8.80	8.80	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	8.85	10.84	HGL ok
P-74	MH-74	DI-75	1.20	8.57	8.57	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	8.80	11.24	HGL ok
P-75	DI-75	DI-76	1.20	8.01	8.01	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	8.57	10.63	HGL ok
P-76	DI-76	DI-77	1.20	7.35	7.35	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	8.01	10.34	HGL ok
P-70	DI-70	DI-71	1.00	8.96	8.96	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	8.97	11.60	HGL ok
P-80	DI-80	MH-74	1.20	8.80	8.80	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	8.90	11.00	HGL ok
P-90	DI-90	DI-91	1.00	6.46	6.46	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	6.50	9.20	HGL ok
P-91	DI-91	MH-87	1.20	6.04	6.04	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	6.46	8.33	HGL ok
P-92	B6 North	DI-91	1.20	6.46	6.46	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	6.54	10.00	HGL ok
P-95	TD-04	MH-86	0.80	6.18	8.00	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	8.45	10.50	HGL ok
P-38	DI-38	DI-39	1.00	6.85	6.85	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	6.85	10.67	HGL ok
P-39	DI-39	DI-40	1.00	6.83	6.83	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	6.85	10.16	HGL ok
P-40	DI-40	DI-85	1.20	6.80	6.80	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	6.83	9.98	HGL ok
P-35	MH-35	DI-36	2.40	7.70	7.70	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	8.34	11.72	HGL ok
P-36	DI-36	DI-37	2.40	7.24	7.24	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	7.70	10.67	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth: (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	6.80	6.80	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	7.24	10.16	HGL ok
P-30	DI-30	MH-35	1.20	8.34	8.34	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.34	11.24	HGL ok
P-11	DI-11	DI-12	1.00	9.53	9.53	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	9.53	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	9.42	9.42	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	9.53	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	9.24	9.24	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	9.42	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	9.09	9.09	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	9.24	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	8.88	8.88	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	9.09	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	8.61	8.61	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	8.88	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	9.24	9.24	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	9.31	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	9.55	9.55	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	9.60	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	9.48	9.48	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	9.55	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	9.33	9.33	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	9.48	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	9.10	9.10	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	9.33	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	8.86	8.86	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	9.10	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	8.61	8.61	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	8.86	9.87	HGL ok
P-17	MH-17	MH-35	1.60	8.34	8.34	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	8.61	10.61	HGL ok
P-08	DI-08	MH-07	1.00	8.93	8.93	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	8.93	11.39	HGL ok
P-07	MH-07	DI-06	1.20	8.86	8.86	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	8.93	10.19	HGL ok
P-09	B9/J	MH-04	1.20	9.33	9.33	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	9.35	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	8.93	8.93	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	8.96	10.00	HGL ok
P-20	TD-05	DI-21	0.53	10.12	10.12	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	10.34	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	9.92	9.92	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	10.12	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	9.82	9.82	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	9.92	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	9.17	9.17	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	9.82	10.97	HGL ok
P-24	MH-24	MH-35	1.20	8.34	8.34	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	9.17	11.20	HGL ok
P-25	DI-25	MH-22	1.00	9.92	9.92	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	9.94	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	9.82	9.82	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	9.87	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	9.82	9.82	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	9.89	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	9.17	9.17	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.17	10.95	HGL ok
P-29	DI-29	MH-24	1.20	9.17	9.17	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	9.17	10.95	HGL ok

