Wilmington Riverfront Transportation Infrastructure Project

Draft Environmental Assessment
Appendix E: Air Quality Technical Report

March 29, 2024

SEAL OF THE CITY OF WILMINGTON DELAWARE

U.S. Department of Transportation
Federal Highway Administration

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List of Acronyms

AADT - Annual Average Daily Traffic

ADT - Average Daily Traffic

CAA - Clean Air Act

CAAA - Clean Air Act Amendments

CFR - Code of Federal Regulations

CH_4 - Methane

CO - Carbon Monoxide

CO_2 - Carbon Dioxide

CTP - Capital Transportation Program

DelDOT- Delaware Department of Transportation

EA - Environmental Assessment

EIS - Environmental Impact Statement

EO - Executive Order

EPA - Environmental Protection Agency

FHWA - Federal Highway Administration

GHG - Greenhouse Gas

HC - Hydrocarbons

HEI - Health Effects Institute

HFCs - Hydrofluorocarbons

IRIS - Integrated Risk Information System

LOS - Level of Service

MPO - Metropolitan Planning Organization

MSATs - Mobile Source Air Toxics

MOVES - Motor Vehicle Emissions Simulator

N_2O - Nitrous Oxide

NAAQS - National Ambient Air Quality Standards

NEPA - National Environmental Policy Act

NOx - Nitrogen Oxides

O_3 - Ozone

O_3 - Ozone

PM - Particulate Matter

PPM - Parts Per Million STIP – Statewide Transportation Improvement Plan

VPD – Vehicles Per Day

VMT - Vehicle Miles Traveled

VOCs - Volatile Organic Compounds

WILMAPCO - Wilmington Area Planning Council

I. Introduction

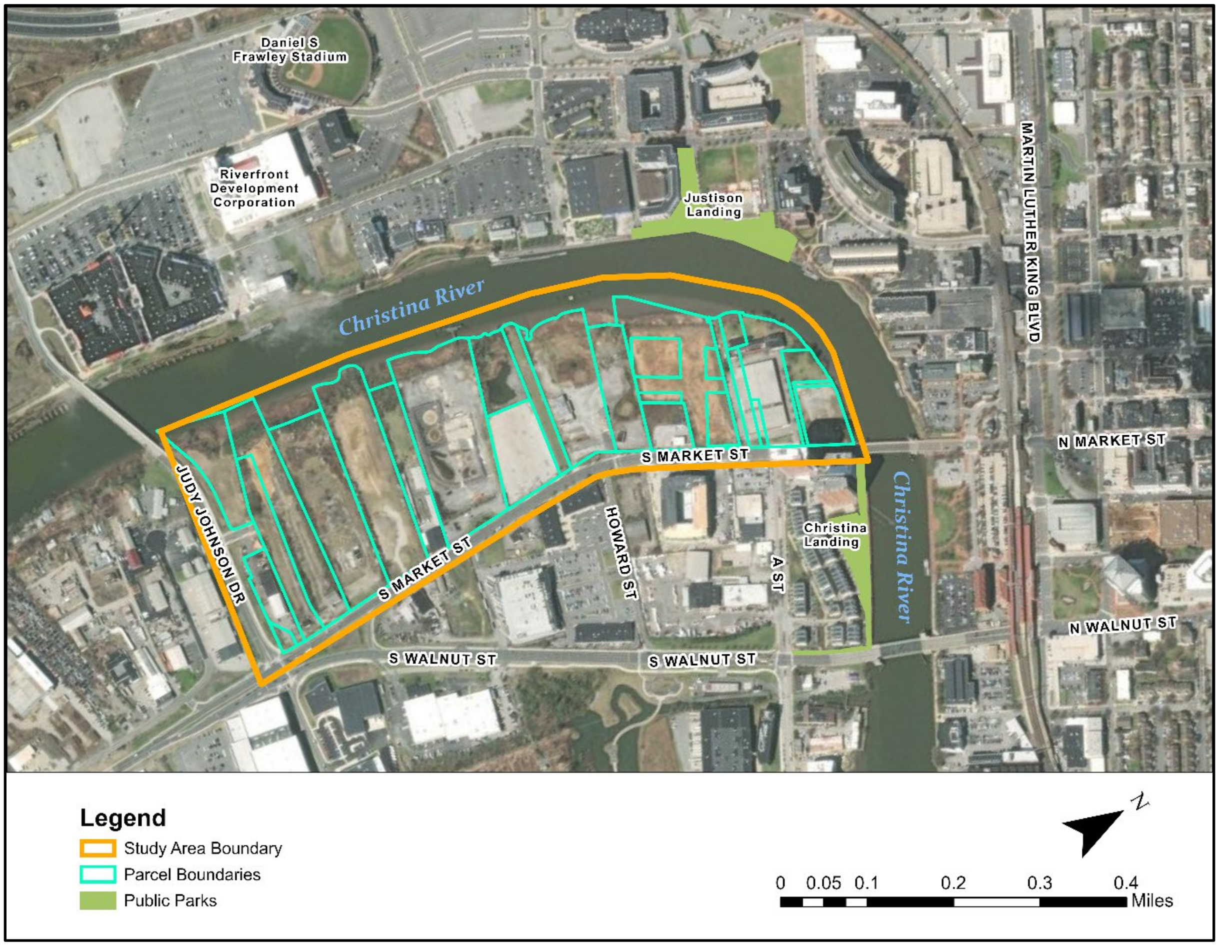
On November 19, 2021, the City of Wilmington, Delaware, was awarded federal funds though a U.S. Department of Transportation FY 2021 Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grant. The Federal Highway Administration (FHWA), as the lead Federal Agency; the City of Wilmington, as project sponsor and joint lead agency; and in partnership with the Riverfront Development Corporation (RDC), are preparing an Environmental Assessment (EA) for the Wilmington Riverfront Transportation Infrastructure Project (formerly known as the South Market Street Redevelopment Project) in accordance with the requirements of the National Environmental Policy Act of 1969 (NEPA), the Council on Environmental Quality (CEQ) regulations implementing NEPA, FHWA regulations implementing NEPA, and applicable Federal, state, and local laws and regulations.

The Air Quality Technical Report was developed to support the Draft EA for the Wilmington Riverfront Transportation Infrastructure Project (Project). The following technical report presents the existing conditions and an assessment of potential effects of the Build Alternatives to potential air quality impacts. The report begins with a description of the Project study area followed by a summary of the Purpose and Need, and a description of the alternatives evaluated.

A. Study Area

The Project is located along the east Christina riverbank in Wilmington, New Castle County, Delaware. The Project's study area is bound by the Christina River on the north and west and by South Market Street on the east and by Judy Johnson Drive (formerly New Sweden Street) in the south (**Figure 1**).

Figure 1: Wilmington Riverfront Transportation Infrastructure Project Study Area Map



The existing conditions of the Project study area include former industrial buildings and accessory structures, surface parking, former junkyards, miscellaneous uses, and brownfields. This area has been shaped by its history of shipping and manufacturing and was an active industrial area until its decline after World War II. The *Wilmington 2028: A Comprehensive Plan for Our City and Communities*[1] *(herein, City of Wilmington's Comprehensive Master Plan)* defines the land use in the Project study area as waterfront mixed use and the entire Project study area is within the 100-year floodplain caused by coastal storm surge from the Delaware Bay. The parcels located within the Project study area have limited access for vehicles, pedestrians, and bicycles.

The Christina riverbank on the western and northern boundary of the study area is marshy and largely inaccessible. Significant differences of elevation between the high and low tide conditions have created a mud flat condition along the northern and western edges of the site of the Project study area. South Market Street, the eastern project border, is a one-way, four-lane arterial road that extends 0.57 mile along the study area.

[1] https://www.wilmingtonde.gov/government/city-departments/planning-and-development/wilmington-2028

The purpose of the Project is to provide transportation infrastructure to further the connectivity of the riverfront area and provide multi-modal resources. The needs of the project are the following:

- An expanded road network branching from South Market Street west into the Project study area;
- Pedestrian and cyclist accommodation on new roadways and a new set of pedestrian and bicycle pathways that connect to the existing network of pathways surrounding the site along the Christina riverbank; and
- Rehabilitate and create effective stormwater management.

The proposed improvements would replicate the city grid characteristics of the North Market Street corridor, north of the Christina River and southward to the intersection of South Market Street and Judy Johnson Drive.

B. Alternatives Considered

The alternatives considered in the EA include a No Build and a Build Alternative and are briefly described below.

1. No Build Alternative

The No Build Alternative assumes the roadway infrastructure; Riverwalk; pedestrian, bicycle and mobility improvements; and flood prevention measures; and drainage work would not occur. The No Build Alternative does not meet the purpose and need for this Project, as it would not provide transportation infrastructure to further the connectivity or the area; provide multi-modal resources, including pedestrian and cyclist accommodations; nor rehabilitate or create effective stormwater management. However, the No Build Alternative does provide a baseline condition with which to compare to the Build Alternative. Therefore, the No Build Alternative is retained for evaluation purposes.

2. Build Alternative

The Build Alternative proposes to construct transportation infrastructure improvements for the South Market Street Riverfront East area of the City. The Build Alternative proposes an expanded road network branching from South Market Street towards the Christina River and replicating the downtown Wilmington grid system in the Project study area (**Figure 2**). Infrastructure improvements are proposed to create continuity of intersection type / spacing and provide key points of access into the Project study area.

The proposed street grid is a balance of defining buildable parcels as well as appropriate infrastructure access for vehicles (local, commuter, public transportation), pedestrians, and bicyclists and will include on street parking. The proposed grid considers major circulation movements, creating three east-west and evenly spaced signalized movements across South Market Street, and connecting the major north-south Market Street and Walnut Street corridors to Orange Street within the limits of the Project study area (from north to south: at A Street, Howard Street, and Jones Street).

Pedestrian routes were also considered while laying out the proposed grid. The Build Alternative proposes to include pedestrian and cyclist accommodations on new roadways and a new set of pedestrian and bicycle pathways that connect to the existing network of pathways surrounding the Project study area (shown in orange in **Figure 2**). The proposed location of the east-west movements at A Street and Howard Street provides direct pedestrian access to and from the South Market Street Bridge, the Walnut Street corridor, the Wilmington Wetland Park, and the Southbridge neighborhood located east of the proposed Project study area. At the south end of the Project study area, proposed pedestrian and bicycle connections from the proposed street grid connect directly to existing pedestrian and bicycle connections that currently cross the river to the western Riverfront via Judy Johnson Drive and the Senator Margaret Rose Henry Bridge.

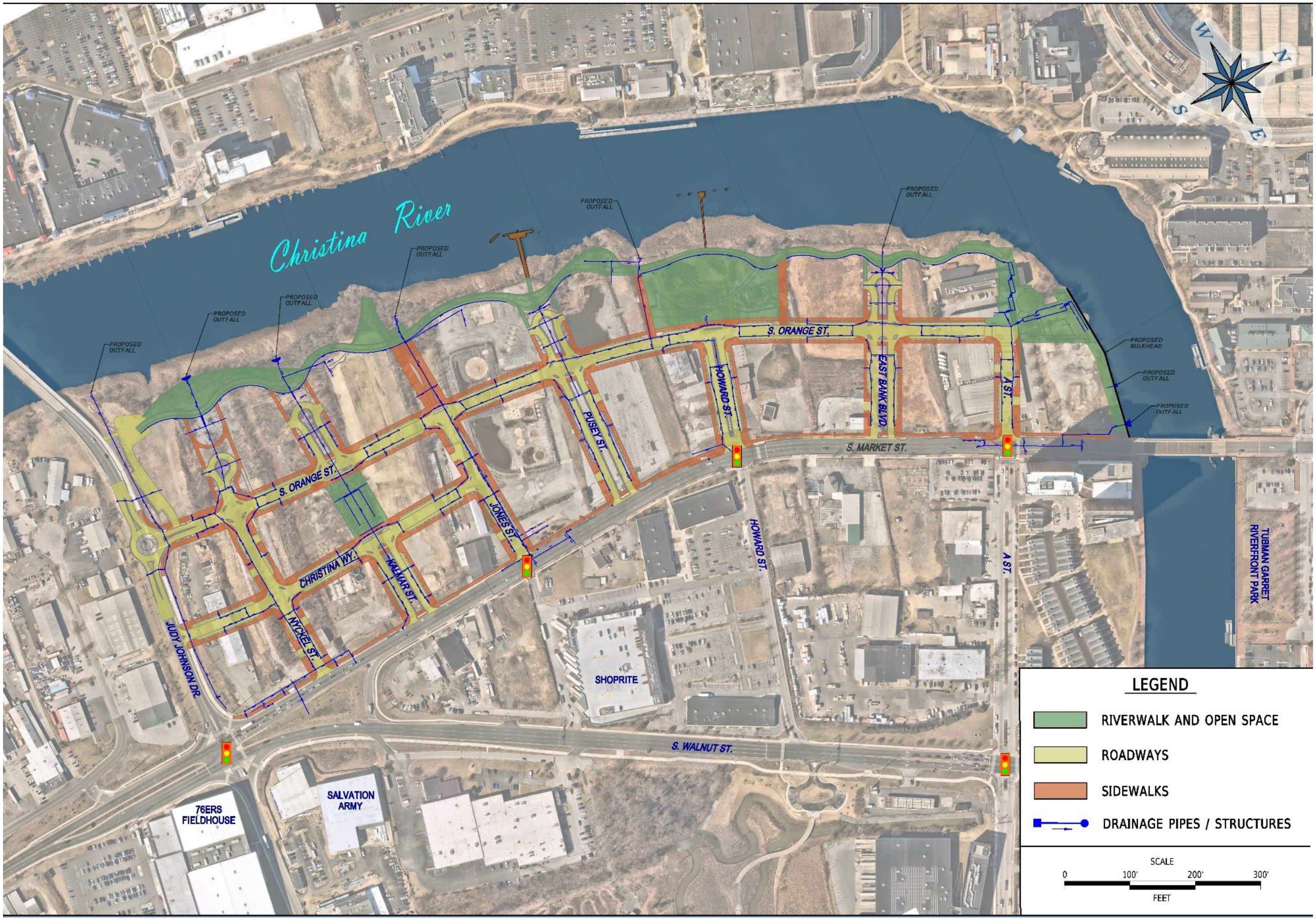
Adjacent to the eastern riverbank, a Riverwalk similar to the existing Riverwalk on the western riverbank is proposed to be built as part of the Build Alternative to provide access to this currently inaccessible riverfront. The Riverwalk would be a minimum width of 18 feet and include a dedicated eight-foot bike lane alongside a pedestrian walkway. Under the Build Alternative, connections between the east and west Riverwalks are proposed via the existing Senator Margaret Henry Rose Bridge to the south and the South Market Street bridge to the north.

Under the Build Alternative, the proposed in-water work would include repairing the existing bulkhead which is in current disrepair. The Build Alternative proposes to construct a new bulkhead in front of the existing bulkhead. The new bulkhead would be a higher elevation to allow the new Riverwalk to be constructed at a minimum of 18 inches above the 100-year flood elevation. The tidal influence of the river exposes mud flats in front of the existing bulkhead during the tide cycles. The new bulkhead would be constructed from the landside of the existing bulkhead.

The transportation infrastructure improvements under the Build Alternative also incorporate strategic resiliency solutions to environmental challenges currently faced by the site. The Project Study Area is expected to be entirely inundated in the case of a 100-year flood event under its current condition. The Build Alternative would elevate the transportation elements in compliance with the Federal Emergency Management Agency (FEMA) Floodplain Regulations to protect the site from inundation and flood-related damage. While the existing South Market Street roadway will remain at its existing elevation below the 100-year flood event, all other proposed roads would be constructed at elevations above the 100-year flood event except where they would connect to existing streets at lower elevations. Additionally, proposed sidewalks and the Riverwalk would also be at elevations above the 100-year flood event. These Project elements are aligned with the City of Wilmington's strategies to harden infrastructure vulnerable to sea level rise and extreme weather events.

Currently, the Project study area has 23.3 acres of impervious area. As part of the Build Alternative, all of the existing impervious surface would be removed accordingly. The proposed transportation improvements would reduce impervious area to 18.6 acres (a decrease of 4.7 acres). The Build Alternative proposes to add drainage outfalls to support the proposed transportation infrastructure. The outfalls would be strategically located throughout the Project study area to address ongoing drainage issues and provide adequate conveyance for the proposed transportation infrastructure. All proposed outfalls would be designed to discharge above Mean Low Water elevation of the Christina River at higher elevations than existing outfalls. In addition to the higher outfall elevation, there would be tide control valves installed at each outfall to eliminate the backup of the tidal water during the tidal fluctuations. The proposed storm drain and trench drain systems would be designed to provide efficient collection of surface runoff and adequate conveyance of stormwater throughout the Project study area. The separation of storm drain networks and proposed construction of new outfalls would provide an overall improvement to the current drainage conditions to the tidally influenced Christina River throughout the Project study area.

Figure 2: Build Alternative Site Plan



II. Regulatory Requirements

This section provides an overview of regulations and guidance applicable to the project-level air quality analysis.

A. National Environmental Policy Act

NEPA applies to all federally-funded transportation projects and federal agencies must consider environmental factors in the decision making process. Changes in air quality, and the effects of such changes on human health and welfare, are included among the factors to be considered. NEPA requirements have been defined in the Council on Environmental Quality's (CEQ) NEPA regulations that apply to all federal agencies. FHWA's policies and regulations for the implementation of NEPA are found at Title 23 Code of Federal Regulations (CFR), Part 771. However, the NEPA statute, the CEQ NEPA regulations (40 CFR 1500), and FHWA's NEPA regulations do not contain specific requirements for air quality analyses. For air quality, FHWA has issued guidance for Mobile Source Air Toxics (MSAT) and Carbon Monoxide (CO) analyses.

B. Clean Air Act

Pursuant to the Federal Clean Air Act of 1970 (CAA), the U.S. Environmental Protection Agency (EPA) established National Ambient Air Quality Standards (NAAQS) for major pollutants known as "criteria pollutants." Currently, the EPA regulates six criteria pollutants: ozone (O_3), CO, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), Particulate Matter (PM), and lead (Pb). PM is divided into two particle size categories: particles with a diameter less than 10 micrometers (PM_{10}) and those with a diameter of less than 2.5 micrometers ($PM_{2.5}$). **Table 1** shows the primary and secondary NAAQS for the criteria pollutants. The NAAQS are two-tiered: the first tier (primary) is intended to protect public health; the second tier (secondary) is intended to protect public welfare and prevent degradation of the environment.

The NAAQS apply to the concentration of a pollutant in outdoor ambient air. If the air quality in a geographic area is equal to, or is better than the national standard, the EPA will designate the region as an attainment area. Areas where air quality does not meet the national standards are designated as non-attainment areas. Once the air quality in a non-attainment area improves to the point where it meets the standards and the additional redesignation requirements in the CAA (Section 107(d)(3)(E)), the EPA may redesignate the area as an attainment/maintenance area, which is typically referred to as "maintenance areas."

Section 176(c) of the CAA requires federal agencies to ensure that all of their actions conform to applicable implementation plans for achieving and maintaining the NAAQS. Federal actions must not cause or contribute to any new violation of any standard, increase the frequency or severity of any existing violation, or delay timely attainment of any standard in nonattainment and maintenance areas.

The CAA requires the EPA to designate the status of all areas as being in or out of compliance with the NAAQS. The CAA further defines non-attainment areas for ozone based on the severity of the violation as marginal, moderate, serious, severe, and extreme.

Table 1: National Ambient Air Quality Standards

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 μg/m^3 (1)	Not to be exceeded
Nitrogen Dioxide (NO_2)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	12.0 μg/m^3	annual mean, averaged over 3 years
		secondary	1 year	15.0 μg/m^3	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 μg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 μg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

Notes:

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5ug/m3 as a calendar quarter average) also remain in effect.

(2) The level of the annual NO_2 standard is 0.053ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards are not revoked and remain in effect for designated areas. Additionally, some areas may have certain continuing implementation obligations under the prior revoked 1-hour (1979) and 8-hour (1997) O_3 standards..

(4) The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current 2010 standards, and (2) any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a State Implementation Plan (SIP) call under the previous SO_2 standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its SIP to demonstrate attainment of the required NAAQS.

Source: Table and footnotes above are excerpted from the US Environmental Protection Agency Website: https://www.epa.gov/criteria-air-pollutants/naaqs-table

C. Carbon Monoxide

CO is a toxic colorless and odorless gas that results from the incomplete combustion of gasoline and other fossil fuels. Because CO disperses quickly, the concentrations can vary greatly over relatively short distances. Relatively high concentrations of CO may occur near congested intersections, along heavily used roadways conveying slow-moving traffic, and in areas where atmospheric dispersion is inhibited by urban "street canyon" conditions. While the Study Area is an EPA attainment area for CO, a qualitative CO analysis of emissions from affected signalized intersections was conducted for transparency to demonstrate the proposed Project will not exceed the CO NAAQS.

In 1987, FHWA issued a Technical Advisory providing guidance for preparing and processing of environmental impacts for EAs and Environmental Impact Statements (EIS) under NEPA.[2] Section V(G)(8) pertains to air quality, including a summary of the project-related CO analysis. The proposed Project is located in an attainment area for CO and so EPA project-level ("hot-spot") transportation conformity requirements do not apply. However, a qualitative CO analysis of emissions was conducted to demonstrate CO traffic emissions from the proposed Project would be below the NAAQS.

D. Particulate Matter

PM is a broad class of air pollutants that exists as liquid droplets or solids, with a wide range of size and chemical composition. It is emitted by a variety of sources, both natural and man-made. Major man-made sources of PM include the combustion of fossil fuels in vehicles, power plants and homes, construction activities, agricultural activities, and wood-burning fireplaces. Smaller particulates less than or equal to 10 and 2.5 microns in size (PM_{10} and $PM_{2.5}$ respectively) are of particular health concern because they can get deeper into the lungs and affect respiratory and heart function. The Study Area is in an EPA maintenance area for $PM_{2.5}$ (2006). Thus, transportation conformity requirements pertaining to PM apply and a project criteria assessment consistent with EPA regulatory requirements (40 CFR 93.123(b)(1)) and other guidance was conducted to determine if the proposed Project is one of potential air quality concern for $PM_{2.5}$.