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	13.61	13.61	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	13.78	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	13.51	13.51	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	13.61	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.34	13.34	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	13.51	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.13	13.13	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	13.34	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	12.91	12.91	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	13.13	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	12.70	12.70	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	12.91	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.29	12.29	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	12.70	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.01	12.01	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	12.29	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	11.66	11.66	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	12.01	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.35	11.35	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	11.66	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	10.85	10.85	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	11.35	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.30	10.30	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	10.85	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	9.68	9.68	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	10.30	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	9.54	9.54	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	9.68	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.44**	**9.44**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**9.54**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	13.61	13.61	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	13.72	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	12.91	12.91	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	13.00	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	11.51	11.51	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	11.58	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.35	11.35	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	11.51	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	12.82	12.82	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.82	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	12.77	12.77	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	12.82	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	12.68	12.68	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	12.77	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	12.52	12.52	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	12.68	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.29	12.29	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	12.52	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	12.68	12.68	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	12.75	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.47	12.47	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.48	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.46	12.46	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.47	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.41	12.41	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	12.46	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.35	12.35	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	12.41	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.30	12.30	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	12.35	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.07	12.07	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	12.30	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	11.51	11.51	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	12.07	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	10.85	10.85	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	11.51	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.46	12.46	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.47	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.30	12.30	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	12.40	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	9.96	9.96	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.00	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	9.54	9.54	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	9.96	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	9.96	9.96	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	10.04	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	9.68	9.68	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	10.13	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.35	10.35	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.35	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.33	10.33	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	10.35	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.30	10.30	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	10.33	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.20	11.20	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	11.84	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	10.74	10.74	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	11.20	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.30	10.30	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	10.74	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	11.84	11.84	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.84	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.03	13.03	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.03	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	12.92	12.92	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	13.03	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	12.74	12.74	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	12.92	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	12.59	12.59	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	12.74	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.38	12.38	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	12.59	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.11	12.11	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	12.38	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	12.74	12.74	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.81	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.05	13.05	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	13.10	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	12.98	12.98	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	13.05	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	12.83	12.83	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	12.98	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	12.60	12.60	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	12.83	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.36	12.36	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	12.60	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.11	12.11	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	12.36	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	11.84	11.84	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	12.11	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.43	12.43	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.43	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.36	12.36	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	12.43	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	12.83	12.83	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.85	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.43	12.43	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.46	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	13.62	13.62	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	13.84	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.42	13.42	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	13.62	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.32	13.32	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	13.42	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	12.67	12.67	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	13.32	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	11.84	11.84	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	12.67	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.42	13.42	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.44	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.32	13.32	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	13.37	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.32	13.32	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	13.39	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	12.67	12.67	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.67	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	12.67	12.67	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.67	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by:	TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\ adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	14.11	14.11	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	14.28	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.01	14.01	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	14.11	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	13.84	13.84	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	14.01	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	13.63	13.63	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	13.84	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.41	13.41	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	13.63	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.20	13.20	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	13.41	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	12.79	12.79	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	13.20	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.51	12.51	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	12.79	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.16	12.16	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	12.51	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	11.85	11.85	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	12.16	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.35	11.35	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	11.85	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	10.80	10.80	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	11.35	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.18	10.18	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	10.80	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.04	10.04	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	10.18	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**9.94**	**9.94**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	0.5	**0.09**	**0.10**	**10.04**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.11	14.11	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	14.22	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.41	13.41	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	13.50	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.01	12.01	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.08	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	11.85	11.85	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	12.01	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.32	13.32	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.32	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.27	13.27	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	13.32	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.18	13.18	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	13.27	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.02	13.02	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	13.18	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	12.79	12.79	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	13.02	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.18	13.18	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	13.25	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	12.97	12.97	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.98	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	12.96	12.96	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	12.97	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	12.91	12.91	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	12.96	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	12.85	12.85	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	12.91	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	12.80	12.80	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	12.85	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.57	12.57	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	12.80	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.01	12.01	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	12.57	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.35	11.35	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	12.01	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	12.96	12.96	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	12.97	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	12.80	12.80	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	12.90	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.46	10.46	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.50	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.04	10.04	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	10.46	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.46	10.46	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	10.54	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.18	10.18	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	10.63	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	10.85	10.85	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	10.85	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	10.83	10.83	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	10.85	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	10.80	10.80	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	10.83	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	11.70	11.70	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	12.34	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.24	11.24	36	35.9	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	11.70	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	10.80	10.80	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	11.24	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.34	12.34	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.34	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.53	13.53	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.53	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.42	13.42	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	13.53	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.24	13.24	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	13.42	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.09	13.09	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	13.24	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	12.88	12.88	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	13.09	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	12.61	12.61	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	12.88	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.24	13.24	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	13.31	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.55	13.55	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	13.60	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.48	13.48	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	13.55	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.33	13.33	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	13.48	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.10	13.10	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	13.33	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	12.86	12.86	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	13.10	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	12.61	12.61	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	12.86	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.34	12.34	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	12.61	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	12.93	12.93	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.93	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	12.86	12.86	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	12.93	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.33	13.33	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.35	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	12.93	12.93	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	12.96	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.12	14.12	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	14.34	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	13.92	13.92	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	14.12	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	13.82	13.82	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	13.92	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.17	13.17	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	13.82	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.34	12.34	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	13.17	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	13.92	13.92	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	13.94	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	13.82	13.82	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	13.87	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	13.82	13.82	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	13.89	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.17	13.17	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.17	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.17	13.17	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.17	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23
County:	New Castle	Checked by:	TMC	Date:	3/23/23
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)	

Sheet No.: 2 of 5
Cm. No.: 20077

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvature (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t = H_o + H_i + H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\ adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\ adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	14.51	14.51	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	14.68	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.41	14.41	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	14.51	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	14.24	14.24	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	14.41	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.03	14.03	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	14.24	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	13.81	13.81	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	14.03	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	13.60	13.60	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	13.81	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.19	13.19	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	13.60	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	12.91	12.91	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	13.19	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	12.56	12.56	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	12.91	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.25	12.25	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	12.56	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	11.75	11.75	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	12.25	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.20	11.20	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	11.75	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	10.58	10.58	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	11.20	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.44	10.44	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	10.58	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.34**	**10.34**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**10.44**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	14.51	14.51	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	14.62	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	13.81	13.81	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	13.90	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.41	12.41	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.48	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.25	12.25	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	12.41	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	13.72	13.72	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.72	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	13.67	13.67	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	13.72	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	13.58	13.58	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	13.67	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.42	13.42	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	13.58	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.19	13.19	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	13.42	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	13.58	13.58	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	13.65	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.37	13.37	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.38	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.36	13.36	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.37	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.31	13.31	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	13.36	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.25	13.25	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	13.31	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.20	13.20	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	13.25	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	12.97	12.97	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	13.20	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.41	12.41	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	12.97	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	11.75	11.75	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	12.41	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.36	13.36	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.37	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.20	13.20	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	13.30	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	10.86	10.86	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	10.90	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.44	10.44	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	10.86	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	10.86	10.86	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	10.94	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	10.58	10.58	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	11.03	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.25	11.25	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.25	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.23	11.23	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	11.25	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.20	11.20	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	11.23	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.10	12.10	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	12.74	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	11.64	11.64	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	12.10	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23
Sheet No.: 2 of 5
Cm. No.: 20077

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.20	11.20	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	11.64	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	12.74	12.74	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.74	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	13.93	13.93	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.93	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	13.82	13.82	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	13.93	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	13.64	13.64	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	13.82	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.49	13.49	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	13.64	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.28	13.28	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	13.49	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.01	13.01	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	13.28	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	13.64	13.64	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	13.71	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	13.95	13.95	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	14.00	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	13.88	13.88	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	13.95	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	13.73	13.73	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	13.88	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	13.50	13.50	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	13.73	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.26	13.26	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	13.50	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.01	13.01	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	13.26	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	12.74	12.74	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	13.01	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.33	13.33	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.33	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.26	13.26	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	13.33	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	13.73	13.73	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.75	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.33	13.33	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.36	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	14.52	14.52	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	14.74	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.32	14.32	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	14.52	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	14.22	14.22	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	14.32	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	13.57	13.57	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	14.22	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	12.74	12.74	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	13.57	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.32	14.32	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.34	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	14.22	14.22	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	14.27	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	14.22	14.22	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	14.29	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	13.57	13.57	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.57	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	13.57	13.57	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.57	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR | Date: 2/23/23 | Sheet No.: 2 of 5
Checked by: TMC | Date: 3/23/23 | Cm. No.: 20077
Design Freq.: 200 -year (50-year for sumps)

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D (0.8D, ft)	Tailwater, link to Inlet WSE of downstream pipe (TW, ft)	Outlet W. S. Elevation (HGL Dn, ft)	Outflow Pipe Diameter (D_o, in)	Outflow Pipe Design Flow (Q_o, cfs)	Pressure-flow Vel., $V_o=Q_o/A$ (V_o, fps)	Skew angle vs. (Δ_o, deg)	Outflow Pipe Length (L, ft)	Friction Slope (S_{fo}, ft/ft)	Friction Loss (H_f, ft)	Angle of Curvatu (O, deg)	Curved align; add Hc = $0.002*O*V_o^2/2g$ (H_c, ft)	Contraction Loss (H_o, ft)	Q*V for determining controlling inflow pipe (Q1V1, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q2V2, ft^4/s^2)	Q*V for determining controlling inflow pipe (Q3V3, ft^4/s^2)	Controlling Inflow Velocity (Vi)	Expansion Loss (Hi, ft)	Controlling In-flow skew (Δ_i, deg)	Bend Loss (H_Δ, ft)	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ (H_t, cfs)	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss ($H_{t\,adj}$, ft)	Tot. H Loss, $H = H_f + H_{t\,adj}$ (H, ft)	Inlet W. S. Elevation (HGL Up, ft)	Top of Grate (T/G, ft)	HGL Check
P-41	MH-41	MH-42	1.60	15.01	15.01	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	15.18	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	14.91	14.91	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	15.01	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	14.74	14.74	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	14.91	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	14.53	14.53	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	14.74	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	14.31	14.31	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	14.53	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	14.10	14.10	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	14.31	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	13.69	13.69	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	14.10	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	13.41	13.41	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	13.69	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	13.06	13.06	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	13.41	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	12.75	12.75	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	13.06	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.25	12.25	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	12.75	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	11.70	11.70	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	12.25	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.08	11.08	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	11.70	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	10.94	10.94	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	11.08	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**10.84**	**10.84**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**10.94**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	15.01	15.01	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	15.12	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	14.31	14.31	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	14.40	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	12.91	12.91	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	12.98	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	12.75	12.75	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	12.91	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	14.22	14.22	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.22	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	14.17	14.17	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	14.22	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.08	14.08	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	14.17	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	13.92	13.92	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	14.08	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	13.69	13.69	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	13.92	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.08	14.08	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	14.15	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	13.87	13.87	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.88	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	13.86	13.86	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	13.87	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	13.81	13.81	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	13.86	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	13.75	13.75	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	13.81	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	13.70	13.70	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	13.75	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	13.47	13.47	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	13.70	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	12.91	12.91	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	13.47	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.25	12.25	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	12.91	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	13.86	13.86	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	13.87	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	13.70	13.70	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	13.80	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	11.36	11.36	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	11.40	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	10.94	10.94	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	11.36	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	11.36	11.36	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	11.44	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.08	11.08	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	11.53	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	11.75	11.75	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	11.75	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	11.73	11.73	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	11.75	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	11.70	11.70	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	11.73	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	12.60	12.60	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	13.24	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.14	12.14	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	12.60	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	11.70	11.70	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	12.14	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.24	13.24	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.24	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	14.43	14.43	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.43	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	14.32	14.32	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	14.43	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	14.14	14.14	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	14.32	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	13.99	13.99	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	14.14	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	13.78	13.78	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	13.99	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	13.51	13.51	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	13.78	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	14.14	14.14	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	14.21	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	14.45	14.45	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	14.50	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	14.38	14.38	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	14.45	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	14.23	14.23	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	14.38	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	14.00	14.00	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	0.0	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	14.23	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	13.76	13.76	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	14.00	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	13.51	13.51	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	13.76	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.24	13.24	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	13.51	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	13.83	13.83	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.83	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	13.76	13.76	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	13.83	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	14.23	14.23	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	14.25	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	13.83	13.83	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	13.86	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	15.02	15.02	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	15.24	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	14.82	14.82	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	15.02	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	14.72	14.72	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	14.82	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.07	14.07	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	14.72	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.24	13.24	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	14.07	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	14.82	14.82	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	14.84	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	14.72	14.72	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	14.77	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	14.72	14.72	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	14.79	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.07	14.07	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.07	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.07	14.07	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.07	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by: SNR	Date: 2/23/23	Sheet No.: 2 of 5
County:	New Castle	Checked by: TMC	Date: 3/23/23	Cm. No.: 20077
Segment:	Central Green Outfall	Design Freq.: 200	-year (50-year for sumps)	

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to Inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_f + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-41	MH-41	MH-42	1.60	15.71	15.71	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	15.88	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	15.61	15.61	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	15.71	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	15.44	15.44	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	15.61	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	15.23	15.23	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	15.44	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	15.01	15.01	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	15.23	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	14.80	14.80	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	15.01	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	14.39	14.39	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	14.80	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	14.11	14.11	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	14.39	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	13.76	13.76	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	14.11	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	13.45	13.45	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	13.76	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	12.95	12.95	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	13.45	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.40	12.40	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	12.95	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	11.78	11.78	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	12.40	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	11.64	11.64	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	11.78	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**11.54**	**11.54**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	*0.5*	**0.09**	**0.10**	**11.64**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	15.71	15.71	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	15.82	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	15.01	15.01	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	15.10	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	13.61	13.61	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	13.68	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	13.45	13.45	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	13.61	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	14.92	14.92	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.92	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	14.87	14.87	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	14.92	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	14.78	14.78	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	14.87	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	14.62	14.62	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	14.78	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	14.39	14.39	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	14.62	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	14.78	14.78	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	14.85	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	14.57	14.57	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.58	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	14.56	14.56	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	14.57	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	14.51	14.51	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	14.56	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	14.45	14.45	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	14.51	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	14.40	14.40	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	14.45	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	14.17	14.17	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	14.40	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	13.61	13.61	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	14.17	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	12.95	12.95	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	13.61	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	14.56	14.56	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	14.57	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	14.40	14.40	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	14.50	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	12.06	12.06	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.10	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	11.64	11.64	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	12.06	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	12.06	12.06	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	12.14	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	11.78	11.78	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	12.23	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.45	12.45	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.45	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.43	12.43	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	12.45	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.40	12.40	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	12.43	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	13.30	13.30	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	13.94	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	12.84	12.84	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	13.30	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