E. Ozone

Ozone is a colorless toxic gas and is found in both the Earth's upper and lower atmospheric levels. In the upper atmosphere, ozone is a naturally occurring gas that helps to prevent the sun's harmful ultraviolet rays from reaching the Earth. In the lower layer of the atmosphere, ozone is man-made. Although ozone is not directly emitted, it forms in the lower atmosphere through a chemical reaction between hydrocarbons (HC), also referred to as volatile organic compounds or Volatile Organic Compounds (VOCs), and nitrogen oxides (NOx), which are emitted from industrial sources and from automobiles.

F. Mobile Source Air Toxics

On January 18, 2023, FHWA issued an updated interim guidance regarding MSATs in a NEPA analysis to include the United States Environmental Protection Agency's (EPA) recent MOVES3 Mobile Source Emissions Model.[3]

The EPA identified nine compounds with significant contributions from mobile sources that are among the national and regional-scale cancer drivers from their 1999 National Air Toxics Assessment. The nine

[2] https://www.environment.fhwa.dot.gov/projdev/impTA6640.asp#aq

[3] https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/msat/fhwa_nepa_msat_memorandum_2023.pdf

compounds identified were: acetaldehyde; acrolein; benzene; 1, 3-butadiene; diesel PM plus diesel exhaust organic gases; ethylbenzene; formaldehyde; naphthalene; and polycyclic organic matter (POM). While FHWA considers these the priority MSATs, the list is subject to change and may be adjusted in consideration of future EPA rules.

The FHWA guidance of January 18, 2023, presents a tiered approach for assessing MSATs in NEPA documents. The three levels are for projects with: (1) no meaningful MSAT effects; (2) low potential MSAT effects; and (3) high potential MSAT effects, respectively. The FHWA guidance defines the levels of analysis for each type of MSAT effect as:

- No analysis for projects with no potential for meaningful MSAT effects;
- A qualitative analysis for projects with low potential MSAT effects; and
- A quantitative analysis for projects with high potential MSAT effects.

The Build Alternative was evaluated against each threshold criteria to determine the type of MSAT analysis required to satisfy NEPA.

G. Transportation Conformity

The EPA promulgated the transportation conformity rule (40 CFR Parts 51 and 93) pursuant to the requirements of the CAA. The rule **only** applies in EPA-designated non-attainment or maintenance areas (40 CFR 93.102(b)). The study area is located in the New Castle County where the United States Environmental Protection Agency's (EPA) Green Book shows the county to be designated as attainment for all NAAQS except the 2008 and 2015 8-hour ozone and maintenance for the 2006 $PM_{2.5}$ standard. Therefore, project-level transportation conformity rule requirements for $PM_{2.5}$ and Ozone specifically apply for this region.

Areas designated as non-attainment with the eight-hour ozone standards have certain federal conformity rule requirements related to plans, programs, and projects. Specifically, these requirements state that a conforming transportation plan and program must be in place at the time of project approval (40 CFR 93.114), and that the project must be included in the conforming plan and program (40 CFR 93.115). Additionally, the design concept and scope of the project as specified in the program at the time of the regional conformity determination should be adequate to determine its contribution to regional emissions, and any mitigation measures associated with the project should have written commitments from the project sponsor and/or operator (40 CFR 93.115(c)).

The Wilmington Area Planning Council (WILMAPCO) is the federally designated Metropolitan Planning Organization (MPO) for the Wilmington region and, as such, is the regional transportation planning agency for New Castle County, Delaware.

The FY 2023-2026 Transportation Improvement Program (TIP) is developed in cooperation with WILMAPCO, Dover/Kent County Metropolitan Planning Organization, Salisbury-Wicomico Metropolitan Planning Organization, and Sussex County. The TIP prioritizes and documents anticipated projects including roads, buses, rail, bicycle, and pedestrian. Each project includes a description and the expected schedule of funding. The document is separated into Delaware Statewide, New Castle County and Cecil County projects, and is incorporated into the Delaware Capital Transportation Program and Maryland Consolidated Transportation Program. The proposed Project is listed in the currently conforming FY 2023-

2026 TIP.[4] Based on the criteria specified in the Transportation Conformity rule and associated guidance, the implementation the proposed Project is not considered to be ones of "air quality concern" for fine particulate matter. Therefore, the CAA and 40 CFR 93.116 requirements for $PM_{2.5}$ were met without a hot-spot analysis, since such projects have been found not to be of air quality concern under 40 CFR 93.123(b)(1). (See **Section IV.C.**)

H. Climate Change and Greenhouse Gas Impact

The CEQ published interim, effective guidance on January 9, 2023, regarding how to evaluate GHG emissions and climate change under NEPA. According to the guidance, when conducting climate change analyses in NEPA reviews, agencies should consider the potential effects of a proposed action on climate change, including by assessing both GHG emissions and reductions from the proposed action, as well as the effects of climate change on a proposed action and its environmental impacts. The CEQ guidance does not establish any particular quantity of GHG emissions as "significantly" affecting the quality of the human environment (CEQ 2023).

In order to meet the 2016 CEQ guidance, a quantitative GHG analysis was conducted for this proposed Project to document GHG impacts. The GHG and climate change impact analysis for the proposed Project in accordance with the CEQ (2023) guidance is summarized in **Appendix B** of this Air Quality Technical Report.

III. Existing Conditions

A. Air Quality Attainment Status of the Project Area

The EPA Green Book[5], which lists non-attainment, maintenance, and attainment areas, was reviewed to determine the designations for the Wilmington area in which the proposed Project is located. The EPA Green Book shows that New Castle County is located in an area designated as attainment for all NAAQS except the 2008 and 2015 8-hour ozone and maintenance for the 2006 $PM_{2.5}$ standard.

B. Climate and Meteorology

Wilmington is located in the northern portion of the state with the Delaware River approximately 3 miles to the east. The climate of the area in which the proposed Project is located consists of four distinct seasons; winter, spring, summer, and fall. Winters are mild with limited snowfall and summers are hot and humid. According to the National Weather Service data[6], the average annual temperature for nearby Wilmington Airport is 54.9 degrees Fahrenheit. The area typically receives slightly over 43 inches of rainfall annually.

C. Ambient Air Quality Data and Trends

The latest annual air quality monitoring report released by the Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Air Quality[7] shows measured pollutant concentrations from all stations representative of the study area.

[4] Wilmington Area Planning Council FY2023 to FY2026 Transportation Improvement Program (TIP). May 12, 2022 http://www.wilmapco.org/Tip/fy2023/FY2023TIP.pdf

[5] USEPA Green Book: https://www3.epa.gov/airquality/greenbook/anayo_nh.html (accessed on August 20, 2021)

[6] https://w2.weather.gov/climate/getclimate.php?wfo=phi

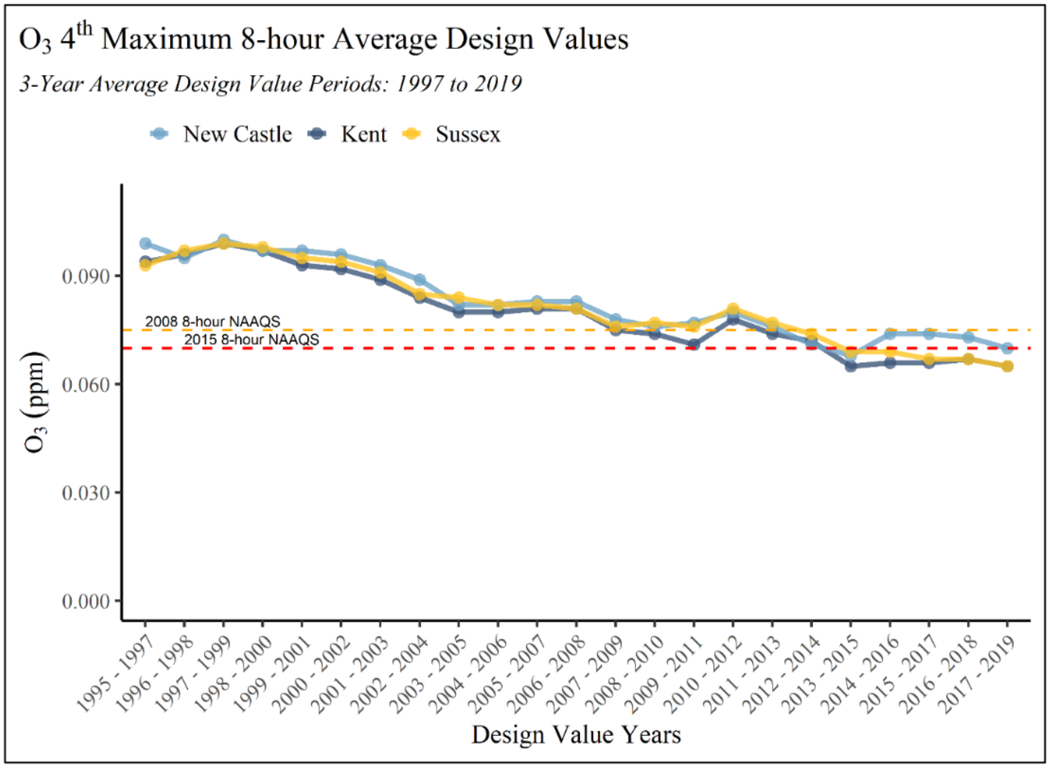
[7] https://documents.dnrec.delaware.gov/Air/Documents/2019-Delaware-Annual-Air-Quality-Report.pdf

As presented in **Table 2**, and in **Figure 3** through **Figure 8**, historical monitoring data indicates that criteria pollutants concentrations have been decreasing in the state. For 2019 Delaware met all of the NAAQS with the exception of the 2008 and 2015 8-hour ozone (O_3) standards; for 2019, the measurement was equal to the standard. The reduction in CO, SO_2, NOx, PM, and ozone emissions is due to a variety of control measures that have been implemented over the last two decades, including motor vehicle engine controls and reductions in evaporative emissions from gasoline stations and consumer products, as well as reductions from power plants, businesses, and residential combustion sources.

Table 2: Delaware CO Annual Maximum Values (ppm)

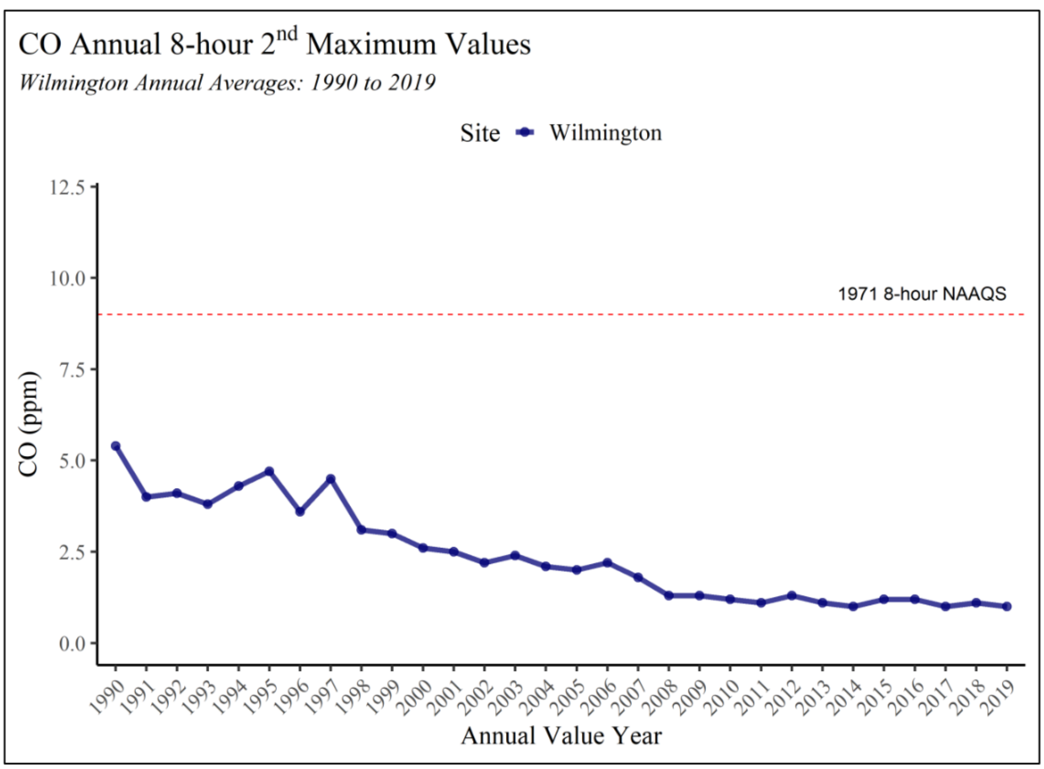
Site	1 - Hour Avg. NAAQS = 35 ppm		8-Hour Avg. NAAQS = 9 ppm	
	1st Max.	2nd Max.	1st Max.	2nd Max.
10-003-2004 101 Justison St MLK National Core Wilmington	1.423	1.230	1.1	1.0

Figure 3: Ozone 4th Maximum 8-Hour Average Design Values (PPM) – 1995-2019



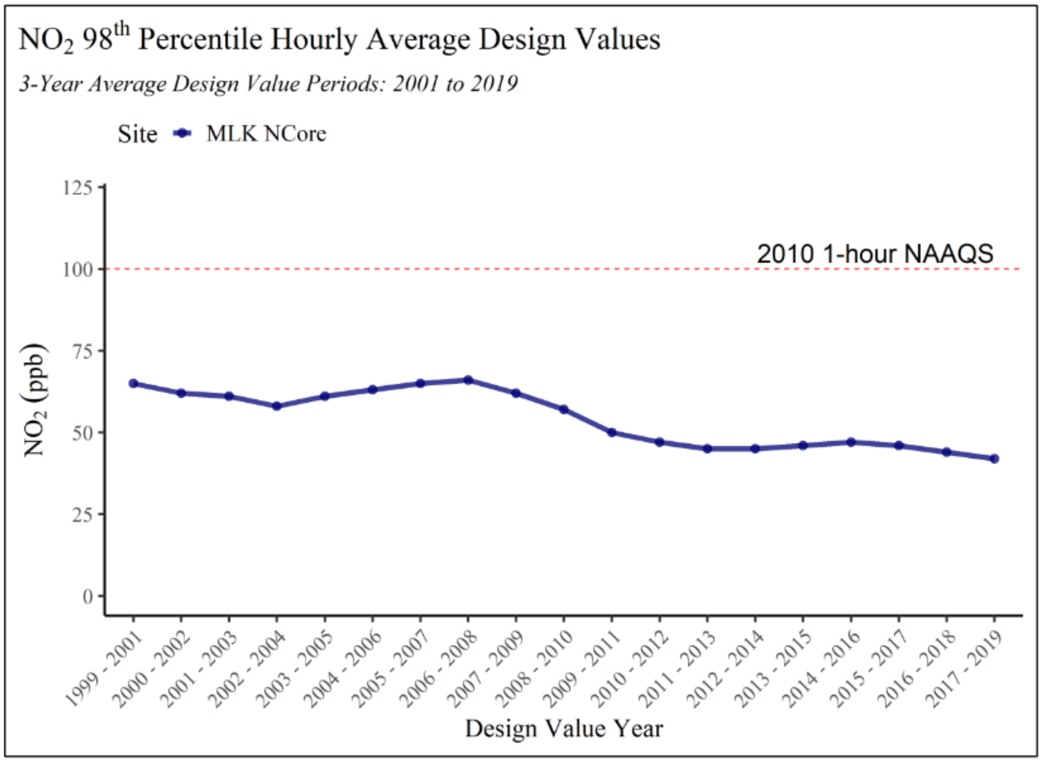
Source: Delaware Annual Air Quality Report 2019

Figure 4: CO Annual 8-Hour 2nd Maximum Values Trends (PPM) – 1990-2019



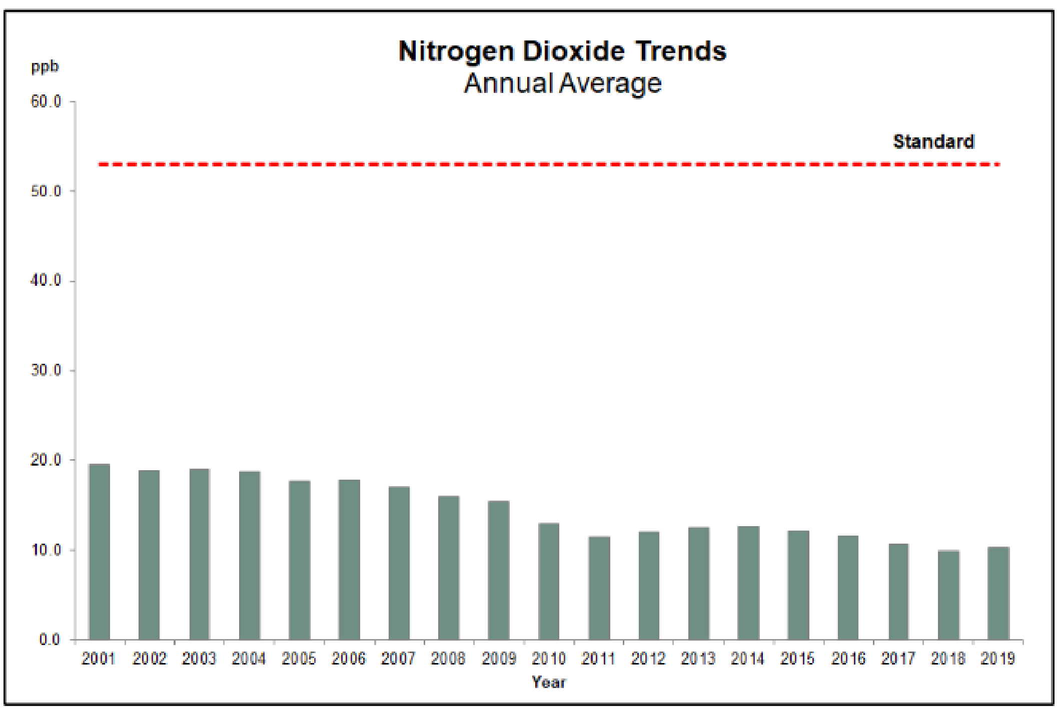
Source: Delaware Annual Air Quality Report 2019

Figure 5: Nitrogen Dioxide 98th Percentile Hourly Average Design Values (PPB) – 2001-2019



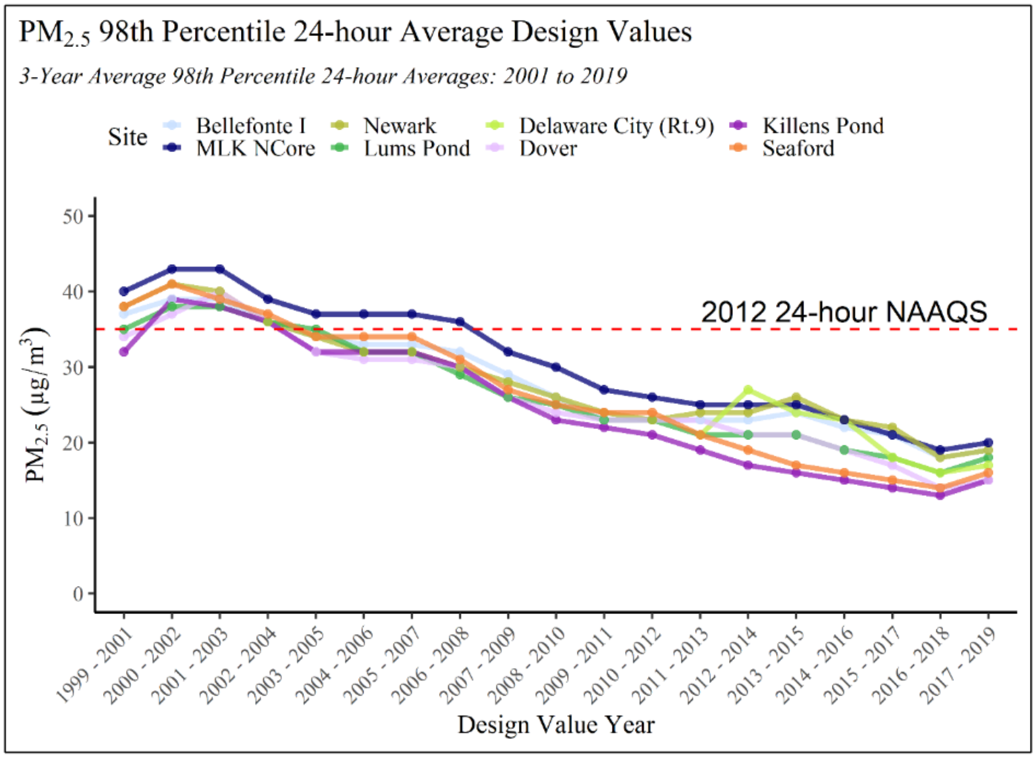
Source: Delaware Annual Air Quality Report 2019

Figure 6: Nitrogen Dioxide Trends Annual Average (PPB) – 2001 to 2019



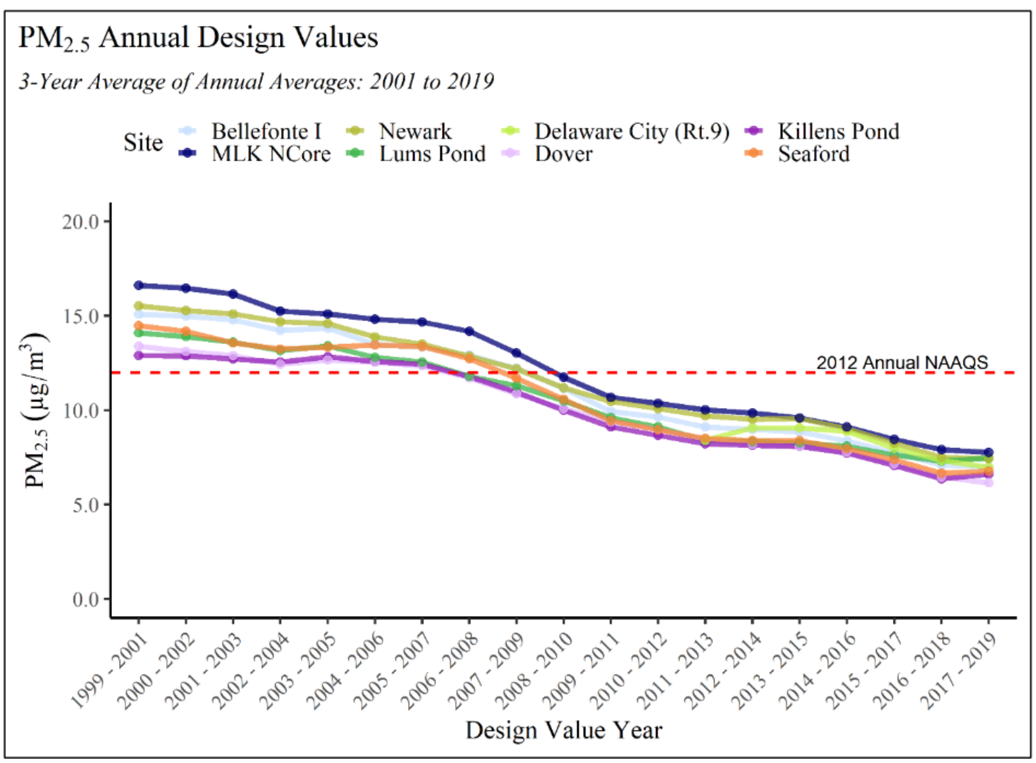
Source: Delaware Annual Air Quality Report 2019

Figure 7: $PM_{2.5}$ 98th Percentile 24-hour Average Design Values (ug/m3) – 1999 to 2019



Source: Delaware Annual Air Quality Report 2019

Figure 8: $PM_{2.5}$ Annual Design Values (ug/m3) – 1999 to 2019



Source: Delaware Annual Air Quality Report 2019

IV. Project Assessment

Project-level analyses for highway projects typically consist of evaluations of CO, PM, and MSATs. While the Project study area is an EPA attainment area for CO and maintenance area for $PM_{2.5}$, EPA project-level ("hot spot") transportation conformity requirements only apply for $PM_{2.5}$. A qualitative CO analysis of emissions from affected intersections was conducted to demonstrate CO traffic emissions from the proposed Project would be below the CO NAAQS. MSAT emissions were evaluated consistent with the latest FHWA guidance. An assessment was conducted to determine if the proposed Project is a potential Project of Air Quality Concern for PM2.5 according to the criteria in 40 CFR 93.123(b)(1) and if PM2.5 hot spot analyses were required. Greenhouse Gas (GHG) emissions were quantitatively evaluated to satisfy the most recent CEQ guidance for evaluating GHG and climate change in an EA.