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Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2 of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)			

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.40	12.40	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	12.84	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	13.94	13.94	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	13.94	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	15.13	15.13	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.13	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	15.02	15.02	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	15.13	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	14.84	14.84	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	15.02	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	14.69	14.69	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	14.84	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	14.48	14.48	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	14.69	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	14.21	14.21	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	14.48	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	14.84	14.84	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	14.91	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	15.15	15.15	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	15.20	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	15.08	15.08	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	15.15	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	14.93	14.93	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	15.08	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	14.70	14.70	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	8.3	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	14.93	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	14.46	14.46	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	14.70	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	14.21	14.21	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	14.46	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	13.94	13.94	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	14.21	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	14.53	14.53	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.53	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	14.46	14.46	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	14.53	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	14.93	14.93	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	14.95	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	14.53	14.53	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	14.56	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	15.72	15.72	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	15.94	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	15.52	15.52	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	15.72	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	15.42	15.42	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	15.52	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	14.77	14.77	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	15.42	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	13.94	13.94	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	14.77	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	15.52	15.52	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	15.54	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	15.42	15.42	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	15.47	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	15.42	15.42	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	15.49	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	14.77	14.77	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.77	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	14.77	14.77	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.77	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR Date: 2/23/23 Sheet No.: 2 of 5
Checked by: TMC Date: 3/23/23 Cm. No.: 20077
Design Freq.: 200 -year (50-year for sumps)

Location No.	From	To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add $Hc = 0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	16.21	16.21	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	16.38	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	16.11	16.11	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	16.21	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	15.94	15.94	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	16.11	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	15.73	15.73	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	15.94	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	15.51	15.51	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	15.73	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	15.30	15.30	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	15.51	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	14.89	14.89	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	15.30	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	14.61	14.61	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	14.89	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	14.26	14.26	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	14.61	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	13.95	13.95	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	14.26	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	13.45	13.45	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	13.95	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	12.90	12.90	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	13.45	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	12.28	12.28	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	12.90	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	12.14	12.14	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	12.28	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**12.04**	**12.04**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**12.14**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	16.21	16.21	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	16.32	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	15.51	15.51	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	15.60	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	14.11	14.11	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	14.18	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	13.95	13.95	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	14.11	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	15.42	15.42	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.42	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	15.37	15.37	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	15.42	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	15.28	15.28	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	15.37	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	15.12	15.12	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	15.28	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	14.89	14.89	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	15.12	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	15.28	15.28	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	15.35	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	15.07	15.07	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.08	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	15.06	15.06	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	15.07	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	15.01	15.01	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	15.06	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	14.95	14.95	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	15.01	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	14.90	14.90	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	14.95	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	14.67	14.67	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	14.90	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	14.11	14.11	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	14.67	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	13.45	13.45	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	14.11	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	15.06	15.06	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.07	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	14.90	14.90	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	15.00	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	12.56	12.56	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	12.60	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	12.14	12.14	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	12.56	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	12.56	12.56	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	12.64	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	12.28	12.28	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	12.73	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	12.95	12.95	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	12.95	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	12.93	12.93	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	12.95	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	12.90	12.90	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	12.93	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	13.80	13.80	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	14.44	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	13.34	13.34	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	13.80	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth, (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	12.90	12.90	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	13.34	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	14.44	14.44	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.44	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	15.63	15.63	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	15.63	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	15.52	15.52	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	*1.3*	1.0	0.02	0.11	15.63	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	15.34	15.34	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	*1.3*	1.0	0.06	0.18	15.52	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	15.19	15.19	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	*0.5*	0.10	0.15	15.34	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	14.98	14.98	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	15.19	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	14.71	14.71	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	14.98	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	15.34	15.34	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	*0.5*	0.02	0.07	15.41	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	15.65	15.65	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	15.70	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	15.58	15.58	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	*1.3*	1.0	0.03	0.06	15.65	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	15.43	15.43	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	*1.3*	1.0	0.06	0.16	15.58	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	15.20	15.20	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	8.3	0.0	2.6	0.0	14	0.02	0.12	1.0	*0.5*	0.06	0.23	15.43	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	14.96	14.96	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	*1.3*	1.0	0.17	0.24	15.20	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	14.71	14.71	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	14.96	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	14.44	14.44	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	*0.5*	0.16	0.28	14.71	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	15.03	15.03	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.03	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	14.96	14.96	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	*0.5*	0.05	0.07	15.03	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	15.43	15.43	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.03	15.45	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	15.03	15.03	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.03	15.06	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	16.22	16.22	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	16.44	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	16.02	16.02	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	*1.3*	1.0	0.16	0.20	16.22	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	15.92	15.92	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	*0.5*	0.04	0.10	16.02	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	15.27	15.27	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	*0.5*	0.08	0.66	15.92	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	14.44	14.44	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	*0.5*	0.19	0.83	15.27	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	16.02	16.02	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	16.04	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	15.92	15.92	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	*0.5*	0.01	0.05	15.97	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	15.92	15.92	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	*0.5*	0.01	0.06	15.99	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	15.27	15.27	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.27	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	15.27	15.27	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.27	10.95	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project: South Market Street Infrastructure Improvements
County: New Castle
Segment: Central Green Outfall