A. Traffic Data

Traffic forecasts for the Proposed Action were developed for the Design-Year (2040) condition for average daily traffic (ADT) including the Build Condition and No Build Condition.

Comparison of the ADT according to vehicles per day (VPD), and vehicle miles traveled (VMT) for the No Build and Build Alternatives are presented in **Table 3,** a comparison of diesel truck percentage included in **Table 4**, and the Level of Service (LOS) of the 2040 No Build and 2040 100% Build conditions in **Table 5.** The vehicle classifications shown in **Table 6** below are assumed for all roads within the Project area under 2040 No Build and 2040 100% Build conditions.

The Build Alternative is anticipated to result in greater traffic volumes throughout the Project study area comparative to the Existing and No Build Alternatives. The Wilmington Riverfront development is projected to include 6.9M square feet of new development which is expected to generate 5,323 new vehicle trips during the AM peak period and 3,640 trips during the PM peak period to the surrounding roadway network. Regionally, the influence of the proposed Project results in greater operational distribution of traffic. EPA guidance provides an example of a "project of air quality concern" covered under (40 CFR 93.123(b)(1) as a project on a new highway or expressway that serves a significant volume of diesel truck traffic, such as facilities with greater than 125,000 annual average daily traffic (AADT) and 8 percent or more of such AADT is diesel truck traffic (which equates to 10,000 or more diesel trucks per day). The traffic of both the Build and No Build conditions show a significant level of diesel truck traffic. The most substantial traffic among build condition segments is 30,000 ADT, of which 5.3 percent is diesel traffic for a total of 1,590 diesel ADT. The traffic of the Build condition shows that this proposed Project does not have a significant volume of diesel truck and is not considered as a project of air quality concern. Additionally, the distribution of vehicle class will remain the same between the Build and No Build Alternatives. Safety improvements to the intersection of Howard Street and South Market Street result in a higher Level of Service (LOS); however, the LOS at all other intersections within the Project area are expected to either improve or remain the same under the Build Alternative compared to the No Build Alternative.

Table 3: Design Year (2040) ADT and VMT

				No Build	Build	No Build	Build	
Status	**Roadway**	**Location**	**Segment Length (Miles)**	**ADT (vpd)**	**ADT (vpd)**	**VMT**	**VMT**	**% Growth VMT**
Existing Alignment	**SB Market Street**	**A Street to Howard Street**	**0.16**	**21,300**	**27,700**	**3,453**	**4,441**	**28.6%**
		Howard Street to U-Turn	**0.26**	**20,400**	**29,200**	**5,363**	**8,110**	**51.2%**
		U-Turn to New Sweden Street	**0.07**	**19,100**	**30,000**	**1,400**	**1,733**	**23.8%**
	New Sweden Street	**US 13 to Christina River Bridge**	**0.23**	**4,800**	**10,100**	**1,104**	**2,323**	**110.4%**
New Alignment Roadway	*Howard Street*	*Orange St to South Market St*	*0.07*	*--*	*6,500*	*--*	*475*	*--*
	A St	*S Market St to Orange St*	*0.08*	*--*	*4,400*	*--*	*356*	*--*
	1st St	*S Market St to Orange St*	*0.07*	*--*	*3,400*	*--*	*236*	*--*
	2nd St	*S Market St to Orange St*	*0.09*	*--*	*4,100*	*--*	*349*	*--*
	3rd St	*S Market St to Middle St*	*0.06*	*--*	*5,600*	*--*	*347*	*--*
		Middle St to Orange St	*0.05*	*--*	*4,600*	*--*	*214*	*--*
	4th St	*S Market St to Middle St*	*0.07*	*--*	*500*	*--*	*35*	*--*
	5th St	*S Market St to Middle St*	*0.10*	*--*	*1,900*	*--*	*185*	*--*
		Middle St to Orange St	*0.06*	*--*	*2,800*	*--*	*169*	*--*
	Middle St	*3rd St to 4th St*	*0.07*	*--*	*2,200*	*--*	*151*	*--*
		4th St to 5th St	*0.06*	*--*	*2,700*	*--*	*153*	*--*
		5th St to New Sweden St	*0.06*	*--*	*3,100*	*--*	*188*	*--*
	Orange St	*A St to 1st St*	*0.08*	*--*	*2,400*	*--*	*198*	*--*
		1st St to Howard St	*0.09*	*--*	*3,500*	*--*	*330*	*--*
		Howard St to 2nd St	*0.07*	*--*	*5,600*	*--*	*407*	*--*
		2nd St to 3rd St	*0.09*	*--*	*4,100*	*--*	*384*	*--*
		3rd St to 4th St	*0.06*	*--*	*5,600*	*--*	*316*	*--*
		4th St to 5th St	*0.06*	*--*	*5,800*	*--*	*347*	*--*
		5th St to New Sweden St	*0.07*	*--*	*4,800*	*--*	*320*	*--*

Table 4: Design Year (2040) ADT and Diesel Volumes/Percentage

				No Build	Build	No Build	Build	No Build	Build
Status	**Roadway**	**Location**	**Segment Length (Miles)**	**ADT (vpd)**	**ADT (vpd)**	**Percent Diesel**	**Percent Diesel**	**Diesel ADT**	**Diesel ADT**
Existing Alignment	**SB Market Street**	**A Street to Howard Street**	**0.16**	**21,300**	**27,700**	**5.3%**	**5.3%**	**1,130**	**1,470**
		Howard Street to U-Turn	**0.26**	**20,400**	**29,200**	**5.3%**	**5.3%**	**1,080**	**1,550**
		U-Turn to New Sweden Street	**0.07**	**19,100**	**30,000**	**5.3%**	**5.3%**	**1,010**	**1,590**
	New Sweden Street	**US 13 to Christina River Bridge**	**0.23**	**4,800**	**10,100**	**5.3%**	**5.3%**	**250**	**540**
New Alignment Roadway	*Howard Street*	*Orange to South Market*	*0.07*	*--*	*6,500*	*--*	*5.3%*	*--*	*340*
	A St	*S Market St to Orange St*	*0.08*	*--*	*4,400*	*--*	*5.3%*	*--*	*230*
	1st St	*S Market St to Orange St*	*0.07*	*--*	*3,400*	*--*	*5.3%*	*--*	*180*
	2nd St	*S Market St to Orange St*	*0.09*	*--*	*4,100*	*--*	*5.3%*	*--*	*220*
	3rd St	*S Market St to Middle St*	*0.06*	*--*	*5,600*	*--*	*5.3%*	*--*	*300*
	3rd St	*Middle St to Orange St*	*0.05*	*--*	*4,600*	*--*	*5.3%*	*--*	*240*
	4th St	*S Market St to Middle St*	*0.07*	*--*	*500*	*--*	*5.3%*	*--*	*30*
	5th St	*S Market St to Middle St*	*0.10*	*--*	*1,900*	*--*	*5.3%*	*--*	*100*
		Middle St to Orange St	*0.06*	*--*	*2,800*	*--*	*5.3%*	*--*	*150*
	Middle St	*3rd St to 4th St*	*0.07*	*--*	*2,200*	*--*	*5.3%*	*--*	*120*
		4th St to 5th St	*0.06*	*--*	*2,700*	*--*	*5.3%*	*--*	*140*
		5th St to New Sweden St	*0.06*	*--*	*3,100*	*--*	*5.3%*	*--*	*160*
	Orange St	*A St to 1st St*	*0.08*	*--*	*2,400*	*--*	*5.3%*	*--*	*130*
		1st St to Howard St	*0.09*	*--*	*3,500*	*--*	*5.3%*	*--*	*190*
		Howard St to 2nd St	*0.07*	*--*	*5,600*	*--*	*5.3%*	*--*	*300*
		2nd St to 3rd St	*0.09*	*--*	*4,100*	*--*	*5.3%*	*--*	*220*
		3rd St to 4th St	*0.06*	*--*	*5,600*	*--*	*5.3%*	*--*	*300*
		4th St to 5th St	*0.06*	*--*	*5,800*	*--*	*5.3%*	*--*	*310*
		5th St to New Sweden St	*0.07*	*--*	*4,800*	*--*	*5.3%*	*--*	*250*

Table 5: 2040 100% Build LOS Results

<table>
<tr><th rowspan="2"></th><th colspan="2">2040 No Build</th><th colspan="2">2040 Build</th></tr>
<tr><th>AM</th><th>PM</th><th>AM</th><th>PM</th></tr>
<tr><td>S Market Street
@
A Steet</td><td colspan="2">Unsignalized</td><td>C</td><td>C</td></tr>
<tr><td>S Market Street
@
Howard Steet</td><td>B</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td>S Market Street
@
3rd Steet</td><td colspan="2">Unsignalized</td><td>C</td><td>D</td></tr>
<tr><td>S Market Street
@
New Sweden Steet</td><td>D</td><td>E</td><td>E</td><td>D</td></tr>
</table>

Table 6: Vehicle Classification

	2040 No Build	2040 Build
Auto	91.6%	91.6%
Medium	3.3%	3.3%
Heavy	2.5%	2.5%
Bus	2.4%	2.4%
Motorcycle	0.1%	0.1%

B. CO Analysis

The Project is in New Castle County, which is designated as “Attainment” for CO. Since the Study Area is in a CO Attainment area, conformity determination is not required.

A review of the forecasted ADT for the Build Alternative shows no significant increase in traffic volumes, changes to the vehicular mix, or any other significant factor that would cause an increase in CO emissions or ground level concentrations compared to the No Build Alternative. Additional details supporting these conclusions are presented below.

According to the historical monitoring data presented in the 2019 Delaware Annual Air Quality Report, and as detailed in **Table 2**, the highest monitored 1-hour carbon monoxide (CO) concentration for 2019 at the MLK National Core Wilmington monitoring station (ID: 100032004), located at 101 Justison St. and near the study area, was 1.4 parts per million (ppm). This level represents only 4.0% of the National Ambient Air Quality Standards (NAAQS) for 1-hour CO exposure, which is set at 35.0 ppm. Furthermore, the peak 8-hour monitored CO concentration in 2019 was 1.0 ppm, amounting to merely 11.1% of the 8-hour CO NAAQS of 9.0 ppm.

Due to low concentrations of CO in the region, relative to NAAQS thresholds, and the minimal changes to traffic in the Build condition, the increase in the number of vehicles due to the South Market Street development would not be significant enough to cause or result in any meaningful change or impact to the CO NAAQS.

In conclusion, the proposed improvements under the Build Alternative would not cause or contribute to a new violation of the CO NAAQS. The monitored data shows a steady decrease in monitored CO concentrations. This decrease in monitored concentrations is expected to continue as vehicle emission control technology and fuel efficiency continues to improve and older cars are retired. Therefore, it can reasonably be concluded the proposed Project is not expected to increase CO emissions or impacts. With these conclusions coupled with monitored CO background values in the area being well below the NAAQS (See **Table 2**), the proposed Project is not expected to significantly impact air quality and would not cause or contribute to a new violation the CO NAAQS.

C. PM2.5 Assessment

The EPA has established a list of criteria (40 CFR 93.123(b)(1)) in determining whether a project is of “air quality concern” for $PM_{2.5}$, and the proposed Project was assessed against each of these criteria below.

> *(i) New highway projects that have a significant number of diesel vehicles, and expanded highway projects that have a significant increase in the number of diesel vehicles;*

The proposed Project is designed to provide improved infrastructure and access to underutilized properties east of the Christina River.

EPA guidance provides an example of a “project of air quality concern” covered under (40 CFR 93.123(b)(1)) as a project on a new highway or expressway that serves a significant volume of diesel truck traffic, such as facilities with greater than 125,000 AADT and 8% or more of such AADT is diesel truck traffic (which equates to 10,000 or more diesel trucks per day).

AADT (ADT in the traffic tables represent AADT) was estimated for existing and proposed new alignment for the Build Alternative 2040 conditions. Included in the forecast are expected diesel truck volumes for each segment based on expected traffic fleet mix as shown above in **Table 4** shows the forecasted ADT and diesel truck volumes for 2040 for the Build Alternative.

Worst-case traffic in the region, which correlates with the highest diesel traffic, is forecast to reach up to 30,000 ADT for the 2040 Build Condition for the southbound Market Street from 5th Street to New Sweden Street roadway segment. The 30,000 ADT is comprised of approximately 5.3% diesel vehicles, or about 1,590 total diesel vehicles, which is well below the level of 10,000 diesel trucks provided by EPA as an example of a project of air quality concern in their guidance for new highway projects.

All other roadways within the Project study area are also projected to have total ADT well below 125,000 and total diesel trucks well below 10,000 per day, and therefore fall well below the level considered to be of air quality concern.

In summary, based on the criteria specified in the transportation conformity rule and associated guidance, this proposed Project is not considered to be one of air quality concern for fine particulate matter.

> *(ii) Projects affecting intersections that are at Level of Service D, E, or F with a significant number of diesel vehicles, or those that will change to Level of Service D, E, F because of increased traffic volumes from a significant number of diesel vehicles related to the project;*

As noted above, the total ADT and diesel truck traffic associated with the Build Alternative considered for this Project are not expected to reach the 125,000 AADT or 10,000 diesel truck level that EPA has provided as an example of a project of air quality concern for fine particulate matter. Additionally, with the exception of the intersection at Howard Street and South Market Street, the LOS at each intersection within the Project study area is expected to either improve or remain the same under the Build Alternative compared to the No Build conditions for the 2040 analysis year.

In summary, all segments and intersections of the proposed improvement are not expected to see a significant increase in the number of diesel vehicles as a result of the proposed improvements. In addition, the LOS at the majority of intersections within the Project corridor are expected to either improve or remain the same under the Build Alternative compared to the No Build Alternative. Therefore, this proposed Project is not considered to be one of air quality concern for fine particulate matter.

> *(iii) New bus and rail terminals and transfer points that have a significant number of diesel vehicles congregating at a single location;*

The Project does not involve bus or rail terminals.

> *(iv) Expanded bus and rail terminals and transfer points that significantly increase the number of diesel vehicles congregating at a single location; and*

This Project does not involve bus or rail terminals.

> *(v) Projects in or affecting locations, areas, or categories of sites which are identified in the PM_{10} or $PM_{2.5}$ applicable implementation plan or implementation plan submissions, as appropriate, as sites of violation or possible violation.*

This Project is not located in such an area.

Based on the criteria specified in the Transportation Conformity rule and associated guidance, the implementation of the proposed Project is not considered to be ones of "air quality concern" for fine particulate matter. Therefore, the CAA and 40 CFR 93.116 requirements for $PM_{2.5}$ were met without a hot-spot analysis, since such projects have been found not to be of air quality concern under 40 CFR 93.123(b)(1).

D. Mobile Source Air Toxics Analysis

1. Methodology

On January 18, 2023 FHWA issued updated interim guidance[8] regarding MSATs in a NEPA analysis. This update was prompted by recent changes in the emissions model required for conducting emissions analysis. In 2021, the EPA released MOVES3[9], the latest major update of the Motor Vehicle Emissions Simulator (MOVES) vehicle emissions model, and started a 2-year grace period to phase in the requirement of using MOVES3 for transportation conformity analysis. The guidance includes three categories and criteria for analyzing MSATs in NEPA documents:

1. No meaningful MSAT effects;
2. Low potential MSAT effects; and
3. High potential MSAT effects.

A qualitative analysis is required for projects which meet the low potential MSAT effects criteria, while a quantitative analysis is required for projects meeting the high potential MSAT effects criteria.

Projects with low potential MSAT effects are described as:

- Those that serve to improve operations of highway, transit, and freight without adding substantial new capacity or without creating a facility that is likely to significantly increase emissions. This category covers a broad range of project types, including minor widening projects and new interchanges, such as those that replace a signalized intersection on a surface street or where Design-Year traffic is not projected to meet the 140,000 to 150,000 AADT criteria.

Projects with high potential MSAT effects must:

- Create or significantly alter a major intermodal freight facility that has the potential to concentrate high levels of diesel particulate matter in a single location;
- Create new or add significant capacity to urban highways such as interstates, urban arterials, or urban collector-distributor routes with traffic volumes where the AADT is projected to be in the range of 140,000 to 150,000 or greater by the Design-Year; and
- Proposed to be located in proximity to populated areas.

In accordance with the MSAT guidance, the study area is best characterized as a project with "low potential MSAT effects" since projected Design-Year traffic is expected to be well below the 140,000 to 150,000 AADT criteria. Specifically, the Design year of the proposed Project is expected to have the highest ADT volumes of 30,000 along South Market Street from the U-Turn location to New Sweden Street. A table summarizing the ADT throughout the Project corridor is presented **Table 3**.

[8] https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/msat/fhwa_nepa_msat_memorandum_2023.pdf

[9] https://www.govinfo.gov/content/pkg/FR-2021-01-07/pdf/2021-00023.pdf

The results demonstrate that the forecast ADT volumes would be much less than the 140,000 to 150,000 AADT MSAT criteria. As a result, a qualitative assessment of MSAT emissions projections was conducted for the affected network consistent with FHWA guidance.

2. MSAT Background

Controlling air toxic emissions became a national priority with the passage of the Clean Air Act Amendments (CAAA) of 1990, whereby Congress mandated that the EPA regulate 188 air toxics, also known as hazardous air pollutants. The EPA assessed this expansive list in its rule on the Control of Hazardous Air Pollutants from Mobile Sources (Federal Register, Vol. 72, No. 37, page 8430, February 26, 2007), and identified a group of 93 compounds emitted from mobile sources that are part of EPA's Integrated Risk Information System (IRIS).[10] In addition, EPA identified nine compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers or contributors and non-cancer hazard contributors from the 2011 National Air Toxics Assessment (NATA).[11] These are *1,3-butadiene, acetaldehyde, acrolein, benzene, diesel particulate matter (diesel PM), ethylbenzene, formaldehyde, naphthalene, and polycyclic organic matter*. While FHWA considers these the priority mobile source air toxics, the list is subject to change and may be adjusted in consideration of future EPA rules.

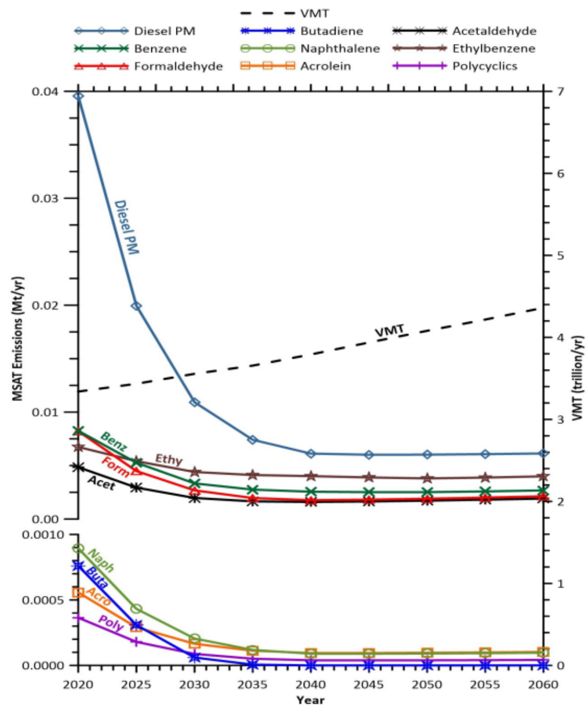
3. Motor Vehicles Emissions Simulator (MOVES)

According to EPA, MOVES3 is a major revision to MOVES2014 and improves upon it in many respects. MOVES3 includes new data, new emissions standards, and new functional improvements and features. It incorporates substantial new data for emissions, fleet, and activity developed since the release of MOVES2014. These new emissions data are for light- and heavy-duty vehicles, exhaust and evaporative emissions, and fuel effects. MOVES3 also adds updated vehicle sales, population, age distribution, and VMT data. In the November 2020 EPA issued MOVES3 Mobile Source Emissions Model Questions and Answers[12] EPA states that for on-road emissions, MOVES3 updated heavy-duty (HD) diesel and compressed natural gas (CNG) emission running rates and updated HD gasoline emission rates. They updated light-duty (LD) emission rates for hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxide (NOx) and updated light-duty (LD) particulate matter rates, incorporating new data on Gasoline Direct Injection (GDI) vehicles.