Prepared by: SNR
Checked by: TMC
Design Freq.: 200 -year (50-year for sumps)

Date: 2/23/23
Date: 3/23/23

Sheet No.: 2 of 5
Cm. No.: 20077

Location No.	Location From	Location To	Minimum Starting Depth, (dc+D)/2 or 0.8D 0.8D ft	Tailwater, link to Inlet WSE of downstream pipe TW ft	Outlet W. S. Elevation HGL Dn ft	Outflow Pipe Diameter D_o in	Outflow Pipe Design Flow Q_o cfs	Pressure-flow Vel., $V_o=Q_o/A$ V_o fps	Skew angle vs. Δ_o deg	Outflow Pipe Length L ft	Friction Slope S_{fo} ft/ft	Friction Loss H_f ft	Angle of Curvature O deg	Curved align; add Hc = $0.002*O*V_o^2/2g$ H_c ft	Contraction Loss H_o ft	Q*V for determining controlling inflow pipe Q1V1 ft^4/s^2	Q*V for determining controlling inflow pipe Q2V2 ft^4/s^2	Q*V for determining controlling inflow pipe Q3V3 ft^4/s^2	Controlling Inflow Velocity Vi	Expansion Loss Hi ft	Controlling In-flow skew Δ_i deg	Bend Loss H_Δ ft	Total Jct. Loss, $H_t= H_o +H_i +H_\Delta$ H_t cfs	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss $H_{t\ adj}$ ft	Tot. H Loss, $H = H_f + H_{t\ adj}$ H ft	Inlet W. S. Elevation HGL Up ft	Top of Grate T/G ft	HGL Check
P-41	MH-41	MH-42	1.60	17.51	17.51	24	8.1	2.6	69	92	0.0011	0.10	0	0.00	0.03	21.3	0.0	0.0	2.6	0.0	90	0.07	0.14	1.0	0.5	0.07	0.17	17.68	7.00	HGL Too High!
P-42	MH-42	DI-43	2.00	17.41	17.41	30	15.7	3.2	13	30	0.0013	0.04	0	0.00	0.04	21.1	20.8	0.0	2.6	0.0	69	0.06	0.14	1.0	0.5	0.07	0.11	17.51	7.86	HGL Too High!
P-43	DI-43	DI-44	2.00	17.24	17.24	30	16.4	3.3	0	25	0.0014	0.03	0	0.00	0.04	50.5	0.0	0.0	3.2	0.1	13	0.03	0.13	1.0	1.0	0.13	0.16	17.41	7.11	HGL Too High!
P-44	DI-44	DI-45	2.00	17.03	17.03	30	17.2	3.5	6	69	0.0015	0.10	0	0.00	0.05	54.6	0.0	0.0	3.3	0.1	0	0.00	0.11	1.0	1.0	0.11	0.21	17.24	7.03	HGL Too High!
P-45	DI-45	MH-46	2.00	16.81	16.81	30	17.8	3.6	13	52	0.0016	0.08	0	0.00	0.05	60.0	0.0	0.0	3.5	0.1	6	0.02	0.14	1.0	1.0	0.14	0.22	17.03	7.59	HGL Too High!
P-46	MH-46	DI-47	2.00	16.60	16.60	30	22.9	4.7	83	42	0.0027	0.11	0	0.00	0.08	64.7	20.0	0.0	3.6	0.1	13	0.04	0.19	1.0	0.5	0.10	0.21	16.81	8.54	HGL Too High!
P-47	DI-47	MH-60	2.40	16.19	16.19	36	23.6	3.3	90	23	0.0011	0.02	0	0.00	0.04	106.6	0.0	0.0	4.7	0.1	83	0.23	0.39	1.0	1.0	0.39	0.41	16.60	9.09	HGL Too High!
P-60	MH-60	MH-61	2.40	15.91	15.91	36	32.1	4.5	82	75	0.0020	0.15	0	0.00	0.08	78.5	28.2	0.0	3.3	0.1	90	0.12	0.26	1.0	0.5	0.13	0.28	16.19	9.84	HGL Too High!
P-61	MH-61	DI-62	2.40	15.56	15.56	36	31.8	4.5	7	76	0.0019	0.15	0	0.00	0.08	146.0	0.0	0.0	4.5	0.1	82	0.21	0.40	1.0	0.5	0.20	0.35	15.91	11.03	HGL Too High!
P-62	DI-62	DI-63	2.40	15.25	15.25	36	31.7	4.5	89	50	0.0019	0.10	0	0.00	0.08	143.1	0.0	0.0	4.5	0.1	7	0.03	0.22	1.0	1.0	0.22	0.32	15.56	10.34	HGL Too High!
P-63	DI-63	DI-77	1.93	14.75	14.75	36	37.0	5.2	92	25	0.0026	0.07	0	0.00	0.11	142.4	20.1	0.0	4.5	0.1	89	0.22	0.43	1.0	1.0	0.43	0.50	15.25	10.08	HGL Too High!
P-77	DI-77	DI-85	3.20	14.20	14.20	48	45.6	3.6	91	50	0.0009	0.04	0	0.00	0.05	193.7	51.5	0.0	5.2	0.1	92	0.30	0.50	1.0	1.0	0.50	0.54	14.75	10.08	HGL Too High!
P-85	DI-85	MH-86	4.00	13.58	13.58	60	80.2	4.1	17	186	0.0008	0.15	0	0.00	0.06	165.4	2.0	176.6	5.0	0.1	90	0.27	0.47	1.0	1.0	0.47	0.62	14.20	9.98	HGL Too High!
P-86	MH-86	MH-87	4.00	13.44	13.44	60	83.5	4.3	0	45	0.0009	0.04	0	0.00	0.07	327.4	46.6	0.0	4.1	0.1	17	0.05	0.21	1.0	0.5	0.11	0.14	13.58	10.50	HGL Too High!
P-87	**MH-87**	**OUTFALL**	**4.00**	**13.34**	**13.34**	**60**	**88.7**	**4.5**	**0**	**9**	**0.0010**	**0.01**	**0**	**0.00**	**0.08**	**355.4**	**24.1**	**0.0**	**4.3**	**0.1**	**0**	**0.00**	**0.18**	**1.0**	**0.5**	**0.09**	**0.10**	**13.44**	**10.50**	**HGL Too High!**
P-48	MSS MH-08	MH-49	1.60	17.51	17.51	24	8.1	2.6	51.7	64	0.0011	0.07	0	0.00	0.03	13.1	2.8	0.0	2.0	0.0	51	0.03	0.08	1.0	0.5	0.04	0.11	17.62	8.07	HGL Too High!
P-50	B7 North	1.00	1.20	16.81	16.81	18	6.0	3.4	83	16	0.0027	0.04	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.09	16.90	10.00	HGL Too High!