Using EPA's MOVES3 model, as shown in **Figure 9**, FHWA estimates that even if VMT increases by 31 percent from 2020 to 2060 as forecast, a combined reduction of 76 percent in the total annual emissions for the priority MSAT is projected for the same time period.

[10] https://www.epa.gov/iris
[11] https://www.epa.gov/national-air-toxics-assessment/2011-nata-assessment-results
[12] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1010M06.pdf

Figure 9: National MSAT Emission Trends 2020 – 2060 for Vehicles Operating on Roadways



Note: Trends for specific locations may be different, depending on locally derived information representing vehicle-miles travelled, vehicle speeds, vehicle mix, fuels, emission control programs, meteorology, and other factors.

Source: EPA MOVES3 model runs conducted by FHWA, March 2021.

Diesel PM is the dominant component of MSAT emissions, making up 36 to 56 percent of all priority MSAT pollutants by mass, depending on calendar year. Users of MOVES3 will notice some differences in emissions compared with MOVES2014. MOVES3 is based on updated data on some emissions and pollutant processes compared to MOVES2014, and also reflects the latest Federal emissions standards in place at the time of its release. In addition, MOVES3 emissions forecasts are based on slightly higher VMT projections than MOVES2014, consistent with nationwide VMT trends.

4. MSAT Research

Air toxics analysis is a continuing area of research. While much work has been done to assess the overall health risk of air toxics, many questions remain unanswered. In particular, the tools and techniques for assessing project-specific health outcomes as a result of lifetime MSAT exposure remain limited. These limitations impede the ability to evaluate how potential public health risks posed by MSAT exposure should be factored into project-level decision-making within the context of NEPA.

Nonetheless, air toxics concerns continue to arise on highway projects during the NEPA process. Even as the science emerges, the public and other agencies expect FHWA to address MSAT impacts in its environmental documents. The FHWA, EPA, the Health Effects Institute, and others have funded and conducted research studies to try to more clearly define potential risks from MSAT emissions associated with highway projects. The FHWA will continue to monitor the developing research in this field.

5. Project Qualitative MSAT Analysis

For the proposed improvements of this Project, the amount of MSATs emitted would be proportional to the VMT assuming that other variables such as fleet mix are the same for the No Build and Build Alternative. As shown in **Table 4**, the VMT estimated for the Build Alternative is expected to be higher compared to the No Build Alternative as result of the roadway network improvements accommodating future traffic and development to improve the local roadway network. Any increase in VMT would lead to higher MSAT emissions for the Build Alternative along the roadway corridor, along with a corresponding decrease in MSAT emissions along the parallel routes. Regardless of the alternative, emissions will likely be lower than present levels in the design year as a result of EPA's national control programs that are projected to reduce annual MSAT emissions by over 90 percent between 2020 and 2060. Local conditions may differ from these national projections in terms of fleet mix and turnover, VMT growth rates, and local control measures. However, the magnitude of the EPA-projected reductions is so great (even after accounting for VMT growth) that MSAT emissions in the Project study area are likely to be lower in the future in nearly all cases.

The new alignment roadway and additional travel lanes in the Build Alternative associated with the proposed Project may have the effect of moving some traffic closer to existing nearby homes and businesses; therefore, under the Build Alternative, there may be localized areas where ambient concentrations of MSAT could be higher than the No Build Alternative. However, the magnitude and the duration of these potential increases compared to the No Build Alternative cannot be reliably quantified due to incomplete or unavailable information in forecasting project-specific MSAT health impacts. In sum, when the capacity of a roadway is increased, the localized level of MSAT emissions for the Build Alternative could be higher relative to the No Build Alternative, but this could be offset due to increases in speeds and reductions in congestion (which are associated with lower MSAT emissions). Overall, EPA's vehicle and fuel regulations, coupled with fleet turnover, will over time cause substantial reductions that, in almost all cases, will cause MSAT levels to be significantly lower than today.

6. Incomplete or Unavailable Information for Project Specific MSAT Health Impacts Analysis

In FHWA's view, information is incomplete or unavailable to credibly predict the project-specific health impacts due to changes in MSAT emissions associated with a proposed set of highway alternatives. The outcome of such an assessment, adverse or not, would be influenced more by the uncertainty introduced into the process through assumption and speculation rather than any genuine insight into the actual health impacts directly attributable to MSAT exposure associated with a proposed action.

The EPA is responsible for protecting the public health and welfare from any known or anticipated effect of an air pollutant. They are the lead authority for administering the Clean Air Act and its amendments and have specific statutory obligations with respect to hazardous air pollutants and MSAT. The EPA is in the continual process of assessing human health effects, exposures, and risks posed by air pollutants. They maintain the Integrated Risk Information System (IRIS), which is "a compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects" (EPA, https://www.epa.gov/iris/). Each report contains assessments of non-cancerous and cancerous effects for individual compounds and quantitative estimates of risk levels from lifetime oral and inhalation exposures with uncertainty spanning perhaps an order of magnitude.

Other organizations are also active in the research and analyses of the human health effects of MSAT, including the Health Effects Institute (HEI). A number of HEI studies are summarized in Appendix D of FHWA's Updated Interim Guidance on Mobile Source Air Toxic Analysis in NEPA Documents. Among the adverse health effects linked to MSAT compounds at high exposures are cancer in humans in occupational settings; cancer in animals; and irritation to the respiratory tract, including the exacerbation of asthma. Less obvious is the adverse human health effects of MSAT compounds at current environmental concentrations (HEI Special Report 16, https://www.healtheffects.org/publication/mobile-source-air-toxics-critical-reviewliterature-exposure-and-health-effects) or in the future as vehicle emissions substantially decrease.

The methodologies for forecasting health impacts include emissions modeling; dispersion modeling; exposure modeling; and then final determination of health impacts – each step in the process building on the model predictions obtained in the previous step. All are encumbered by technical shortcomings or uncertain science that prevents a more complete differentiation of the MSAT health impacts among a set of project alternatives. These difficulties are magnified for lifetime (i.e., 70 year) assessments, particularly because unsupportable assumptions would have to be made regarding changes in travel patterns and vehicle technology (which affects emissions rates) over that time frame, since such information is unavailable.

It is particularly difficult to reliably forecast 70-year lifetime MSAT concentrations and exposure near roadways; to determine the portion of time that people are actually exposed at a specific location; and to establish the extent attributable to a proposed action, especially given that some of the information needed is unavailable. There are considerable uncertainties associated with the existing estimates of toxicity of the various MSAT, because of factors such as low-dose extrapolation and translation of occupational exposure data to the general population, a concern expressed by HEI (HEI Special Report 16, https://www.healtheffects.org/publication/mobile-source-air-toxicscritical-review-literature-exposure-and-health-effects). As a result, there is no national consensus on air dose-response values assumed to protect the public health and welfare for MSAT compounds, and in particular for diesel PM. The EPA states that with respect to diesel engine exhaust, "[t]he absence of adequate data to develop a sufficiently confident dose-response relationship from the epidemiologic studies has prevented the estimation of inhalation carcinogenic risk." (EPA IRIS database, Diesel Engine Exhaust, Section II.C. https://iris.epa.gov/static/pdfs/0642_summary.pdf).

There is also the lack of a national consensus on an acceptable level of risk. The current context is the process used by the EPA as provided by the Clean Air Act to determine whether more stringent controls are required in order to provide an ample margin of safety to protect public health or to prevent an adverse environmental effect for industrial sources subject to the maximum achievable control technology standards, such as benzene emissions from refineries. The decision framework is a two-step process. The first step requires EPA to determine an "acceptable" level of risk due to emissions from a source, which is generally no greater than approximately 100 in a million. Additional factors are considered in the second step, the goal of which is to maximize the number of people with risks less than 1 in a million due to emissions from a source. The results of this statutory two-step process do not guarantee that cancer risks from exposure to air toxics are less than 1 in a million; in some cases, the residual risk determination could result in maximum individual cancer risks that are as high as approximately 100 in a million. In a June 2008 decision, the U.S. Court of Appeals for the District of

Columbia Circuit upheld EPA's approach to addressing risk in its two-step decision framework. Information is incomplete or unavailable to establish that even the largest of highway projects would result in levels of risk greater than deemed acceptable.[13]

Because of the limitations in the methodologies for forecasting health impacts described, any predicted difference in health impacts between alternatives is likely to be much smaller than the uncertainties associated with predicting the impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against project benefits, such as reducing traffic congestion, accident rates, and fatalities plus improved access for emergency response, that are better suited for quantitative analysis.

7. MSAT Conclusions

What is known about MSATs is still evolving. Information is currently incomplete or unavailable to credibly predict the project-specific health impacts due to changes in MSAT emissions associated with the proposed improvements. Under the Build Alternative, there may be the same or slightly higher MSAT emissions in the Design-Year relative to the No Build Alternative due to increased VMT. There could also be increases in MSAT levels in a few localized areas where VMT increases. However, the EPA's vehicle and fuel regulations are expected to result in significantly lower MSAT levels in the future than exist today due to cleaner engine standards coupled with fleet turnover. The magnitude of the EPA-projected reductions is so great that, even after accounting for VMT growth, MSAT emissions in the study area would be significantly lower in the future than they are today, regardless of the preferred alternative chosen.

E. Greenhouse Gas and Climate Change

The Council on Environmental Quality (CEQ) issued the *NEPA Guidance on Consideration of Greenhouse Gas Emissions and Climate Change* on January 9, 2023[14], to assist agencies in analyzing greenhouse gas (GHG) and climate change effects of the proposed actions under NEPA review. According to the guidance, when conducting GHG and climate change analyses in NEPA reviews, agencies should consider:

- The potential effects of a proposed action on climate change, including by assessing both GHG emissions and reductions from the proposed action
- The potential effects of climate change on a proposed action and its environmental impacts

The CEQ guidance defines GHG as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3), and sulfur hexafluoride (SF_6). The unit of measurement for GHG is metric tons of CO_2 equivalent (mt CO_2e). The CEQ guidance does not establish any quantity of GHG emissions as ''significantly'' affecting the quality of the human environment but recommends considering a proposed action's potential GHG emissions and placing those emissions in context to understand their potential effects on climate change. Significance of GHG impacts is26 determined by the comparison of GHG emissions between alternatives and between build and no build scenarios. Emissions are put into context with other natural, social, and cultural resource impacts to determine the overall impacts of each alternative.

[13] https://www.cadc.uscourts.gov/internet/opinions.nsf/284E23FFE079CD59852578000050C9DA/$file/07-1053-1120274.pdf

[14] https://ceq.doe.gov/guidance/ceq_guidance_nepa-ghg.html

Further qualitative and quantitative analysis of GHG and Climate is included in **Appendix B** of this report.

F. Indirect Effects and Cumulative Effects

Indirect effects are defined by the CEQ as "effects which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water or other natural systems, including ecosystems" (40 CFR 1508.1(g)(2)). For transportation projects, induced growth is attributed to changes in accessibility caused by the project that influences the location and/or magnitude of future development.[15]

Cumulative impacts are defined by the CEQ as "effects which are effects on the environment that result from the incremental effects of the action when added to effects of other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time." (40 CFR 1508.1(g)(3)). According to the FHWA's Interim Guidance: Questions and Answers Regarding the Consideration of Indirect and Cumulative Impacts in the NEPA Process[16], cumulative impacts include the total of all impacts to a particular resource that have occurred, are occurring, and will likely occur" as a result of any action or influence, including the direct and reasonably foreseeable indirect impacts of a proposed project. Cumulative effects include indirect effects. The potential for indirect effects or cumulative effects to air quality that may be attributable to this proposed Project are not expected to be significant for several reasons.

First, regarding the potential for indirect effects, the assessments conducted for PM, qualitative analyses for MSAT and the regional conformity analysis conducted for ozone can all be considered indirect effects analyses because they look at air quality impacts attributable to the project that occur in the future and later in time. These analyses demonstrate that, in the future: 1) air quality impacts from PM will not cause or contribute to violations of the PM NAAQS, 2) MSAT and GHG emissions will be significantly lower than they are today, and 3) air quality conformity has been met through the 2050 Regional Transportation Plan (RTP) and FY 2023-2026 Transportation Improvement Program (TIP) Air Quality Conformity Determination.

Regarding the potential for cumulative impacts, USEPA's air quality designations for the region reflect, in part, the accumulated mobile source emissions from past and present actions. The regional conformity analysis conducted by WILMAPCO represents a cumulative impact assessment for purposes of regional air quality. The most recent conformity analysis was completed for the 2015 ozone standard and PM2.5 standard, including an updated conformity finding on March 2023.[17] The 2050 RTP and FY 2023-2026 TIP Air Quality Conformity Determination demonstrated that the proposed Project would not cause or

[15] See: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_466.pdf

[16] Federal Highway Administration, Interim guidance: Questions and answers regarding the consideration of indirect and cumulative impacts. U.S. Department of Transportation, (Januar,2024) https://www.environment.fhwa.dot.gov/nepa/QAimpact.aspx

[17] WILMAPCO, Air Quality Conformity Determination: For the New Castle County, Delaware Portion of the PA-NJ-MD-DE 8-hour Ozone Nonattainment Area & PA-NJ-DE Fine Particulate Matter (PM2.5)Maintenance Area, (March, 2023), http://www.wilmapco.org/Aq/NCCo_Conformity_3-9-23.pdf

contribute to a new violation, increase the frequency or severity of any violation, or delay timely attainment of the NAAQS established by USEPA.

Additionally, the *City of Wilmington's Comprehensive Master Plan* defines future land use for the proposed Project study area as waterfront mixed use to encourage infill and redevelopment in the area. Currently, South Wilmington has a high concentration of brownfields and vacancy, thus the Plan identifies the Project study area as a key area in Wilmington for redevelopment. This area is anticipated to have major land use changes due to the current concentrations of industrial and underutilized land.

Regarding the indirect air quality impact that would result from future commercial, retail, residential, and recreational land use at the site, the EPA conducted a study comparing the environmental performance of brownfield redevelopments with their greenfield counterparts in five municipal areas in the United States.[18] The brownfield redevelopments generally showed significant environmental benefits, including lower vehicle use, reduced carbon dioxide and air pollutant emissions. On average, neighborhoods on former brownfield sites had higher development density, better travel accessibility, and improved transit access. These results align with previous studies comparing brownfield or infill development with conventional and greenfield development. However, the extent of environmental improvement varied between cities and was influenced by factors like geographical barriers, socioeconomic characteristics, and the effectiveness of mass transit. However, there are clear environmental health benefits associated with compact development, such as what is planned for the proposed Project. The study noted several benefits of Brownfield development related to air quality, emissions, and greenhouse gasses:

- Brownfield development results in reduced vehicle miles traveled and fewer roads and highways needed to support these communities. This, in turn, lowers emissions from vehicular sources, leading to improved air quality. The study found that daily vehicle miles traveled per capita in brownfield locations were estimated to be 32-57% lower than their alternative locations. These reduced travel distances significantly contribute to reduced emissions of air pollutants and greenhouse gases, resulting in cleaner air.
- Compact development on brownfields leads to lower energy consumption due to shorter travel distances and better access to alternative transportation modes. The study found that personal vehicle energy use per capita in brownfield locations was estimated to be 32-57% lower compared to their alternative locations. This reduced energy consumption translates to fewer emissions from personal vehicle travel, resulting in improved air quality and reduced emissions of greenhouse gases.
  Compact brownfield development can positively impact climate change by preserving green spaces and reducing the conversion of forests into developed areas. It mentions that forests sequester carbon, and their preservation helps maintain this sequestration, reducing atmospheric carbon dioxide levels. By focusing on brownfield redevelopment and infill development, the study found that these practices contribute to lowering emissions of greenhouse gases, which have a direct positive impact on mitigating climate change.
- Compact brownfield and infill residences are designed to be energy-efficient. The study provides specific results for the Seattle area, where residential energy consumption for brownfield properties was found to average 6% lower than that of the alternative sites. This lower energy

[18] EPA, Air and Water Quality Impacts of Brownfields Redevelopment: A Study of Five Communities; EPA 560-7-10-232, (April 2011), https://www.epa.gov/sites/default/files/2015-09/documents/bfenvironimpacts042811.pdf

consumption translates to fewer emissions from power generation and energy production, contributing to cleaner air and reduced emissions of greenhouse gases.

In summary, compact brownfield development, by reducing infrastructure needs, lowering energy consumption, preserving green spaces, and encouraging energy-efficient residences, has a significant and positive impact on air quality and emissions. These measures contribute to a cleaner and healthier environment while simultaneously addressing the challenges of climate change and greenhouse gas reduction.

Therefore, given the programmed conformity determinations of the Project and the nature of brownfield redevelopment for which the proposed Project is intended, the indirect and cumulative effects of the proposed Project are not expected to be significant and will not cause or contribute to a new violation, increase the frequency or severity of any violation, or delay timely attainment of the NAAQS established by the EPA.

Additional information is provided in the *Indirect and Cumulative Effects Technical Report.*

G. Construction Emissions Analysis

Construction of this proposed Project would cause temporary increases in criteria pollutant emissions. A quantitative assessment of criteria pollutant emissions from construction is not included for the analysis of this project, as construction emissions are not required to be considered for conformity purposes if the emissions occur only last five years or less at any individual site (40 CFR 93.123(c)(5). As cited in Appendix B, the greenhouse analysis for this project did estimate construction GHG emissions, since these emissions would contribute to increasing atmospheric concentration of GHG emissions given the long lifetime of CO_2 and other GHGs.

Trucks traveling to and from the Project study area during the construction would access the area via I-495, US Business 13/ South Market Street and Judy Johnson Drive. The construction plan would include first constructing the main north-south spine road through the Project study area, currently identified as Orange Street. Construction trucks and vehicles would access Orange Street from Judy Johnson Drive, travel through the site and exit via South Market Street. This approach would limit the construction-related traffic to existing regional roadways and minimize Project-related construction traffic traveling through adjacent residential communities.

Fugitive dust is airborne particulate matter, generally of a relatively large particulate size. Construction-related fugitive dust would be generated by haul trucks, concrete trucks, delivery trucks, and earth-moving vehicles operating around the construction sites. This fugitive dust would be caused by particulate matter that is re-suspended ("kicked up") by vehicle movement over paved and unpaved roads, dirt tracked onto paved surfaces from unpaved areas at access points, and material blown from uncovered haul trucks. Generally, the distance that particles drift from their source depends on their size, the emission height, and the wind speed. Small particles (30 to 100 micron range) can travel several hundred feet before settling to the ground. Most fugitive dust, however, is comprised of relatively large particles (that is, particles greater than 100 microns in diameter). These particles are responsible for the reduced visibility often associated with this type of construction. Given their relatively large size, these particles tend to settle within 20 to 30 feet of their source.

Defined areas of the Project study area have been impacted by metals, VOCs, Semi-volatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyl (PCBs) from current and past site operations and are categorized based on the potential presence of contaminants of concern as documented in the EA section regarding Hazardous Materials. Recommendations to minimize and mitigate hazardous materials and dust within the Project study area include:

- Collect soil and groundwater samples from sites that have not been fully characterized
- Prepare a Contaminated Materials Management Plan (CMMP), and a site-specific Health and Safety Plan (HASP) to address soil, sediment, groundwater management, environmental health, and worker safety during construction activities
- Perform remediation, installation and/or maintenance of vapor barriers or impervious caps, and application of environmental covenants (ECs) and/or Operations and Maintenance (O&M) Plans, as necessary, within "yellow" or "red" assigned sites; no additional recommendations are required for "green" assigned sites.

If any hazardous material is encountered during Project construction, coordination with DNREC regarding the appropriate treatment and disposal options will be made. Additionally, proper precautions would be taken during construction to ensure that construction workers are not exposed to hazardous materials.

To minimize the amount of construction dust generated, prevention and mitigation measures can be taken to minimize the potential particulate pollution problem, such as:

- **Site Preparation:**
  - Minimize land disturbance
  - Use watering trucks to minimize dust
  - Cover trucks when hauling dirt
  - Stabilize the surface of dirt piles if they are not removed immediately - Use windbreaks to prevent accidental dust pollution
  - Limit vehicular paths and stabilize temporary roads
- **Construction:**
  - Cover trucks when transferring materials
  - Use dust suppressants on unpaved traveled paths
  - Minimize unnecessary vehicular and machinery activities
  - Minimize dirt track-out by washing or cleaning trucks before leaving the construction site. An alternative to this strategy is to pave a few hundred feet of the exit road just before entering the public road.

To reduce emissions generated by construction, the contactor should consider the following best management practices (BMPs) for reducing construction emissions and improving energy efficiency during construction, as outlined by EPA's Diesel Emissions Reduction Act program, and employing the operational and equipment strategies detailed in the EPA publication, "Cleaner Diesels: Low Cost Ways to Reduce Emissions from Construction Equipment." These strategies include use of the following BMPs association with on-site construction:

- Utilize appropriate dust suppression methods during on-site construction activities. Available methods include application of water, soil stabilizers, or vegetation; use of enclosures, covers, silt fences, or wheel washers; and suspension of earth-movement activities during high wind conditions;

- Maintain a speed of less than 15 mph with construction equipment on unpaved surfaces as well as utilize fuel with lower sulfur content;
- Employ a construction management plan in order to minimize interference with regular motor vehicle traffic;
- Use electricity from power poles instead of generators whenever possible;
- Repair and service construction equipment according to the regular maintenance schedule recommended for each individual equipment type;
- Use low-VOC architectural materials and supplies equipment; and
- Incorporate energy-efficient supplies whenever feasible.

Additional information is provided in the *Hazardous Materials Survey Technical Report*

V. Mitigation

Emissions may be produced in the construction of this proposed Project from heavy equipment and vehicle travel to and from the site, as well as from fugitive sources. Construction emissions are short term or temporary in nature. To mitigate these emissions, all construction activities are to be performed per the DelDOT *Standard Specifications for Road and Bridge Construction*.[19] The specifications require compliance with all applicable local, state, and federal regulations.

Measures will also be taken to minimize exposed earth by stabilizing with grass, mulch, pavement, or other cover as early as possible, applying water as a stabilizing agent to working or haulage areas, covering, shielding, or stabilizing of stockpiled materials as necessary, and the use of covered trucks.

VI. Conclusion

The proposed improvements associated with the proposed Project were assessed for potential air quality impacts and compliance with applicable air quality regulations and requirements. All models, methods/protocols, and assumptions applied in modeling and analyses were made consistent with those provided or specified by EPA and FHWA. The assessment indicates that the proposed Project would meet all applicable air quality requirements of NEPA and federal and state transportation conformity regulations. As such, the proposed Project would not cause or contribute to a new violation, increase the frequency or severity of any violation, or delay timely attainment of the NAAQS established by the EPA.

[19] https://deldot.gov/Publications/manuals/standard_specifications/pdfs/2022/Standard_Specification_Revision2_JUNE2022.pdf?cache=1677532099614

APPENDIX A

Traffic Data

Wilmington Riverfront Transportation Infrastructure Project
Wilmington, Delaware Area 1 and Area 2 Air Quality Analysis
Traffic Data
RK&K – February 2023

Attachments

A	2040 No-Build Peak Hour Volumes
B	2040 100% Build Peak Hour Volumes
C	Annual Average Hourly Distribution Factor Group for Week Days
D	Diesel Percentage Calculation

Sources, Assumptions, and Methodology

- The segment lengths, in miles, were measured from the Synchro network link lengths. The Synchro model was based on existing aerial maps and the South Market Street Master Plan dated October 15, 2019.
- Peak Hour Volume forecasts from the South Market Street Redevelopment Master Planning Traffic Operational Analysis were used as a baseline to determine Average Daily Traffic (ADT) volumes.
    - 100% Build Volumes include 2040 volumes at the intersections within the Phase 1 development area assuming all development (Phases 1-4) is complete.
    - For both 2040 No-Build and 2040 100% Build conditions, DelDOT's most recent Diurnal Distribution Tables (2021) were used to estimate the Average Weekday Daily Traffic (AWDT) on each segment from the AM and PM peak hour forecasts:
        - Traffic Pattern Group (TPG) 2 was used to estimate AWDT on S Market Street: AM and PM peak hour volumes account for 5.3% and 7.63% of AWDT, respectively.
        - TPG 3 was used to estimate AWDT on all other roadways: AM and PM peak hour volumes account for 7.24% and 8.80% of AWDT, respectively.
        - The AWDT was assumed to be the maximum of either:
            a) AWDT calculated from the combined AM and PM peak hour volumes, or
            b) The average of the AWDT calculated from the AM peak hour volumes and the PM peak hour volumes, separately.
        - The AWDT volumes were rounded to the nearest 100 vehicles per day.
    - AWDT was converted to ADT using a factor of 0.863.
        - This factor is the ratio of average weekday daily traffic to average daily traffic from a nearby 7-day tube count on the S Head St Off Ramp to New Castle Ave conducted in late November and early December 2018.
        - ADT volumes were rounded to the nearest 100 vehicles per day.
- Geometric improvements identified in the 100% Build analysis include:
    - The intersection of South Market Street and New Sweden Street will remain the same as existing/No-Build conditions.
    - The intersection of New Sweden Street and S Orange Street will be a one-lane roundabout.
- The diesel percentages were based on a February 2008 classification count on New Castle Avenue, just south of A Street and the gasoline vs. diesel breakdown used by MDOT SHA
    - Out of the existing classification data that was available from past studies and on the DelDOT TMC count database, this location is the most similar to the

proposed land use of the South Market Street redevelopment, including a mix of residential and non-residential uses.

- The MDOT SHA Travel Forecasting Reference Manual includes the following breakdown:

Air Quality Analysis Vehicle Classification	FHWA Vehicle Classification	Gasoline Powered	Diesel Powered
Light Trucks	Class 4 & 10% of Class 5	50%	50%
Medium Trucks	90% of Class 5	50%	50%
Heavy Trucks	Class 6-13	5%	95%

- The resulting network-wide diesel percentage is **5.3%**.
- The fraction of ADT by diesel vehicles is rounded to the nearest 10 vehicles per day.

2040 No-Build

#	Roadway	Start	End	Segment Length (Miles)	ADT (vpd)	Percent Diesel	Diesel ADT (vpd)
1	SB Market St	A St	Howard St	0.16	21,300	5.3%	1,130
2	SB Market St	Howard St	U-Turn	0.26	20,400	5.3%	1,080
3	SB Market St	U-Turn	New Sweden St	0.07	19,100	5.3%	1,010
4	New Sweden St	US 13	Delmarva Ln	0.50	4,800	5.3%	250

2040 100% Build

#	Roadway	Start	End	Segment Length (Miles)	ADT (vpd)	Percent Diesel	Diesel ADT (vpd)
5	SB Market St	A St	1st St	0.08	27,700	5.3%	1,470
6	SB Market St	1st St	Howard St	0.08	27,100	5.3%	1,440
7	SB Market St	Howard St	2nd St	0.07	29,200	5.3%	1,550
8	SB Market St	2nd St	3rd St	0.07	29,000	5.3%	1,540
9	SB Market St	3rd St	4th St	0.07	29,100	5.3%	1,540
10	SB Market St	4th St	5th St	0.07	28,500	5.3%	1,510
11	SB Market St	5th St	New Sweden St	0.06	30,000	5.3%	1,590
12	New Sweden St	US 13	Middle St	0.09	10,100	5.3%	540
13	New Sweden St	Middle St	Orange St	0.07	7,300	5.3%	390
14	Howard St	Orange St	S Market St	0.07	6,500	5.3%	340
15	A St	S Market St	Orange St	0.08	4,400	5.3%	230
16	1st St	S Market St	Orange St	0.07	3,400	5.3%	180
17	2nd St	S Market St	Orange St	0.09	4,100	5.3%	220
18	3rd St	S Market St	Middle St	0.06	5,600	5.3%	300
19	3rd St	Middle St	Orange St	0.05	4,600	5.3%	240
20	4th St	S Market St	Middle St	0.07	500	5.3%	30
21	5th St	S Market St	Middle St	0.10	1,900	5.3%	100
22	5th St	Middle St	Orange St	0.06	2,800	5.3%	150
23	Middle St	3rd St	4th St	0.07	2,200	5.3%	120
24	Middle St	4th St	5th St	0.06	2,700	5.3%	140
25	Middle St	5th St	New Sweden St	0.06	3,100	5.3%	160
26	Orange St	A St	1st St	0.08	2,400	5.3%	130

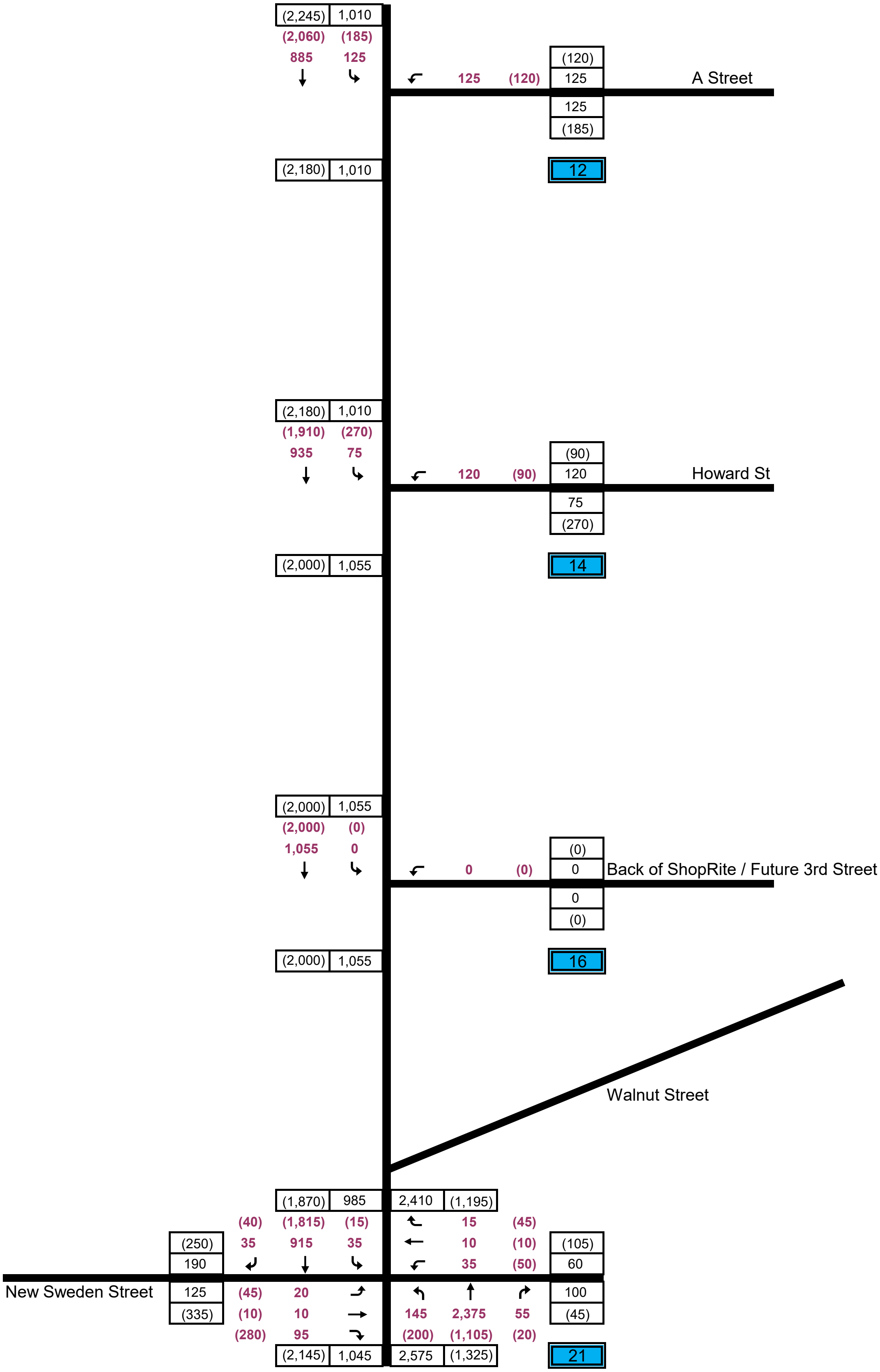
2040 100% Build (cont.)

#	Roadway	Start	End	Segment Length (Miles)	ADT (vpd)	Percent Diesel	Diesel ADT (vpd)
27	Orange St	1st St	Howard St	0.09	3,500	5.3%	190
28	Orange St	Howard St	2nd St	0.07	5,600	5.3%	300
29	Orange St	2nd St	3rd St	0.09	4,100	5.3%	220
30	Orange St	3rd St	4th St	0.06	5,600	5.3%	300
31	Orange St	4th St	5th St	0.06	5,800	5.3%	310
32	Orange St	5th St	New Sweden St	0.07	4,800	5.3%	250

Attachment A

2040 No-Build Peak Hour Volumes

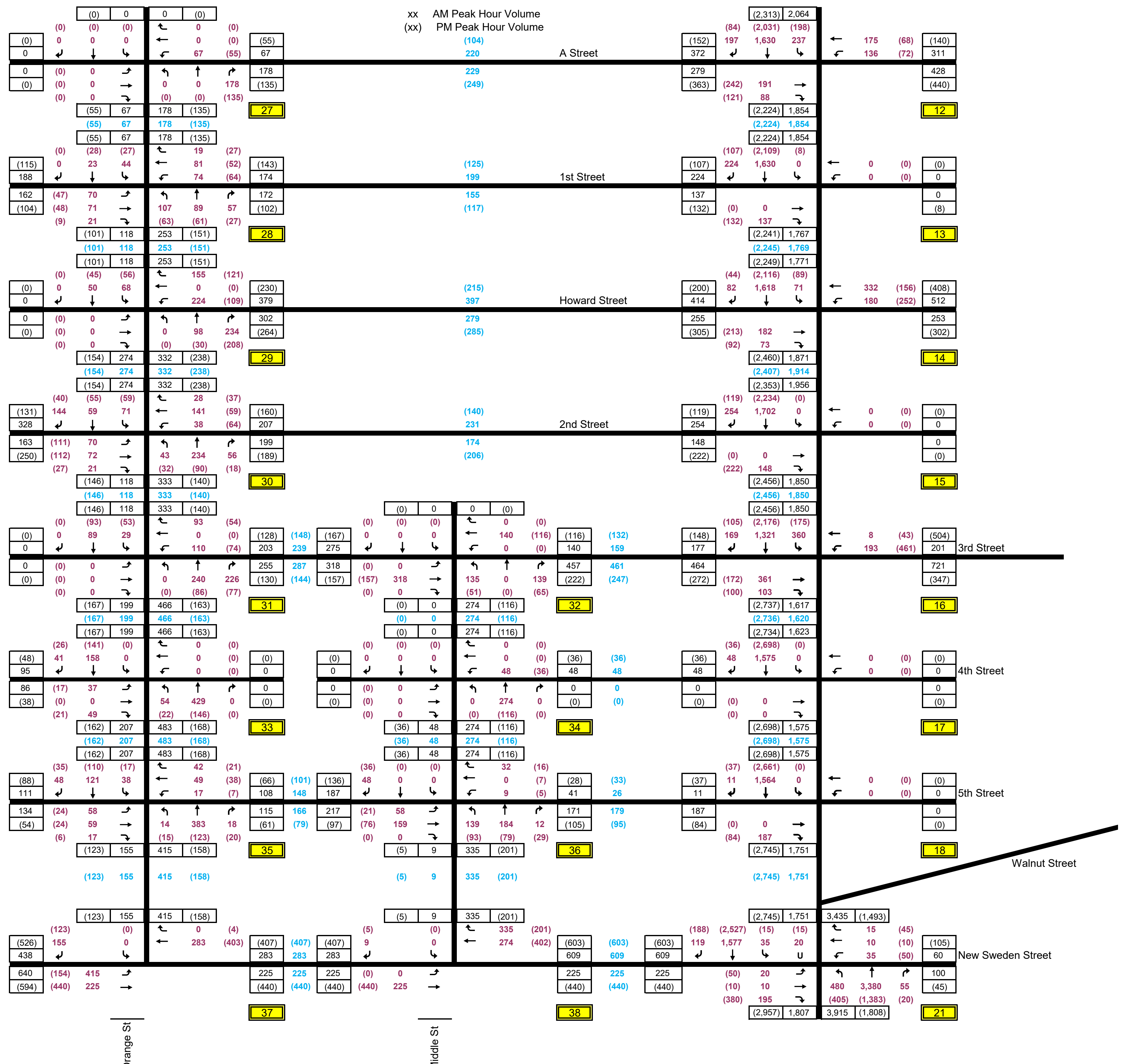
2040 No-Build Volumes
xx AM Peak Hour
(xx) PM Peak Hour



Attachment B

2040 100% Build Peak Hour Volumes

2040 100% Build Volumes



Attachment C

Delaware DOT

Annual Average Hourly Distribution Factor Group for Week Days

Delaware DOT

Annual Average Hourly Distribution By Factor Group for Week Days

2021

	1	2	3	5	6	7	8
0	1.14	0.71	0.61	0.68	1.28	0.61	0.64
1	0.82	0.46	0.38	0.51	1.17	0.40	0.45
2	0.74	0.40	0.29	0.52	1.25	0.43	0.38
3	0.85	0.53	0.32	0.68	1.93	0.65	0.41
4	1.38	0.97	0.68	1.03	2.46	1.28	0.77
5	2.76	1.93	1.75	2.11	3.50	3.13	1.66
6	4.91	3.63	4.11	4.57	5.59	4.97	4.17
7	6.19	5.30	7.24	6.58	6.63	6.64	6.44
8	5.81	5.31	5.89	5.84	5.32	6.02	5.93
9	5.23	5.08	4.65	5.60	4.74	5.17	5.71
10	5.30	5.61	4.75	5.94	4.92	5.01	6.10
11	5.55	6.34	5.13	6.32	5.14	5.16	6.33
12	5.76	6.88	5.80	6.53	5.46	5.53	6.53
13	5.89	6.78	5.94	6.64	5.72	5.78	6.58
14	6.36	7.11	7.03	6.97	6.23	6.25	7.03
15	6.94	7.64	7.96	7.53	6.67	7.30	7.76
16	7.17	8.08	9.12	7.88	7.27	8.63	7.87
17	6.85	7.63	8.80	7.10	6.93	8.46	7.14
18	5.52	5.95	6.13	5.10	5.14	6.26	5.11
19	4.42	4.68	4.53	3.82	3.67	4.31	4.25
20	3.63	3.54	3.51	3.04	3.05	3.29	3.26
21	2.87	2.52	2.44	2.27	2.42	2.36	2.52
22	2.21	1.72	1.77	1.61	1.95	1.47	1.83
23	1.69	1.20	1.17	1.13	1.55	0.89	1.10

Diurnal used for S Market Street

Diurnal used for all other roadways

Attachment D
Diesel Percentage Calculations

Diesel Percentages

NOTE: The vehicle classifications shown in the table below are assumed for all roads within the project area under 2040 No-Build and 2040 100% Build conditions

Autos	91.6%
Medium	3.3%
Heavy	2.5%
Buses	2.4%
Cycles	0.1%

	% of Volume	% Diesel by Type	Total % Diesel
Light Trucks	2.8%	50%	1.4%
Medium Trucks	3.0%	50%	1.5%
Heavy Trucks	2.5%	95%	2.4%
			5.3%

Data Source: February 2008 Classification Count - New Castle Avenue just South of A Street

Class 1	17	0.1%
Class 2	9626	79.7%
Class 3	1431	11.9%
Class 4	294	2.4%
Class 5	396	3.3%
Class 6	142	1.2%
Class 7	20	0.2%
Class 8	34	0.3%
Class 9	75	0.6%
Class 10	20	0.2%
Class 11	0	0.0%
Class 12	1	0.0%
Class 13	6	0.0%
Class 14	0	0.0%
Class 15	9	0.1%
Total	12071	100%

Wilmington Riverfront Transportation Infrastructure Project

Draft Environmental Assessment

Appendix E - Air Quality Technical Report

Greenhouse Gas Analysis Appendix B

March 29, 2024

Table of Contents

Figures

Tables

Attachments

List of Acronyms

CAFE - Corporate Average Fuel Economy

CEQ - Council on Environmental Quality

CH_4 - Methane

CO_2 - Carbon Dioxide

DNREC - Delaware Department of Natural Resources and Environmental Control

EA - Environmental Assessment

EPA - Environmental Protection Agency

EO - Executive Order

FEMA - Federal Emergency Management Agency

FHWA - Federal Highway Administration

GHG - Greenhouse Gas

GWP - Global Warming Potential

ICE - Infrastructure Carbon Estimator

IWG - Interagency Working Group

MT CO_2e - Metric Tons of Carbon Dioxide Equivalent

MMT CO_2e - Million Metric Tons of Carbon Dioxide Equivalent

MOVES - Motor Vehicle Emission Simulator

N_2O - Nitrous Oxide

NCA - National Climate Assessment

NEPA - National Environmental Policy Act

NHTSA - National Highway Traffic Safety Administration

RAISE - Rebuilding American Infrastructure with Sustainability and Equity

RCP - Representative Concentration Pathway

RDC - Riverfront Development Corporation of Delaware

RTP - Regional Transportation Plan

SC-GHG - Social Cost of Greenhouse Gas

SLR - Sea Level Rise

TSD - Technical Support Document

USDOT - United States Department of Transportation

USGCRP - U.S. Global Change Research Program

VMT - Vehicle Miles Traveled

WILMAPCO - Wilmington Area Planning Council

I. Introduction

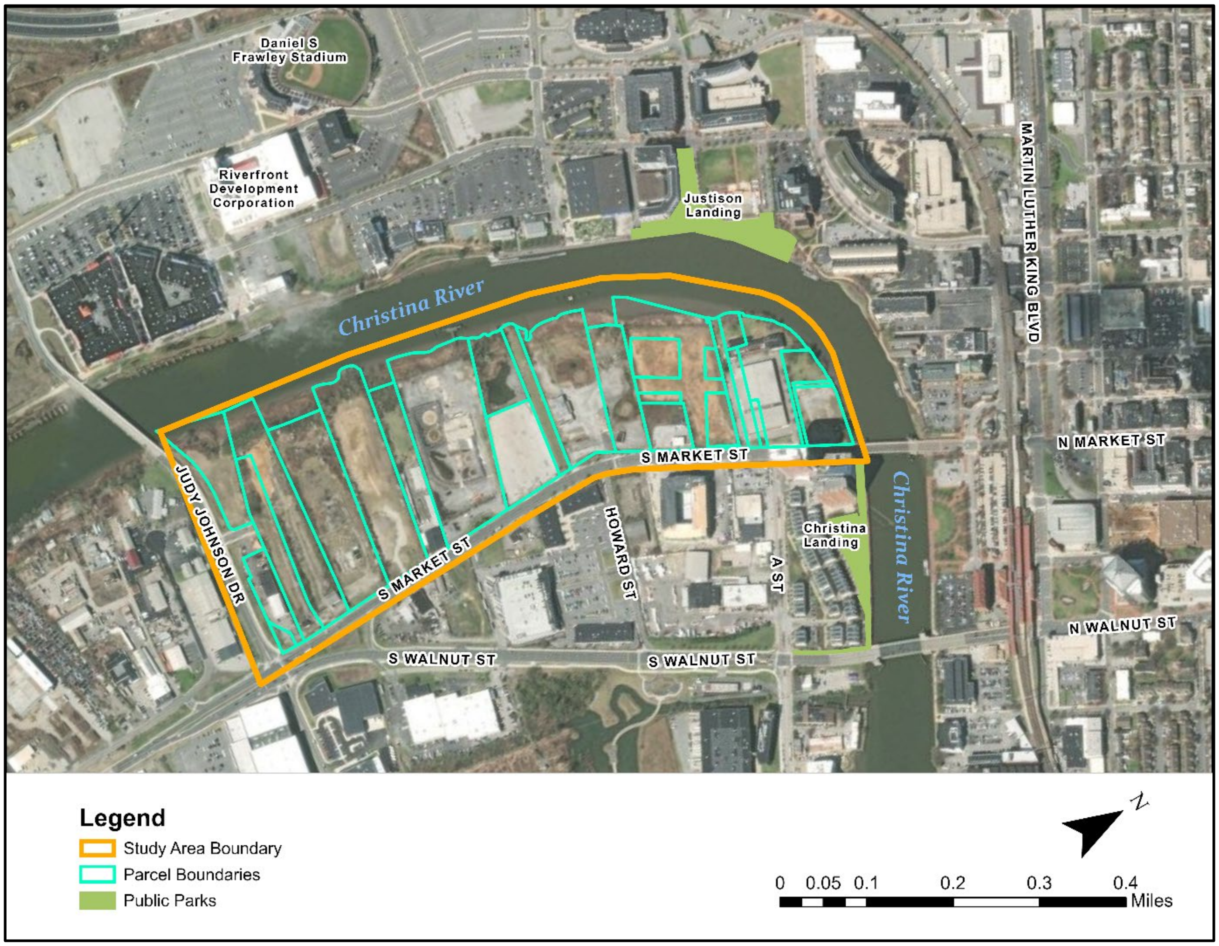
On November 19, 2021, the City of Wilmington, Delaware, was awarded federal funds though a U.S. Department of Transportation FY 2021 Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grant. The Federal Highway Administration (FHWA), as the lead Federal Agency; the City of Wilmington, as project sponsor and joint lead agency; and in partnership with the Riverfront Development Corporation (RDC), are preparing an Environmental Assessment (EA) for the Wilmington Riverfront Transportation Infrastructure Project (formerly known as the South Market Street Redevelopment Project) in accordance with the requirements of the National Environmental Policy Act of 1969 (NEPA), the Council on Environmental Quality (CEQ) regulations implementing NEPA, FHWA regulations implementing NEPA, and applicable Federal, state, and local laws and regulations.