P-65	B7 West	MH-64	1.20	15.41	15.41	18	6.0	3.4	75	17	0.0028	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	15.48	10.00	HGL Too High!
P-64	MH-64	DI-63	1.20	15.25	15.25	18	6.0	3.4	74	20	0.0027	0.05	0	0.00	0.04	20.3	0.0	0.0	3.4	0.1	75	0.11	0.22	1.0	0.5	0.11	0.17	15.41	10.14	HGL Too High!
P-51	DI-51	DI-52	1.00	16.72	16.72	15	0.6	0.5	1	26	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.72	7.11	HGL Too High!
P-52	DI-52	DI-53	1.00	16.67	16.67	15	1.5	1.2	7	69	0.0005	0.03	0	0.00	0.01	0.3	0.0	0.0	0.5	0.0	1	0.00	0.01	1.3	1.0	0.01	0.04	16.72	7.03	HGL Too High!
P-53	DI-53	MH-54	1.00	16.58	16.58	15	2.4	2.0	13	51	0.0012	0.06	0	0.00	0.02	1.9	0.0	0.0	1.2	0.0	7	0.00	0.03	1.3	1.0	0.03	0.09	16.67	7.59	HGL Too High!
P-54	MH-54	DI-55	1.60	16.42	16.42	24	8.4	2.7	83	41	0.0012	0.05	0	0.00	0.03	4.8	21.9	0.0	3.5	0.1	83	0.13	0.23	1.0	0.5	0.11	0.16	16.58	8.54	HGL Too High!
P-55	DI-55	MH-60	1.60	16.19	16.19	24	9.4	3.0	90	23	0.0015	0.03	0	0.00	0.03	22.6	0.0	0.0	2.7	0.0	83	0.08	0.15	1.3	1.0	0.19	0.23	16.42	9.09	HGL Too High!
P-56	B5 South	MH-54	1.20	16.58	16.58	18	6.2	3.5	83	17	0.0030	0.05	0	0.00	0.05	0.0	0.0	0.0	0.0	0.0	0	0.00	0.05	1.0	0.5	0.02	0.07	16.65	10.00	HGL Too High!
P-78	DI-78	DI-79	1.00	16.37	16.37	15	0.7	0.6	89	84	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.38	11.60	HGL Too High!
P-79	DI-79	DI-71	1.20	16.36	16.36	18	1.3	0.8	82	29	0.0001	0.00	0	0.00	0.00	0.4	0.0	0.0	0.6	0.0	89	0.00	0.01	1.3	1.0	0.01	0.01	16.37	11.15	HGL Too High!
P-71	DI-71	DI-72	1.20	16.31	16.31	18	2.8	1.6	2	42	0.0006	0.03	0	0.00	0.01	1.0	0.5	0.0	0.8	0.0	82	0.01	0.02	1.3	1.0	0.02	0.05	16.36	11.15	HGL Too High!
P-72	DI-72	DI-73	1.20	16.25	16.25	18	3.1	1.8	8	29	0.0008	0.02	0	0.00	0.01	4.4	0.0	0.0	1.6	0.0	2	0.00	0.03	1.3	1.0	0.03	0.06	16.31	10.99	HGL Too High!
P-73	DI-73	MH-74	1.20	16.20	16.20	18	3.3	1.9	8	17	0.0009	0.01	0	0.00	0.01	5.6	0.0	0.0	1.8	0.0	8	0.00	0.04	1.0	1.0	0.04	0.05	16.25	10.84	HGL Too High!
P-74	MH-74	DI-75	1.20	15.97	15.97	18	8.8	5.0	5	17	0.0060	0.10	0	0.00	0.10	6.3	18.3	0.0	3.2	0.1	82	0.11	0.26	1.0	0.5	0.13	0.23	16.20	11.24	HGL Too High!
P-75	DI-75	DI-76	1.20	15.41	15.41	18	9.2	5.2	9	43	0.0066	0.28	0	0.00	0.11	44.2	0.0	0.0	5.0	0.1	5	0.04	0.28	1.0	1.0	0.28	0.56	15.97	10.63	HGL Too High!
P-76	DI-76	DI-77	1.20	14.75	14.75	18	9.5	5.4	2	51	0.0070	0.36	0	0.00	0.11	48.1	0.0	0.0	5.2	0.1	9	0.04	0.30	1.0	1.0	0.30	0.66	15.41	10.34	HGL Too High!
P-70	DI-70	DI-71	1.00	16.36	16.36	15	0.8	0.6	7	86	0.0001	0.01	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.37	11.60	HGL Too High!
P-80	DI-80	MH-74	1.20	16.20	16.20	18	5.7	3.2	82	24	0.0025	0.06	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	1.0	0.04	0.10	16.30	11.00	HGL Too High!
P-90	DI-90	DI-91	1.00	13.86	13.86	15	1.4	1.1	0	79	0.0004	0.03	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.04	13.90	9.20	HGL Too High!
P-91	DI-91	MH-87	1.20	13.44	13.44	18	6.5	3.7	86	81	0.0033	0.27	0	0.00	0.05	1.6	7.5	0.0	2.1	0.0	90	0.05	0.12	1.3	1.0	0.16	0.43	13.86	8.33	HGL Too High!
P-92	B6 North	DI-91	1.20	13.86	13.86	18	3.6	2.1	90	63	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.07	13.94	10.00	HGL Too High!
P-95	TD-04	MH-86	0.80	13.58	13.58	12	6.0	7.7	90	16	0.0206	0.33	0	0.00	0.23	0.0	0.0	0.0	0.0	0.0	0	0.00	0.23	1.0	0.5	0.12	0.45	14.03	10.50	HGL Too High!
P-38	DI-38	DI-39	1.00	14.25	14.25	15	0.3	0.2	2	99	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	14.25	10.67	HGL Too High!
P-39	DI-39	DI-40	1.00	14.23	14.23	15	1.0	0.8	89	70	0.0002	0.01	0	0.00	0.00	0.1	0.0	0.0	0.2	0.0	2	0.00	0.00	1.3	1.0	0.00	0.02	14.25	10.16	HGL Too High!
P-40	DI-40	DI-85	1.20	14.20	14.20	18	1.9	1.1	0	26	0.0003	0.01	0	0.00	0.00	0.8	0.0	0.0	0.8	0.0	89	0.01	0.02	1.3	1.0	0.02	0.03	14.23	9.98	HGL Too High!
P-35	MH-35	DI-36	2.40	15.10	15.10	36	35.0	4.9	2	94	0.0023	0.22	0	0.00	0.09	0.0	77.4	83.8	6.9	0.3	78	0.49	0.84	1.0	0.5	0.42	0.64	15.74	11.72	HGL Too High!
P-36	DI-36	DI-37	2.40	14.64	14.64	36	35.0	4.9	3	98	0.0023	0.23	0	0.00	0.09	172.8	0.0	0.0	4.9	0.1	2	0.00	0.23	1.0	1.0	0.23	0.46	15.10	10.67	HGL Too High!

Delaware Department of Transportation
Hydraulic Grade Line Computations

RK&K

Project:	South Market Street Infrastructure Improvements	Prepared by:	SNR	Date:	2/23/23	Sheet No.:	2	of 5
County:	New Castle	Checked by:	TMC	Date:	3/23/23	Cm. No.:	20077	
Segment:	Central Green Outfall	Design Freq.:	200	-year (50-year for sumps)				

Location			Minimum Starting Depth; (dc+D)/2 or 0.8D	Tailwater, link to inlet WSE of downstream pipe	Outlet W. S. Elevation	Outflow Pipe Diameter	Outflow Pipe Design Flow	Pressure-flow Vel., $V_o=Q_o/A$	Skew angle vs.	Outflow Pipe Length	Friction Slope	Friction Loss	Angle of Curvature	Curved align; add Hc = $0.002*O*V_o^2/2g$	Contraction Loss	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Q*V for determining controlling inflow pipe	Controlling Inflow Velocity	Expansion Loss	Controlling In-flow skew	Bend Loss	Total Jct Loss, $H_t = H_o + H_i + H_\Delta$	Coefficient for inlet of >10% mainline Q	Coeff for MH or JB (1.0 for inlet, 0.5 for MH or JB shaping)	Adjusted Junction Loss	Tot. H Loss, $H = H_t + H_{t\,adj}$	Inlet W. S. Elevation	Top of Grate	HGL Check
No.	From	To	0.8D	TW	HGL Dn	D_o	Q_o	V_o	Δ_o	L	S_{fo}	H_f	O	H_c	H_o	Q1V1	Q2V2	Q3V3	Vi	Hi	Δ_i	H_Δ	H_t			$H_{t\,adj}$	H	HGL Up	T/G	
			ft	ft	ft	in	cfs	fps	deg	ft	ft/ft	ft	deg	ft	ft	ft^4/s^2	ft^4/s^2	ft^4/s^2		ft	deg	ft	cfs			ft	ft	ft	ft	
P-37	DI-37	DI-85	2.40	14.20	14.20	36	35.3	5.0	90	70	0.0024	0.17	0	0.00	0.10	172.8	0.0	0.0	4.9	0.1	3	0.04	0.27	1.0	1.0	0.27	0.44	14.64	10.16	HGL Too High!
P-30	DI-30	MH-35	1.20	15.74	15.74	18	0.3	0.1	4	47	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	15.74	11.24	HGL Too High!
P-11	DI-11	DI-12	1.00	16.93	16.93	15	1.0	0.8	5	20	0.0002	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.01	16.93	6.84	HGL Too High!
P-12	DI-12	DI-13	1.00	16.82	16.82	15	2.1	1.7	6	92	0.0009	0.09	0	0.00	0.01	0.8	0.0	0.0	0.8	0.0	5	0.00	0.02	1.3	1.0	0.02	0.11	16.93	6.99	HGL Too High!
P-13	DI-13	MH-14	1.00	16.64	16.64	15	3.2	2.6	14	54	0.0021	0.11	0	0.00	0.03	3.8	0.0	0.0	1.7	0.0	6	0.00	0.05	1.3	1.0	0.06	0.18	16.82	7.91	HGL Too High!
P-14	MH-14	DI-15	1.60	16.49	16.49	24	9.0	2.8	9	38	0.0013	0.05	0	0.00	0.03	8.5	19.9	0.0	3.4	0.1	82	0.12	0.21	1.0	0.5	0.10	0.15	16.64	8.68	HGL Too High!
P-15	DI-15	DI-16	1.60	16.28	16.28	24	9.8	3.1	91	73	0.0016	0.12	0	0.00	0.04	25.5	0.0	0.0	2.8	0.0	9	0.01	0.09	1.0	1.0	0.09	0.21	16.49	9.01	HGL Too High!
P-16	DI-16	MH-17	1.60	16.01	16.01	24	10.7	3.4	90	31	0.0019	0.06	0	0.00	0.04	30.5	0.0	0.0	3.1	0.1	91	0.11	0.20	1.0	1.0	0.20	0.26	16.28	9.77	HGL Too High!
P-18	B7 South	MH-14	1.20	16.64	16.64	18	5.9	3.4	82	17	0.0027	0.05	0	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0	0.00	0.04	1.0	0.5	0.02	0.07	16.71	10.00	HGL Too High!
P-01	DI-01	DI-02	1.00	16.95	16.95	15	1.6	1.3	4	77	0.0005	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.05	17.00	6.84	HGL Too High!
P-02	DI-02	DI-03	1.00	16.88	16.88	15	2.1	1.7	11	38	0.0009	0.03	0	0.00	0.01	2.2	0.0	0.0	1.3	0.0	4	0.00	0.02	1.3	1.0	0.03	0.06	16.95	7.35	HGL Too High!