The *Greenhouse Gas Analysis Appendix B* was developed to support the *Air Quality Technical Report Appendix E* of the Draft EA for the Wilmington Riverfront Transportation Infrastructure Project (Project). The following analysis presents the existing conditions and an assessment of potential effects of the Build Alternatives to greenhouse gases and climate change. The analysis begins with a description of the Project study area followed by a summary of the Purpose and Need, and a description of the alternatives evaluated.

A. Study Area

The Project is located along the east Christina riverbank in Wilmington, New Castle County, Delaware. The Project's study area is bound by the Christina River on the north and west and by South Market Street on the east and by Judy Johnson Drive (formerly New Sweden Street) in the south (**Figure 1**).

Figure 1: Wilmington Riverfront Transportation Infrastructure Project Study Area Map



The existing conditions of the Project study area include former industrial buildings and accessory structures, surface parking, former junkyards, miscellaneous uses, and brownfields. This area has been shaped by its history of shipping and manufacturing and was active industrial area until its decline after World War II. The *City of Wilmington's 2028 Comprehensive Plan*[1] defines the land use in the Project study area as waterfront mixed use and the entire Project study area is within the 100-year floodplain caused by coastal storm surge from the Delaware Bay. The parcels located within the Project study area have limited access for vehicles, pedestrians, and bicycles.

The Christina riverbank on the western and northern boundary of the study area is marshy and largely inaccessible. Significant differences of elevation between the high and low tide conditions have created a mud flat condition along the northern and western edges of the Project study area. South Market Street, the eastern project border, is a one-way, four-lane arterial road that extends 0.57 mile along the study area.

[1] https://www.wilmingtonde.gov/government/city-departments/planning-and-development/wilmington-2028

The purpose of the Project is to provide transportation infrastructure to further the connectivity of the riverfront area and provide multi-modal resources. The needs of the Project are the following:

- An expanded road network branching from South Market Street west into the Project study area;
- Pedestrian and cyclist accommodation on new roadways and a new set of pedestrian and bicycle pathways that connect to the existing network of pathways surrounding the site along the Christina riverbank; and
- Rehabilitate and create effective stormwater management.

The proposed improvements would replicate the city grid characteristics of the North Market Street corridor, north of the Christina River and southward to the intersection of South Market Street and Judy Johnson Drive (formerly New Sweden Street).

B. Alternatives Considered

The alternatives considered in the EA include a No Build and a Build Alternative and are briefly described below.

1. No Build Alternative

The No Build Alternative assumes the roadway infrastructure; Riverwalk; pedestrian, bicycle and mobility improvements; flood prevention measures; and drainage work would not occur. The No Build Alternative does not meet the purpose and need for this Project, as it would not provide transportation infrastructure to further the connectivity or the area; provide multi-modal resources, including pedestrian and cyclist accommodations; nor rehabilitate or create effective stormwater management. However, the No Build Alternative does provide a baseline condition with which to compare the Build Alternative. Therefore, the No Build Alternative is retained for evaluation purposes.

2. Build Alternative

The Build Alternative proposes to construct transportation infrastructure improvements for the South Market Street Riverfront East area of the City. The Build Alternative proposes an expanded road network branching from South Market Street towards the Christina River and replicating the downtown Wilmington grid system in the Project study area (**Figure 2**). Infrastructure improvements are proposed to create continuity of intersection type / spacing and provide key points of access into the Project study area.

The proposed street grid is a balance of defining buildable parcels as well as appropriate infrastructure access for vehicles (local, commuter, public transportation), pedestrians, and bicyclists and will include on street parking. The proposed grid considers major circulation movements, creating three east-west and evenly spaced signalized movements across South Market Street, and connecting the major north-south Market Street and Walnut Street corridors to Orange Street within the limits of the Project study area (from north to south: at A Street, Howard Street, and Jones Street).

Pedestrian routes were also considered while laying out the proposed grid. The Build Alternative proposes to include pedestrian and cyclist accommodations on new roadways and a new set of pedestrian and bicycle pathways that connect to the existing network of pathways surrounding the Project study area (shown in orange in **Figure 2**). The proposed location of the east-west movements at A Street and Howard Street provides direct pedestrian access to and from the South Market Street Bridge, the Walnut Street corridor, the Wilmington Wetland Park, and the Southbridge neighborhood located east of the proposed Project study area. At the south end of the Project study area, proposed pedestrian and bicycle connections from the proposed street grid connect directly to existing pedestrian and bicycle connections that currently cross the river to the western Riverfront via Judy Johnson Drive and the Senator Margaret Rose Henry Bridge.

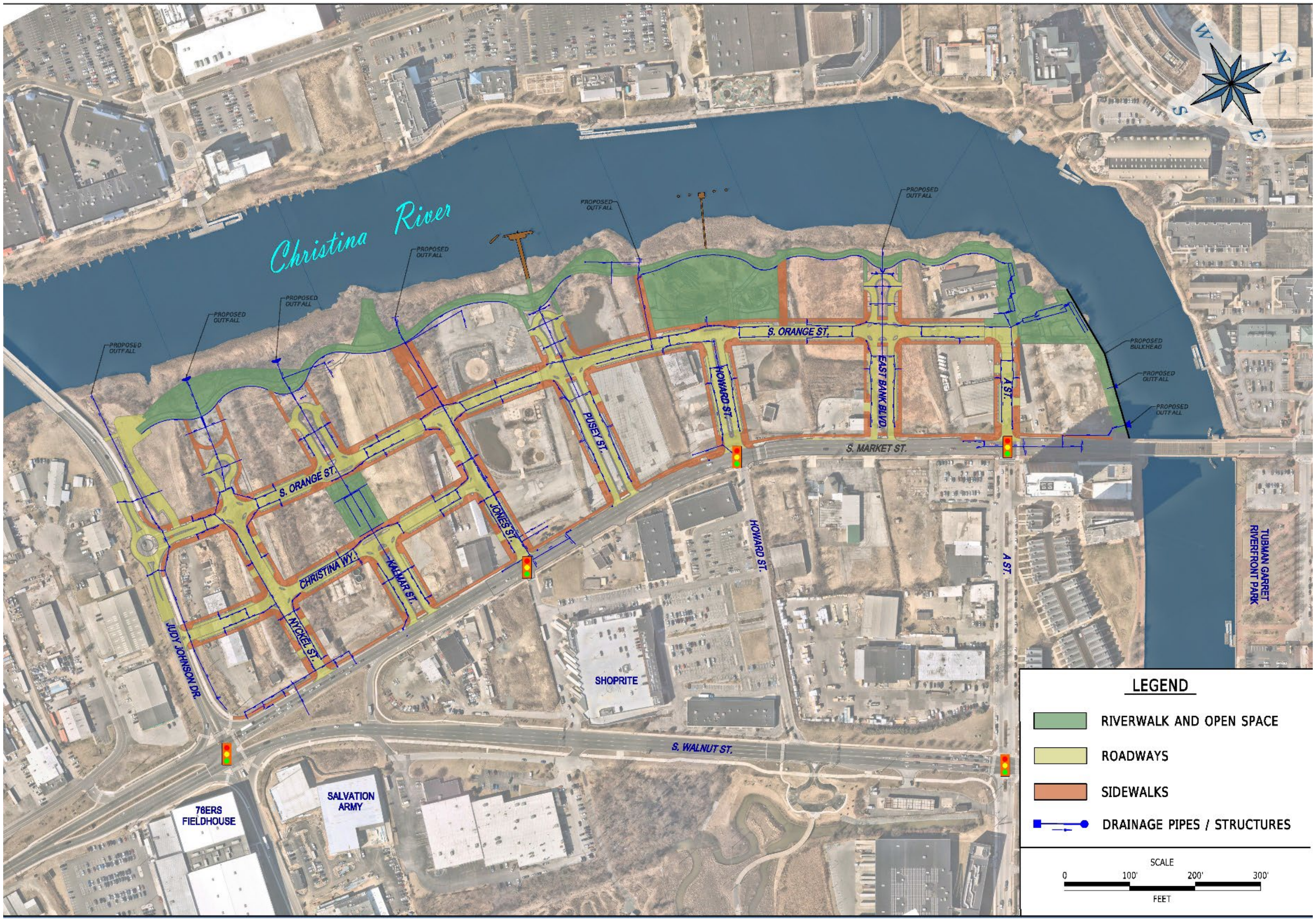
Adjacent to the eastern riverbank, a Riverwalk similar to the existing Riverwalk on the western riverbank is proposed to be built as part of the Build Alternative to provide access to this currently inaccessible riverfront. The Riverwalk would be a minimum width of 18 feet and include a dedicated eight-foot bike lane alongside a pedestrian walkway. Under the Build Alternative, connections between the east and west Riverwalks are proposed via the existing Senator Margaret Henry Rose Bridge to the south and the South Market Street bridge to the north.

Under the Build Alternative, the proposed in-water work would include repairing the existing bulkhead which is in current disrepair. The Build Alternative proposes to construct a new bulkhead in front of the existing bulkhead. The new bulkhead would be a higher elevation to allow the new Riverwalk to be constructed at a minimum of 18 inches above the 100-year flood elevation. The tidal influence of the river exposes mud flats in front of the existing bulkhead during the tide cycles. The new bulkhead would be constructed from the landside of the existing bulkhead.

The transportation infrastructure improvements under the Build Alternative also incorporate strategic resiliency solutions to environmental challenges currently faced by the site. The Project Study Area is expected to be entirely inundated in the case of a 100-year flood event under its current condition. The Build Alternative would elevate the transportation elements in compliance with the Federal Emergency Management Agency (FEMA) Floodplain Regulations to protect the site from inundation and flood-related damage. While the existing South Market Street roadway will remain at its existing elevation below the 100-year flood event, all other proposed roads would be constructed at elevations above the 100-year flood event except where they would connect to existing streets at lower elevations. Additionally, proposed sidewalks and the Riverwalk would also be at elevations above the 100-year flood event. These Project elements are aligned with the City of Wilmington's strategies to harden infrastructure vulnerable to sea level rise and extreme weather events.

Currently, the Project study area has 23.3 acres of impervious area. As part of the Build Alternative, all of the existing impervious surface would be removed accordingly. The proposed transportation improvements would reduce impervious area to 18.6 acres (a decrease of 4.7 acres). The Build Alternative proposes to add drainage outfalls to support the proposed transportation infrastructure. The outfalls would be strategically located throughout the Project study area to address ongoing drainage issues and provide adequate conveyance for the proposed transportation infrastructure. All proposed outfalls would be designed to discharge above Mean Low Water elevation of the Christina River at higher elevations than existing outfalls. In addition to the higher outfall elevation, there would be tide control valves installed at each outfall to eliminate the backup of the tidal water during the tidal fluctuations. The proposed storm drain and trench drain systems would be designed to provide efficient collection of surface runoff and adequate conveyance of stormwater throughout the Project study area. The separation of storm drain networks and proposed construction of new outfalls would provide an overall improvement to the current drainage conditions to the tidally influenced Christina River throughout the Project study area.

Figure 2: Build Alternative Site Plan



II. Greenhouse Gases and Climate Change

Climate change refers to long-term changes in temperature, precipitation, wind patterns, and other elements of the Earth's climate system. The Intergovernmental Panel on Climate Change (IPCC), established by the United Nations and World Meteorological Organization in 1988, is devoted to greenhouse gas (GHG) emissions reduction and climate change research and policy. Climate change in the past has generally occurred gradually over millennia, or more suddenly in response to cataclysmic natural disruptions. The research of the IPCC and other scientists over recent decades, however, has attributed an accelerated rate of climatological changes over the past 150 years to GHG emissions generated from the production and use of fossil fuels. The impacts of climate change are being observed in the form of sea level rise, drought, more intense heat, extended and severe fire seasons, and historic flooding from changing storm patterns. Climate change does not affect all people equally. Some communities experience disproportionate impacts because of existing vulnerabilities, historical patterns of inequity, socioeconomic disparities, and systemic environmental injustices. People who already face the greatest burdens are often the ones affected most by climate change.

Human activities generate GHGs consisting primarily of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), tetrafluoromethane, hexafluoroethane, sulfur hexafluoride, and various hydrofluorocarbons. CO_2 is the most abundant GHG; although CO_2 is a naturally occurring and necessary component of Earth's atmosphere, fossil fuel combustion is the main source of additional, human-generated CO_2 that is the main driver of climate change. In the United States, transportation is the largest source of GHG emissions, mostly CO_2. In Delaware, the transportation sector is the top GHG contributor.

The Council on Environmental Quality (CEQ) published interim guidance on January 9, 2023, regarding how to evaluate GHG emissions and climate change under NEPA. According to the interim guidance, when conducting climate change analyses in NEPA reviews, agencies should consider the potential effects of a proposed action on climate change, including by assessing both GHG emissions and reductions from the proposed action, as well as the effects of climate change on a proposed action and its environmental impacts. The CEQ interim guidance does not establish any particular quantity of GHG emissions as "significantly" affecting the quality of the human environment (CEQ 2023).

The interim guidance also provides considerations to document how GHG emissions impact environmental justice populations. The guidance notes: "Numerous studies have found that environmental hazards (including those driven by climate change) are more prevalent in and pose particular risks to areas where people of color and low-income populations represent a higher fraction of the population compared with the general population." The guidance also notes: "Agencies should be aware of the ongoing efforts to address the effects of climate change on human health and vulnerable communities. Certain groups, including children, the elderly, communities with environmental justice concerns, which often include communities of color, low-income communities, Tribal Nations and Indigenous communities, and underserved communities are more vulnerable to climate-related health effects and may face barriers to engaging on issues that disproportionately affect them" (CEQ 2023). Thus, because there are environmental justice populations present in the Project study area, and the interim guidance notes that environmental justice populations are generally at increased risk for climate change-related harms, this report documents the impacts of GHG emissions on environmental justice populations. Detailed information on project engagement with environmental justice communities and impacts can be found in the **EA, Appendix B**.

This technical memorandum summarizes the GHG and climate change impact analysis of the Wilmington Riverfront Transportation Infrastructure Project following the CEQ (2023) interim guidance.

III. Regulatory Background

A. Federal

The federal government has taken steps to improve fuel economy and energy efficiency to address climate change and its associated effects. The most important of these were the Energy Policy and Conservation Act of 1975 (42 United States Code [USC] Section 6201), as amended by the Energy Independence and Security Act of 2007, and Corporate Average Fuel Economy (CAFE) standards. The National Highway Traffic Safety Administration (NHTSA) of the United States Department of Transportation (USDOT) sets and enforces the CAFE standards based on each manufacturer's average fuel economy for the portion of its vehicles produced for sale in the United States. The United States Environmental Protection Agency (EPA) calculates average fuel economy levels for manufacturers and also sets related GHG emissions standards under the Clean Air Act. Raising CAFE standards leads automakers to create a more fuel-efficient fleet, which improves our nation's energy security, saves consumers money at the pump, and reduces GHG emissions (USDOT 2014).

EPA published a final rulemaking on December 30, 2021 that raised federal GHG emissions standards for passenger cars and light trucks for model years 2023 through 2026, increasing in stringency each year. The updated GHG emissions standards are anticipated to eliminate more than 3 billion tons of GHG emissions through 2050. In April 2022, NHTSA announced corresponding new fuel economy standards for model years 2024 through 2026, which are anticipated to reduce fuel use by more than 200 billion gallons through 2050 compared with the old standards and reduce fuel costs for drivers (EPA 2022; NHTSA 2022). NEPA requires federal agencies to assess the environmental effects of their proposed actions prior to deciding on the action or project. To date, no nationwide mobile-source GHG reduction targets have been established, nor have any regulations or legislation been enacted specifically to address climate change and GHG emissions reduction at the project level.

On December 7, 2023, FHWA published the "National Performance Management Measures; Assessing Performance of the National Highway System, Greenhouse Gas Emissions Measure" (FHWA, 2023). It amends FHWA's regulations governing national performance management measures and establishes a method for the measurement and reporting of GHG emissions associated with transportation. It requires state departments of transportation and metropolitan planning organizations to establish declining CO_2 targets and report on GHG progress toward the achievement of those targets (88 FR 85364). This rule became effective January 8, 2024.

Upon taking office on January 20, 2021, President Biden issued the "Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis" (Executive Order [EO 13990]). EO 13990 calls for all federal agencies to review climate-related regulations and actions taken between 2017 and 2021 and tasks CEQ with updating its "Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews" (81 FR 51866).

On January 9, 2023, CEQ issued interim "National Environmental Policy Act Guidance on Consideration of Greenhouse Gas Emissions and Climate Change" with immediate effect, and the public comment period ended on April 10, 2023 (88 FR 10097). This GHG and climate change analysis for the Wilmington Riverfront Transportation Infrastructure Project followed the CEQ recommendations in this interim guidance.

B. State

Delaware has been active in addressing GHG emissions and climate change. Delaware's Executive Order #41: Preparing Delaware for Emerging Climate Impacts and Seizing Economic Opportunities from Reducing Emissions was signed in 2013. As part of the Executive Order, the state developed the 2014 Climate Framework for Delaware, a summary of efforts that state agencies identified as ways they could better help maximize Delaware's resilience to climate change. In 2016, DNREC released a Climate Action in Delaware report, outlining progress made on efforts included in the Climate Framework.

DNREC's Division of Air Quality prepares a greenhouse gas emissions inventory to provide information on the in-state activities that produce emissions. The inventory is a key component of the mitigation analysis performed for the development of the Delaware's Climate Action Plan because it establishes the baseline from which greenhouse gas emissions should be reduced and reports annual progress towards the established goals. Greenhouse gas emissions from 2005 were considered as the baseline to assess reductions in Delaware. Gross GHG emissions in Delaware were estimated at 23.19 Million Metric Tons of Carbon Dioxide Equivalent (MMT CO_2e) in 2005.

The Delaware Climate Change Solutions Act of 2023 establishes the goal for the state to implement additional greenhouse gas emissions reduction strategies. These strategies aim to ensure that statewide greenhouse gas emissions are reduced by 50% from the 2005 baseline by 2030 and achieve net zero by 2050. According to the most recent greenhouse gas inventory, completed in 2018, greenhouse gas emissions were reported to be 16.89 MMT CO_2e. This figure represents a 27% reduction from the 2005 levels as of 2018.

IV. Environmental Setting

GHGs are trace gases that trap heat in the Earth's atmosphere. Some GHGs such as CO_2 occur naturally and are emitted to the atmosphere through natural processes and human activities. Others (e.g., fluorinated gases) are created and emitted solely through human activities. The principal GHGs that enter the atmosphere because of human activities are CO_2, CH_4, N_2O, and fluorinated gases. This section discusses the Project setting, national and state GHG inventory, and application regional plans and policies.

A. Project Setting

The proposed Project is in an urban area within the City of Wilmington in New Castle County surrounded by a well-developed road and street network. The Project study area is surrounded by a mix of cultural, recreational, residential, office, hotel, and retail uses, which is defined as waterfront mixed use. Under the Build Alternative, a total of 13.6 acres would be impacted by the transportation infrastructure improvements proposed with the Project.

B. GHG Emissions Inventory

A GHG emissions inventory estimates the amount of GHGs discharged into the atmosphere by specific sources over a period of time. Tracking annual GHG emissions allows countries, states, and smaller jurisdictions to understand how emissions are changing and what actions may be needed to attain emission reduction goals. The IPCC developed the global warming potential (GWP) concept to compare the ability of a GHG to trap heat in the atmosphere relative to another gas. CO_2 is the primary GHG emitted through human activities. In 2021, CO_2 accounted for 79 percent of all U.S. GHG emissions from human activities (US EPA 2023a). Amounts of other gases are expressed relative to CO_2, using a metric called “carbon dioxide equivalent” (CO_2e). The GWP of CO_2 is assigned a value of 1, and the warming potentials of other gases are assessed as multiples of CO_2. For example, the *2021 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021* (US EPA 2023a) used the GWP values from the IPCC *Fifth Assessment Report* (IPCC 2014), with the GWP of CH_4 as 28 (1 metric ton of CH_4 is equivalent to the warming effects of 28 metric tons of CO_2) and the GWP of N_2O as 265 (1 metric ton of N_2O is equivalent to the warming effects of 265 metric tons of CO_2), over a 100-year time horizon (IPCC 2014).

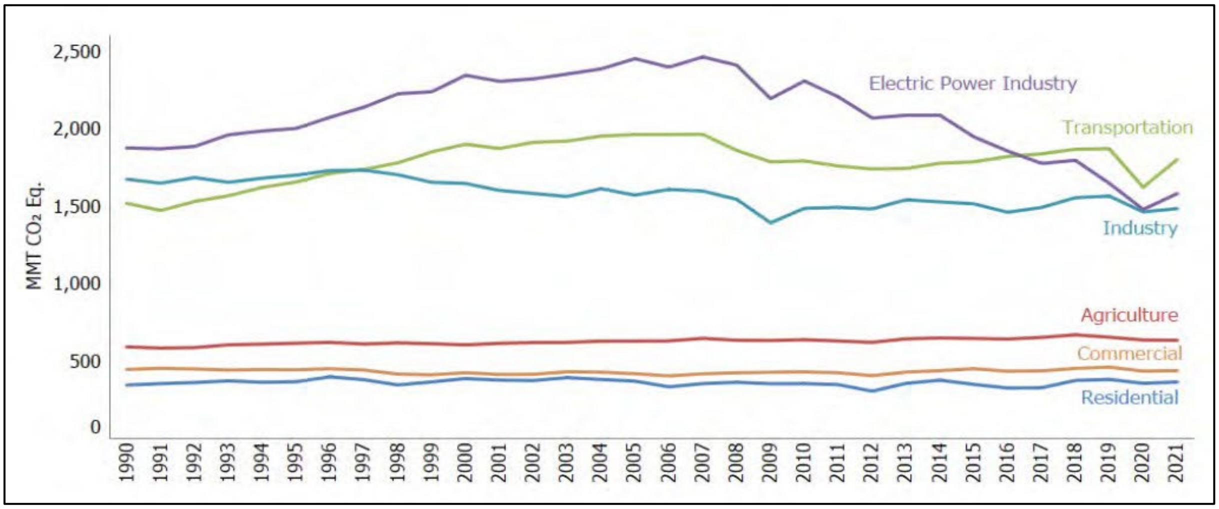
1. National Greenhouse Gas Inventory

According to the most recent GHG inventory, in 2021, net U.S. GHG emissions were 5,586 MMT CO_2e. Net GHG emissions increased by 6 percent in 2021 due to economic activity rebounding after the COVID-19 pandemic. The GHG emissions were 17 percent below 2005 levels. The recent decline is mostly due to a shift to less CO_2-intensive natural gas for generating electricity and a rapid increase in the use of renewable energy in the electric power sector (US EPA 2023a).

Figure 3 presents the GHG emissions trends by sector from 1990 to 2021 in the United States. Overall, from 1990 to 2021, total emissions of CO_2 decreased by 2 percent, total emissions of CH_4 decreased by 16 percent, and total emissions of N_2O decreased by 3 percent. U.S. GHG emissions were partly offset by carbon sequestration in managed forests, trees in urban areas, agricultural soils, landfilled yard trimmings, and coastal wetlands. These were estimated to offset 12 percent of total gross emissions in 2021.

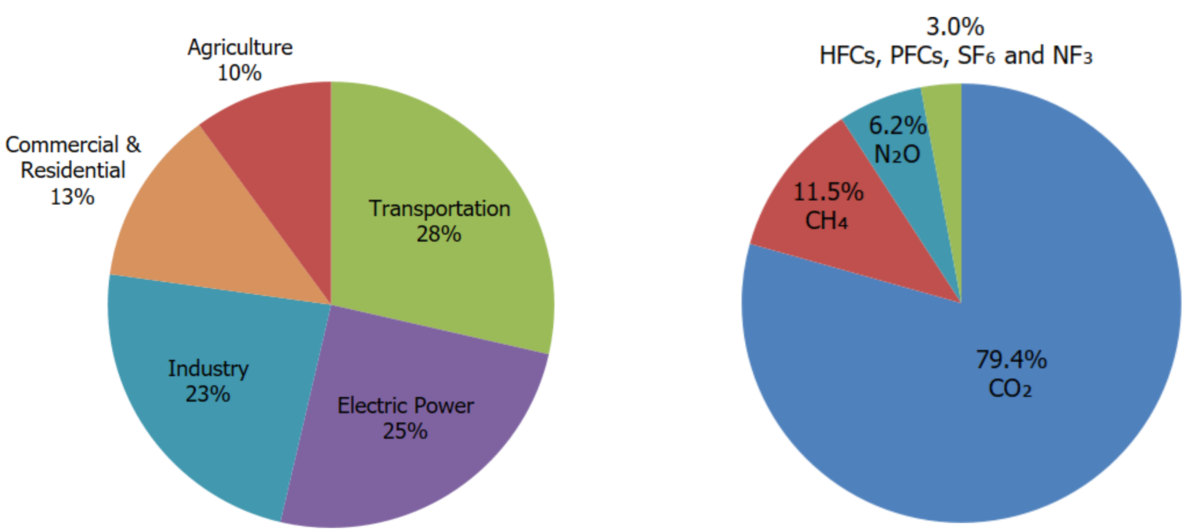
From 1990 to 2021, transportation CO_2 emissions from fossil fuel combustion increased by 19 percent. In 2021, emissions increased by 11 percent, which followed a decline of 13 percent in 2020 due to reduced travel demand during the COVID-19 pandemic. In 2021, light-duty vehicles represented 58 percent of CO_2 emissions from transportation fossil fuel combustion and medium- and heavy-duty trucks and buses represented 25 percent. The remainder was due to off-road sources (US EPA 2023a).

Figure 3: U.S. GHG Emissions 1990 to 2021 by Sector (US EPA 2023a)



Transportation activities were the largest source (28 percent) of total U.S. GHG emissions in 2021, followed by the electric power and industry sectors, and 79.4 percent of the GHG emissions were CO_2, as shown on **Figure 4**.

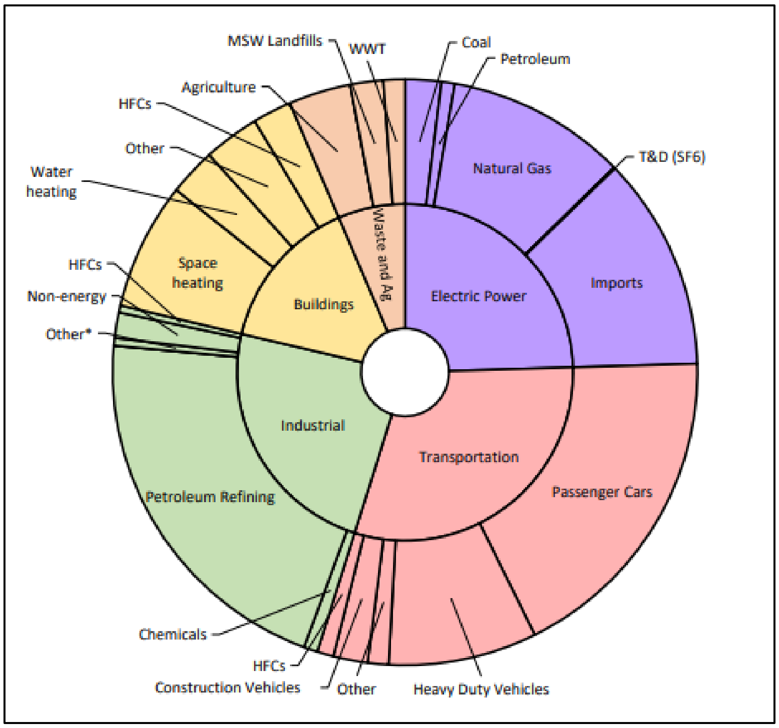
Figure 4: U.S. GHG Emissions in 2021 (US EPA 2023a)



2. State Greenhouse Gas Inventory

According to the *Delaware's Greenhouse Gas Emissions Inventory 2018*, Delaware's gross total GHG emissions were estimated at 16.89 MMT CO_2e, which represents approximately 0.25% of the national gross GHG emissions (U.S. gross total was 6,677 MMT CO_2e in 2018). As shown on **Figure 5**, the largest source of GHG emissions in Delaware in 2018 was the transportation sector. When including electricity consumption-based emissions, the electric power sector is the second largest contributor of GHG emissions. Greenhouse gas emissions from the electric power sector in 2018 accounted for 25% of the gross total in Delaware. The electric power sector was split roughly in half for emissions from in-state generation (13% of total) and imported power for consumption (12% of total).

Figure 5: Gross GHG Emissions in Delaware in 2018 broken out by sector and end-use (where applicable)



C. Regional Plans

1. State and Regional

The Wilmington Area Planning Council (WILMAPCO) is the official metropolitan planning organization for Cecil County, Maryland and New Castle County, Delaware, where the Project is located. WILMAPCO's *2050 Regional Transportation Plan (RTP)* makes recommendations to local and state government to shape and guide land use development and transportation improvement, including public transit, arterial streets and highways, freight, and bicycle and pedestrian facilities, to the year 2050. The 2050 RTP was first released in 2019, and the second edition of the plan was released in 2023 (WILMAPCO 2023). The RTP contains objectives and actions that, if implemented, would both address climate change and lower energy use. Many actions could lead to the reduction of the region's GHG emissions, in turn slowing warming. Such actions include greater investment in public transit, greater investment in the non-motorized network, measures to boost ridesharing, steps to ease highway congestion, and supporting investments relevant to surrounding land use.

The State has adopted *Delaware's Climate Action Plan* as a roadmap for transportation policy making. One of the goals of *Delaware's Climate Action Plan* is to reduce emissions in the transportation sector by shifting to low-carbon technologies, improving fuel efficiency, and increasing opportunities for transportation choice, such as walking and biking. These strategies also provide co-benefits, including economic and job opportunities in low-carbon transportation technologies and vehicle sales, cost savings to drivers, and improved air quality, particularly in urban areas with high traffic congestion.

2. Local

In 2019, The City of Wilmington released *Wilmington 2028: A Comprehensive Plan for Our City and Communities*, detailing the progress toward reducing greenhouse gas emissions, coming in well ahead of its 2020 deadline to reduce harmful emissions 20% below 2008 levels. The City continually seeks to incorporate sustainability in its decision-making and coordinates public and private efforts to improve quality of life in the city and prepare for climate change with the goals of:

- Providing high quality city services, facilities, and infrastructure for existing and future residences and businesses.
- Conserving resources and reduce greenhouse gas emissions to protect air and water quality and mitigate the City's contribution to climate change.
- Promoting resilience to climate change and flooding in all long-range planning, critical public facilities, and infrastructure.
- Promoting community greening for aesthetic and environmental benefit.

In 2019, The Wilmington Department of Public Works also released *Resilient Wilmington: Preparing Today for Tomorrow's Climate Risks*. The Resilient Wilmington plan builds off work already being done by the City of Wilmington and regional partners, and makes recommendations to help Wilmington prepare for and reduce the impacts of climate change.

V. Project's GHG Emissions and Effects

Transportation projects may contribute to climate change due to the GHG emissions from construction and operation of the transportation systems. The primary GHGs produced by the transportation sector are CO_2, CH_4, and N_2O. CO_2 emissions are a product of gasoline or diesel fuel combustion in internal combustion engines, along with relatively small amounts of CH_4 and N_2O. Vehicles with internal combustion engines are a significant source of GHG emissions of the transportation sector and contribute to global climate change, as discussed in **Section IV**.

A. GHG Emissions from the Project

Lifecycle GHG emissions associated with the Project construction and operations were quantified as a proxy to evaluate the Project's impacts to the environment, as discussed in the following sections. This section provides a summary of the GHG emission analysis approach and the results. The GHG emission analysis was performed for the existing condition, future Build and No Build Alternative in completion year of 2040 and horizon year 2060, and cumulative emissions of construction and operation during 2025 to 2060. Construction of the roadway network for this project will be completed in 2030; however, for the purpose of this analysis the year of 2040 utilized to represent the complete build alternative, as this date reflects the completed *South Market Street Master Plan*, assuming the proposed residential and commercial development is completed and the maximum of traffic operating as a result of the development. The 2040 date offers the most conservative representation traffic levels, and therefore the most conservative representation of GHG emissions of the proposed Project.

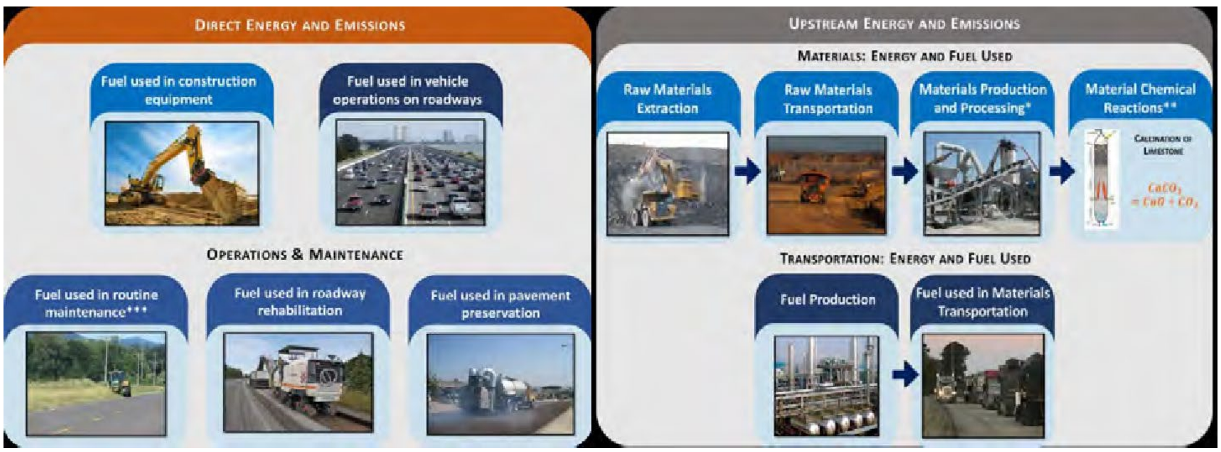
The Project study area for the GHG emission analysis was based on the project-level traffic forecast area established for the Project. Details of the GHG emission calculations, assumptions, and results are in **Attachment 1**.

1. Emissions from Construction and Roadway Operation and Maintenance

GHG emissions from the Project construction and operations and maintenance (O&M) were estimated using FHWA's Infrastructure Carbon Estimator (ICE), Version 2.2.8 (FHWA 2023). ICE 2.2.8 was developed by FHWA to estimate the lifecycle energy and GHG emission from transportation infrastructure construction, maintenance, and operation. Lifecycle GHG accounting evaluates and reports the GHG emissions associated with the raw materials extraction, manufacturing or processing, transportation, use, and end-of-life management of a good or service.

ICE 2.2.8 considers the following direct and indirect (upstream) emissions to estimate construction-, operation-, and maintenance-related emissions. See the ICE model represented below in **Figure 6**.

Figure 6: FHWA's Infrastructure Carbon Estimator (ICE)



Note:
* e.g., crushing of aggregate, asphalt batch plants
** e.g., CO_2 emitted from calcination of limestone
*** activities include sweeping, striping, bridge deck repair, litter pickup, and maintenance of appurtenances Source: ICE, Version 2.2.8 (FHWA 2023).

GHG emissions from the Project were modeled using ICE 2.2.8 and broken into five categories:

- Material: Includes the upstream emissions associated with project materials extraction, production, chemical reaction, and raw material transportation.
- Transportation: Includes upstream emissions associated with fuel used in transportation of materials to site.
- Construction: Includes the emissions from energy and fuel used in construction equipment.
- O&M: Includes the emissions from routine maintenance of the infrastructures, such as snow removal and vegetation management, roadway repair and rehabilitation, and other routine maintenance.
- Usage: Includes emissions from vehicle travel on roadways.

Project construction is anticipated to start in 2025 with an opening year of 2030, and completion of the *South Market Street Master Plan* in 2040. For this analysis, the year 2040 is chosen to represent the full development scenario, aligning with the completion of the South Market Street Master Plan and its associated residential and commercial developments. This timeline ensures the most accurate and conservative estimation of traffic levels and greenhouse gas (GHG) emissions from the proposed Project. GHG construction and maintenance emissions from the Project's Build Alternative was modeled based on Project construction information of the Alternative and design options, and includes the emissions from the following infrastructure and activities:

- Lighting
- Pathways
- Roadways
- Signage
- Vehicle delays during construction

For this analysis, emissions due to travel delay of vehicles during construction period were modeled using the ICE 2.2.8. Vehicle operation emissions from the proposed Project from the construction period through the Project's lifetime was modeled using EPA's Motor Vehicle Emission Simulator (MOVES Version 4.0.1). Therefore, vehicle operation emissions after the Project build-out was evaluated separately. For the calculation of operational emissions MOVES model was employed to estimate the total GHG emissions and all associated precursors within New Castle County, Delaware. This process involved dividing the county's total emissions by the default VMT for the county. The result of this calculation was a summary GHG emission rate. Subsequently, this rate was applied to specific traffic data associated with the proposed project, enabling the estimation of the project's GHG emissions under two scenarios: No-Build and Build. These emissions were calculated for the existing condition, completion date, and horizon year. This methodology ensures a comprehensive understanding of the project's potential environmental impact in terms of GHG operational emissions.

ICE 2.2.8 inputs of each of the activities listed previously were based on anticipated Project construction activities and vehicle delay.

For the calculation of GHG emissions from vehicle delays during construction, it was conservatively assumed that there would be a single lane closure along South Market Street. This worst-case traffic delay scenario was applied consistently throughout the entire construction period.

ICE 2.2.8 annualizes the total project construction emissions over the proposed Project's lifetime. For the purposes of GHG emission analysis, a conservative timeframe of 30 years was selected, despite the typical lifetime of a transportation project being anticipated to span 50 to 75 years. Lifecycle GHG emissions are quantified in metric tons of carbon dioxide equivalent (MT CO_2e), calculated by multiplying the mass of a given GHG by its specific GWP. ICE 2.2.8 adopts the 100-year GWP values from the IPCC's Fourth Assessment Report (2007):

- CO_2: 1
- CH_4: 25
- N_2O: 298

Lifecycle GHG emissions from proposed Project construction and O&M are summarized in **Table 1.**

Table 1: Annualized Lifecycle GHG Emissions from Construction and O&M (MT CO_2e/year)

	No Build	Build
Lighting	0	20
Pathways	0	5
Roadways	24	76
Signage	0	0
Vehicle Delay	0	86
Total	24	187

Table 1 demonstrates the greatest amount of construction and O&M emissions resulting from the build alternative originates from the material energy use and emissions, material transportation, and construction process during the construction phase; in addition to vehicle delays resulting from modification of traffic. In contrast, the No Build Alternative would not result in any construction emissions. Under the No Build scenario, the existing roadways, as modeled in the ICE tool, would require more frequent O&M activities, leading to higher GHG emissions compared to the newly constructed roads in the build alternative. However, it's important to note that the ICE tool does not consider roadway age in its O&M emissions estimates, implying that actual O&M emissions for the No Build alternative might be underestimated in by the ICE tool**.**

There would be no construction emissions from the No-build alternative. O&M emissions from the No-build alternative were estimated using the ICE 2.2.8. The existing roadway under the No-build alternative would likely require more O&M activities and result in higher GHG emissions than the newly constructed roadways of the build alternatives. Because the ICE tool does not consider the age of the roadways when estimating the O&M emissions, O&M emissions from the No-build alternative are likely higher than what is presented in **Table 1**. The O&M emissions calculations for roadways in **Table 1** includes one estimated maintenance project in the 30-year analysis period.

2. Long-term Emissions from Vehicles during Operation

Long-term GHG emissions from vehicle operations for the existing condition in 2020 and for the No Build and Build Alternative in 2040 and 2060 were modeled using US EPA's MOVES4 (Version 4.0.1) program. MOVES4 input data defines the scale, methods, and parameters used for the analysis.

These are described in **Tables 2 and 3**. Additional information regarding US EPA MOVES4 program can be found at https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.

Table 2: MOVES Input Options Used in the Analysis

MOVES Tab	Model Selections
Scale	Default scale; inventory calculation type
Time Span	Hourly time aggregation including weekdays only, all hours for all 12 calendar months
Geographic Bounds	New Castle County, Delaware
Vehicles/Equipment	All MOVES4 vehicle and fuel type combinations
Road Type	Urban unrestricted access and off network
Output	Output included the running exhaust all Greenhouse gases and their prerequisites
Time Aggregation	24-hour

Table 3: MOVES Input: Emission Process Included in the Analysis

Process ID	Process Description
1	Running Exhaust
2	Start Exhaust
15	Crankcase Running Exhaust
16	Crankcase Start Exhaust

The operational GHG emission analysis estimated the annual emissions of the GHG based on Vehicle Miles Traveled (VMT) in the Project's study area as discussed at the beginning of **Section V.A**. The daily VMT of each modeled scenario is included in **Tables 4 and 5** for 2040 and 2060, respectively. In general, VMT of the No Build Alternative and Build Alternative in 2040 and 2060 is higher than existing conditions in 2020 due to growth resulting from the redevelopment of the project area.

Vehicle emissions modeled by MOVES4 program are the direct tailpipe emissions from the vehicles traveling in the Project study area. Well-to-pump emissions were calculated by multiplying the vehicle direct tailpipe emissions by a factor of 1.27 (WSDOT 2018) to account for the upstream indirect GHG emissions associated with fuel extraction, production, and transportation. The overall well-to-wheel GHG emissions are the sum of the direct tailpipe emissions and the indirect upstream emissions. Summaries of the operational well- to-wheel GHG emissions of the existing condition and the Build Alternative are in **Tables 4 and 5**.

When compared to the existing conditions in 2020, the GHG emissions for the No Build Alternative in 2040 are projected to be lower, even though the future year's VMT is higher. Specifically, the GHG emissions under the No Build scenario in 2040 are estimated to be about 30 percent lower than those in 2020. This reduction in future GHG emissions can be attributed to fleet turnover, improvements in fuel economy, and an increased adoption of alternative fuel vehicles. Given that the differences in GHG emissions between future conditions and existing conditions are influenced by a variety of factors not directly related to the proposed Project, the GHG emission analysis for the proposed Project has focused on comparing the Build and No Build Alternatives for 2040 and 2060. The Energy Information Administration (EIA) projects that vehicle energy efficiency (and thus, GHG emissions) across all light-duty vehicles in use, fuel economy increases by 55% by 2050 in the Annual Energy Outlook (AEO) 2020 Reference case as newer, more fuel-efficient vehicles enter the market and cars, which are more fuel efficient than light trucks, gain market share during the projection period. The fuel economy of cars increases from 28.3 miles per gallon (mpg) to 43.6 mpg, and the fuel economy for new light trucks increases from 20.4 mpg to 31.6 mpg. (EIA 2020).

When compared to the No Build Alternative in future years, the Build Alternative has increased emissions. The Build Alternative would increase GHG operation emissions by 1,254 MT CO_2e (68 percent) in, 2040 and 1,247 MT CO_2e (67 percent) in 2060 compared to the No Build Alternative. The comparative increase between the No Build and Build Alterative is primarily the result of new alignment roadway that is accounted for in the increased VMT between the No Build and Build condition.