P-03	DI-03	MH-04	1.00	16.73	16.73	15	3.2	2.6	14	46	0.0021	0.10	0	0.00	0.03	3.5	0.0	0.0	1.7	0.0	11	0.00	0.05	1.3	1.0	0.06	0.16	16.88	7.91	HGL Too High!
P-04	MH-04	DI-05	1.20	16.50	16.50	18	6.9	3.9	7	46	0.0037	0.17	0	0.00	0.06	8.3	8.3	0.0	2.6	0.0	14	0.02	0.12	1.0	0.5	0.06	0.23	16.73	8.60	HGL Too High!
P-05	DI-05	DI-06	1.60	16.26	16.26	24	7.7	2.5	90	73	0.0010	0.07	0	0.00	0.02	27.0	0.0	0.0	3.9	0.1	7	0.02	0.13	1.3	1.0	0.17	0.24	16.50	9.01	HGL Too High!
P-06	DI-06	MH-17	1.60	16.01	16.01	24	12.8	4.1	90	30	0.0027	0.08	0	0.00	0.06	18.9	10.7	0.0	2.5	0.0	90	0.07	0.16	1.0	1.0	0.16	0.24	16.26	9.87	HGL Too High!
P-17	MH-17	MH-35	1.60	15.74	15.74	36	23.4	3.3	102	115	0.0010	0.12	0	0.00	0.04	52.2	36.4	0.0	4.1	0.1	90	0.18	0.31	1.0	0.5	0.16	0.28	16.01	10.61	HGL Too High!
P-08	DI-08	MH-07	1.00	16.33	16.33	15	0.3	0.2	13	58	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.33	11.39	HGL Too High!
P-07	MH-07	DI-06	1.20	16.26	16.26	18	4.3	2.5	67	14	0.0015	0.02	0	0.00	0.02	0.1	9.3	0.0	2.3	0.0	67	0.05	0.10	1.0	0.5	0.05	0.07	16.33	10.19	HGL Too High!
P-09	B9/J	MH-04	1.20	16.73	16.73	18	3.8	2.2	83	17	0.0011	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	16.75	10.00	HGL Too High!
P-10	B9/J	MH-07	1.20	16.33	16.33	18	4.1	2.3	67	17	0.0013	0.02	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.03	16.36	10.00	HGL Too High!
P-20	TD-05	DI-21	0.53	17.52	17.52	8	1.0	2.9	47	39	0.0049	0.19	0	0.00	0.03	0.0	0.0	0.0	0.0	0.0	0	0.00	0.03	1.0	1.0	0.03	0.22	17.74	10.50	HGL Too High!
P-21	DI-21	MH-22	1.00	17.32	17.32	15	2.5	2.0	90	31	0.0013	0.04	0	0.00	0.02	2.9	0.0	0.0	2.9	0.0	47	0.06	0.12	1.3	1.0	0.16	0.20	17.52	9.46	HGL Too High!
P-22	MH-22	MH-23	1.20	17.22	17.22	18	4.1	2.3	0	42	0.0013	0.05	0	0.00	0.02	5.1	2.1	0.0	2.0	0.0	90	0.05	0.09	1.0	0.5	0.04	0.10	17.32	9.72	HGL Too High!
P-23	MH-23	MH-24	1.20	16.57	16.57	18	10.6	6.0	0	66	0.0087	0.57	0	0.00	0.14	9.4	5.2	7.4	2.3	0.0	0	0.00	0.17	1.0	0.5	0.08	0.66	17.22	10.97	HGL Too High!
P-24	MH-24	MH-35	1.20	15.74	15.74	18	12.2	6.9	78	56	0.0114	0.64	0	0.00	0.18	63.7	0.3	0.4	6.0	0.2	0	0.00	0.38	1.0	0.5	0.19	0.83	16.57	11.20	HGL Too High!
P-25	DI-25	MH-22	1.00	17.32	17.32	15	1.6	1.3	90	31	0.0005	0.02	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	1.0	0.01	0.02	17.34	9.46	HGL Too High!
P-26	B8/K	MH-23	1.20	17.22	17.22	18	3.0	1.7	90	56	0.0007	0.04	0	0.00	0.01	0.0	0.0	0.0	0.0	0.0	0	0.00	0.01	1.0	0.5	0.01	0.05	17.27	10.00	HGL Too High!
P-27	B6 South	MH-23	1.20	17.22	17.22	18	3.6	2.0	90	56	0.0010	0.06	0	0.00	0.02	0.0	0.0	0.0	0.0	0.0	0	0.00	0.02	1.0	0.5	0.01	0.06	17.29	10.00	HGL Too High!
P-28	DI-28	MH-24	1.20	16.57	16.57	18	0.8	0.4	90	34	0.0000	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.57	10.95	HGL Too High!
P-29	DI-29	MH-24	1.20	16.57	16.57	18	0.9	0.5	90	34	0.0001	0.00	0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0	0.00	0.00	1.0	1.0	0.00	0.00	16.57	10.95	HGL Too High!