Table 4: VMT and Well-to-Wheel GHG Emissions as CO_2e from Project Operation in 2040

	Existing Condition	No Build	Build
	2020	2040	
Daily VMT (miles/day)	11,309	12,449	20,873
Well-to-Wheel Emissions (MT / CO_2e/year)	2,695	1,853	3,107
Difference Between Build and No Build Alternatives			
Daily VMT	NA	NA	8,424 68%
Well-to-Wheel Emissions (MT CO_2e/year)	NA	NA	1,254 68%

Table 5: VMT and Well-to-Wheel GHG Emissions as CO_2e from Project Operation in 2060

	Existing Condition	No Build	Build
	2020	2060	
Daily VMT (miles/day)	11,309	13,796	2,3070
Well-to-Wheel Emissions (MT / CO_2e/year)	2,695	1,856	3,103
Difference Between Build and No Build Alternatives			
Daily VMT	NA	NA	9,274 67%
Well-to-Wheel Emissions (MT CO_2e/year)	NA	NA	1,247 67%

3. Annualized Project GHG Emissions from Construction and Operation

Annual GHG emissions from the proposed Project were calculated by integrating the annualized construction and maintenance emissions, as determined by the ICE tool, with the vehicle operation emissions, as modeled by MOVES4. Differences in GHG emissions between the Build and No-Build Alternatives are outlined in **Table 6**. According to **Table 6**, the combined construction and operational GHG emissions from the Build Alternative are projected to average 3,292 MT CO_2e annually over the project's 30-year lifespan. A considerable portion of these emissions is linked to the proposed roadway network, which leads to an increase in VMT from the No-Build to the Build conditions. In addition to the tailpipe emissions calculated using the MOVES4 model to determine the vehicle operation emissions, the processes of start exhaust, and crankcase start exhaust were calculated and included. It is also important to note that although VMT rises over time, vehicle energy efficiency increases across all light-duty vehicles in use, fuel economy increases by 55% by 2050 in the Annual Energy Outlook (AEO) 2020 Reference case as newer, more fuel-efficient vehicles enter the market and cars, which are more fuel efficient than light trucks, gain market share.

Table 6: Comparisons of Annualized Total GHG Emissions (Construction and Operation), MT CO_2e/Year

Year	Existing Condition	No Build	Build
2020	2,718		
2040	-	1,876	3,293
2060	-	1,879	3,290
Differences Between Build and No Build			
2040	NA	NA	1,417 76%
2060	NA	NA	1,411 75%

4. Cumulative Project GHG Emissions

Cumulative Project GHG emissions were estimated by adding the proposed Project construction emissions during construction phase, and the O&M and vehicle operation emissions for the development completion date of 2040 and horizon year of 2060. Project construction is anticipated to start in 2025 with an opening year of 2030, and completion of the *South Market Street Master Plan* in 2040. For this analysis, the year 2040 is chosen to represent the full development scenario, aligning with the completion of the *South Market Street Master Plan* and its associated residential and commercial developments. This timeline ensures the most accurate and conservative estimation of traffic levels and greenhouse gas (GHG) emissions from the proposed Project. Year-by-year GHG emissions from vehicle operation between 2030 and 2060 were estimated by linearly interpolating the vehicle emissions. Cumulative GHG emissions of the Project are in **Table 7**. Year-by-year emissions from the proposed Project are detailed in **Attachment 1**.

Table 7: Cumulative GHG Emissions (Construction and Operation in 2030-2060), MT CO_2e

	No Build	Build
Cumulative	46,008	81,642
Differences Between Build and No Build Alternatives		
Cumulative	NA	35,634 77%

5. GHG Equivalency

CEQ interim guidance indicates that agencies may provide accessible comparisons or equivalents for the public and decision makers to understand GHG emissions in more familiar terms, such as placing GHG emissions as household emissions per year, average emissions from a certain number of cars on road, or amount of fuel burned. Based on the GHG emission results, GHG equivalency values were derived using US EPA's Greenhouse Gas Equivalencies Calculator (US EPA 2023b) and are summarized in **Table 8**.

Table 8: GHG Emissions Equivalency for the GHG Emissions Increases from Build Alternative

	Build Alternative
Equivalency to 2040 GHG Emissions	
Barrels of crude oil consumed	7,617.53
Gasoline powered passenger vehicles driven for one year	734.42
Tanker truck's worth of gasoline	43.47
Natural gas fired power plant in one year	0.01
Equivalency to 2060 GHG Emissions	
Barrels of crude oil consumed	7,609.39
Gasoline powered passenger vehicles driven for one year	733.63
Tanker truck's worth of gasoline	43.43
Natural gas fired power plant in one year	0.01

Note: www.epa.gov/energy/greenhouse-gas-equivalencies-caluclator

1000 MT CO_2e is equivalent to:

2313 barrels of oil consumed

223 gasoline powered passenger vehicles driven for one year

13.2 Tanker truck's worth of gasoline

0.003 Natural Gas Fired Power Plan in One Year

B. Social Cost Estimate Methodology

Following the CEQ interim guidance, to provide additional context for GHG emissions, social costs of GHG. (SC-GHG) due to GHG emissions from the Build Alternative were estimated to translate climate impacts into the more accessible metric of dollars, to allow decision makers and the public to make comparisons, help evaluate the significance of an action's climate change effects, and better understand the tradeoffs associated with an action and its alternatives.

The SC-GHG is a measure, in dollars, of the long-term damage done by a ton of GHG emissions in a given year. This dollar figure also represents the value of damages avoided for a small emission reduction (i.e., the benefit of a GHG reduction). The SC-GHG is meant to be a comprehensive estimate of climate change damages and includes changes in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. However, given current modeling and data limitations, it does not include all important damages. The models used to develop SC-GHG estimates, known as integrated assessment models, do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research. Nonetheless, the current estimates of the SC-GHG are a useful measure to assess the climate impacts of CO_2 emission changes (US EPA 2017).

EO 13990 re-established the Interagency Working Group (IWG) on the Social Cost of Greenhouse Gases and directed it to ensure that SC-GHG estimates used by the U.S. government reflect the best available science and the recommendations of the National Academies and work toward approaches that take account of climate risk, environmental justice, and intergenerational equity (IWG 2021). The SC-GHG values used in this analysis are from the February 2021 Technical Support Document (TSD) by the IWG. The TSD presents interim estimates of SC-GHG developed under EO 13990 (IWG 2021).

1. Social Cost Estimate Methodology

The SC-GHG analyzed for the proposed Project includes the social cost of carbon dioxide (SC-CO_2), methane (SC-CH_4), and nitrous oxide (SC-N_2O). SC-GHG associated with the proposed Project's GHG emissions in 2040 and 2060 were calculated for the No Build and Build Alternative. Unit social costs for each GHG were taken from the TSD (IWG 2021) and are presented by emission year in 2020 dollars per MT CO_2e at various discount rates.

The SC-GHG discount rates are important factors influencing SC-CO_2 estimates. A large portion of climate change damages are expected to occur many decades into the future and the present value of those damages (the value at present of damages that occur in the future) is highly dependent on the discount rate. Future costs and benefits are considered less than present costs and benefits, and the discount rate reflects this level of relative significance. A high discount rate means that future effects are considered much less significant than present effects, whereas a low discount rate means that they are closer to equally significant. The SC-GHG analysis for the proposed Project evaluated all three discount rates in the TSD (5 percent, 3 percent, 2.5 percent, and 3 percent 95th percentile), to present the potential ranges of the SC-GHG of the proposed Project.

Annual emissions of CO_2, CH_4, and N_2O were calculated for the Project for emission years 2040 and 2060 for the Build Alternative analyzed in **Section V.A**, taking into account both construction and operational GHG emissions. SC-GHG of the proposed Project was calculated by multiplying the unit SC-CO_2, SC-CH_4, and SC-N_2O cost factors (in 2020 dollars per MT of each respective GHG) by the corresponding GHG emissions. Cumulative SC-GHG during the 20-year period from 2040 to 2060 were estimated for each the Build Alternative by linearly interpolating the SC-GHG cost factors and the GHG emission rates between 2040 and 2060.

2. Annual Social Cost of GHG for the Project Emissions

SC-GHG values resulting from the proposed Project for the Build and No Build Alternative for emission years 2040 and 2060 are summarized in **Tables 9 and 10**, respectively.

For the same emission year and discount rate, and consistent with the proposed Project's cumulative GHG emission trend, the SC-GHG of the Build Alternative would be about 188 percent higher than the No Build Alternative for the 2040 emission year, and about 187 percent higher than the No Build Alternative for the 2060 emission year.

Table 9: Social Cost of Greenhouse Gases for Emissions in 2040 (in 2020 dollars) and Comparisons to No Build Alternative

Discount Rate (%)	SC-GHG ($) for 2040 GHG Emissions	
	No Build	Build
5.00%	$37,112	$65,911
3.00%	$108,144	$192,089
2.00%	$152,506	$270,894
3% 95th Percentile	$332,388	$590,489
Discount Rate (%)	Changes of SC-GHG Compared to No Build ($)	
	No Build	Build
5.00%	N/A	$28,800
3.00%	N/A	$83,944
2.00%	N/A	$118,388
3% 95th Percentile	N/A	$258,101
Discount Rate (%)	Changes of SC-GHG Compared to No Build (%)	
	No Build	Build
5.00%	N/A	77.60%
3.00%	N/A	77.62%
2.00%	N/A	77.63%
3% 95th Percentile	N/A	77.65%

Table 10: Social Cost of Greenhouse Gases for Emissions in 2060 (in 2020 dollars) and Comparisons to No Build Alternative

Discount Rate (%)	SC-GHG ($) for 2060 GHG Emissions	
	No Build	Build
5.00%	$61,007	$108,065
3.00%	$146,987	$260,397
2.00%	$194,453	$344,489
3% 95th Percentile	$444,458	$787,481
Discount Rate (%)	Changes of SC-GHG Compared to No Build ($)	
	No Build	Build
5.00%	N/A	$47,058
3.00%	N/A	$113,410
2.00%	N/A	$150,037
3% 95th Percentile	N/A	$343,023
Discount Rate (%)	Changes of SC-GHG Compared to No Build (%)	
	No Build	Build
5.00%	N/A	77.13%
3.00%	N/A	77.16%
2.00%	N/A	77.16%
3% 95th Percentile	N/A	77.18%

3. Cumulative Social Cost

Cumulative SC-GHG were estimated for the Build Alternative as described in **Section V.B.1** Cumulative SC-GHG of the proposed Project are summarized in **Table 11**. Year-by-year SC-GHG of the Project are in **Attachment 1**. Cumulative SC-GHG trends are consistent with the trends of the annual SC-GHG. The Build Alternative has higher cumulative SC-GHG than the No Build Alternative.

Table 11: Cumulative Social Cost of Greenhouse Gases for Emissions in 2030 to 2060 (in 2020 dollars) and Comparisons to No Build Alternative

Discount Rate (%)	SC-GHG ($) for 2030-2060	
	No Build	Build
5.00%	$1,317,406	$2,208,654
3.00%	$3,677,141	$6,164,852
2.00%	$5,107,391	$8,562,743
3% 95th Percentile	$11,253,812	$18,867,393
Discount Rate (%)	**Changes of SC-GHG Compared to No Build ($)**	
	No Build	**Build**
5.00%	N/A	$891,248
3.00%	N/A	$2,487,711
2.00%	N/A	$3,455,353
3% 95th Percentile	N/A	$7,613,581
Discount Rate (%)	**Changes of SC-GHG Compared to No Build (%)**	
	No Build	**Build**
5.00%	N/A	67.65%
3.00%	N/A	67.65%
2.00%	N/A	67.65%
3% 95th Percentile	N/A	67.65%

C. Mitigation for Greenhouse Gas Emissions

Mitigating GHG emissions is crucial for combating climate change. Throughout construction projects in Delaware, GHG emissions can vary. Although not explicitly required under NEPA or other regulations, 'Delaware's Climate Action Plan (DNREC 2021) details standards and strategies to curb emissions:

- Employ construction detours and schedule work strategically to minimize delays and vehicle idling, reducing GHG emissions.
- Designate construction zones, staging areas, and material transfer points to decrease equipment idle times, directly lowering GHG outputs.
- Collaborate with contractors to implement idling reduction programs, including the use of idling logs to monitor and compare emissions against initial baselines.
- Promote ridesharing and public transportation among construction workers to decrease commute-related emissions. Delaware encourages the use of designated parking areas to centralize emissions and endorses public transit and carpooling through visible signage.
- Prioritize recycling of construction materials such as asphalt, concrete, and metals, transforming waste into valuable resources and reducing the carbon footprint.
- Install LED lighting in project areas to cut electricity use and associated emissions, leveraging energy-efficient technology.
- Plant trees along project corridors to absorb CO_2 and mitigate urban heat, contributing to urban greening efforts. This initiative complements Delaware's broader environmental commitments,

such as the Tree for Every Delawarean Initiative.

- Invest in transit improvements to facilitate construction traffic flow and encourage public transportation use, effectively reducing congestion-related emissions. This includes financial commitments to enhance bus services and infrastructure, fostering a shift towards sustainable transit solutions.

These mitigation measures aim to reduce the environmental and social impacts of construction projects, with a keen focus on supporting environmental justice communities. Prior to commencing construction, comprehensive plans outlining project phases, mitigation strategies, and community engagement efforts are developed and shared for public input.

D. Cumulative GHG Effects

The analysis and public disclosure of cumulative effects of the proposed Project are accomplished by quantifying GHG emissions, as discussed in **Section V.A**, and by providing context for understanding their effects, as discussed in **Section V.B**. The GHG emissions estimates and monetized climate damages serve as a proxy for the proposed Project's potential contribution to global climate change.

GHG emissions from transportation is the largest contributor of U.S. GHG emissions, and the largest contributor of Delaware's GHG emissions. Burning fossil fuels like gasoline and diesel releases GHG into the atmosphere, and the buildup of CO_2 and other GHGs is causing global warming, resulting in changes to the climate we are already starting to see today. Cumulative climate change effects are felt locally and regionally; however, climate change effects that are experienced at local and regional levels are not the direct result of the proposed Project's contributions,, but the result of cumulative, global contributions. GHGs are different from other air pollutants evaluated in federal environmental reviews because their impacts are not localized or regional. GHG impacts are cumulative, global impacts. Each emission source may make a relatively small contribution to global atmospheric GHG concentrations. In the context of greenhouse gases (GHGs) and climate change, it is understood that the climate is influenced by the global cumulative changes in GHG concentrations within the atmosphere. Given the vast scale of these phenomena, the emissions emanating from a single project are too negligible to directly correlate with specific changes in climate metrics such as temperature, sea level, and precipitation patterns. Despite this, the quantification and estimation of GHG emissions from individual projects hold significant value. This analysis aids public understanding and informs decision-makers by illustrating whether specific initiatives are aligning with broader goals aimed at mitigating climate change's impact. Thus, while direct attribution of global climate effects to individual project emissions is not feasible, the assessment of these emissions plays a crucial role in climate change mitigation strategies.

Future global GHG emissions will be affected in ways that cannot be accurately accounted for at this time. Changes to various air quality regulations, technological advances that alter transportation systems, changes to how vehicles are powered, and/or changes in fuels will affect GHG emissions. Likewise, acts of nature (e.g., pandemics), societal changes, market forces, economics, and personal decisions could alter where and how people live, work, or travel, further impacting GHG emissions.

Nonetheless, the GHG emission reduction measures previously described, represent federal, state, and practical project-level measures that may help reduce GHG emissions on an incremental basis and could contribute in the long term to a meaningful cumulative reduction when considered across the federal-aid highway program.

VI. Effects of Climate Change

Reducing GHG emissions is only one part of an approach to addressing climate change. Transportation is currently the largest in-state source of greenhouse gas emissions in Delaware. The State is actively engaged in mitigating the impacts of climate change on Delaware's transportation systems, with goals to enhance resilience and safeguard the infrastructure against the adverse effects of climate change. Globally, climate change is expected to produce increased variability in precipitation, rising temperatures, rising sea levels, variability in storm surges and their intensity, and in the frequency and intensity of wildfires. Flooding and erosion can damage or wash out roads; longer periods of intense heat can buckle pavement and railroad tracks; storm surges combined with rising sea levels can inundate highways. Effects will vary by location and may, in the most extreme cases, require that a facility be relocated or redesigned. Delaware is expected to experience higher temperatures, increased precipitation, and more extreme weather events in future years, as further discussed in **Section VI.A.3.**

Climate change also affects people's health in many ways. As the climate changes, more people may be exposed to extreme weather like heat, floods, droughts, storms, and wildfires. These events can cause illness, injury, and even death. Climate change can also lead to more diseases spread by insects and ticks, and it can affect the quality and safety of air, water, and food, including through the spread of harmful bacteria or viruses. In addition, hazards related to climate change can affect mental health, such as causing anxiety, depression, and post-traumatic stress (US EPA 2023c).

As noted in the interim guidance, most severe harms from climate change fall disproportionately upon underserved communities who are least able to prepare for and recover from heat waves, poor air quality, flooding, and other impacts. Racial and ethnic minority communities are particularly vulnerable to the greatest impacts of climate change per US EPA (US EPA 2021). As noted by the United States Department of Transportation (USDOT), the effects of climate change often have a more detrimental effect on vulnerable populations and can disproportionately impact communities of color and low-income communities (USDOT 2023). Environmental justice communities are typically exposed to a disproportionate amount of air pollution and other environmental hazards.

Appendix B – Socioeconomic Technical Report of the Draft EA provides a robust environmental justice analysis for the Wilmington River Transportation Infrastructure Project. As documented in the Socioeconomic Technical Report, the Equity Analysis of this report found that minority population groups were heavily concentrated surrounding the Project study area and have significantly higher minority concentrations than New Castle County as a whole.

The Build Alternative is not expected to result in a disproportionately high and adverse effect on EJ populations. The proposed Project would improve the livability and community benefits by improving mobility and offering new, convenient options for accessing jobs, local economic destinations and regional transit services, clean-up of brownfields, addressing flooding and drainage issues, redevelopment of the area, improving air quality, and community connectivity.

However, to further support investment in the EJ communities, specifically Southbridge, the City's Office of Economic Development is committing to work with the University of Delaware's Local Government Grant Assistance Program and the Southbridge Civic Association in identifying and applying for grant funding in support of the improvements identified in the Southbridge Transportation Action Plan. In addition, the City and the Riverfront Development Corporation would investigate funding to plan, design and construct a pedestrian connection from the Southbridge Community to the Wetland Park between C Street and South Church Street.

The proposed improvements associated with the Project were assessed for potential air quality impacts and compliance with applicable air quality regulations and requirements in **Appendix E – Air Quality Technical Report**. The assessment indicates that the proposed Project would meet all applicable air quality requirements of NEPA and federal and state transportation conformity regulations. The proposed Project's impacts (including GHG emissions) when combined with proposed mitigation are similar between environmental justice populations and non-environmental justice populations. Environmental justice populations are not anticipated to experience disproportionate impacts due to GHG emissions around the Wilmington Riverfront Transportation Infrastructure Project.

A. Present and Projected Future Climate Change Effects

1. National Level

According to the *Climate Science Special Report: Fourth National Climate Assessment* (USGCRP 2017), the annual average temperature of the contiguous United States is projected to rise throughout the century. Increases for the period 2021–2050 relative to 1976–2005 are projected to be about 2.5 degrees Fahrenheit (°F) for a lower scenario (Representative Concentration Pathway 4.5 [RCP4.5]) and 2.9°F for a higher scenario (RCP8.5). RCP4.5 (low emissions estimated to be approximately 650 ppm CO_2e in 2100) refers to a high level of GHG controls recommended to keep temperature rise below 2 degrees Celsius (3.6°F) in 2100. This scenario assumes global carbon emissions peak and decline by the end of the century. RCP8.5 (high emissions estimated to be approximately 1,370 parts per million [ppm] CO_2e in 2100) is a business-as-usual case with little to no additional worldwide GHG control measures. This scenario assumes that humans continue to have dependence on fossil fuels and increase carbon emissions through the scenario.

Daily extreme temperatures are projected to increase substantially in the contiguous United States. The coldest and warmest daily temperatures of the year are expected to increase at least 5°F in most areas by mid-century (2041-2060). In general, there will be larger increases in the coldest temperatures of the year, especially in the northern half of the United States, whereas the warmest temperatures will exhibit more uniform changes geographically (USGCRP 2017).

Annual precipitation since the beginning of the last century has increased across most of the northern and eastern United States and decreased across much of the southern and western United States. Over the coming century, significant increases are projected in winter and spring over the Northern Great Plains, the Upper Midwest, and the Northeast. Observed increases in the frequency and intensity of heavy precipitation events in most parts of the United States are projected to continue. Surface soil moisture over most of the United States is likely to decrease, accompanied by large declines in snowpack in the western United States and shifts to more winter precipitation falling as rain rather than snow (USGCRP 2018). In the United States, projected changes in seasonal mean precipitation span the range from profound decreases to profound increases.

2. Northeast

The Northeast National Climate Assessment (NCA) region covers Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvanian, Rhode Island, Vermont, and West Virginia. The Northeast region is characterized by a highly diverse climate with large spatial variations. Several geographic factors contribute to this. The moderating effects of the Atlantic Ocean affect coastal areas, and the inland regions are also influenced by large water bodies such as the Great Lakes and Lake Champlain. During much of the year, the prevailing westerly flow brings air masses from the interior North American continent across the entire region, bringing bitter cold to the region during winter. The polar jet stream is often located near or over the region during the winter, with frequent storm systems bringing cloudy skies, windy conditions, and precipitation. In the southern portions of the region, the Appalachian Mountains act to partially shield coastal regions from these interior air masses, while also shielding the western part of the region from the warm, humid air masses characteristic of the western Atlantic Ocean, although there is no barrier to humid air masses from the Gulf of Mexico. (NOAA 2013). Temperatures have generally remained above the 1901-1960 average over the last 30 years. Warming has been more pronounced during the winter and spring seasons. Trends are upward and statistically significant for each season, as well as the year as a whole, with magnitudes ranging from +0.11 to + 0.24°F per decade (NOAA 2013).

The seasonal climate, natural systems, and accessibility of certain types of recreation are threatened by declining snow and ice, rising sea levels, and rising temperatures. By 2035, and under both lower and higher scenarios (USGCRP 2017), the Northeast is projected to be more than 3.6°F (2°C) warmer on average than during the preindustrial era. This would be the largest increase in the contiguous United States and would occur as much as two decades before global average temperatures reach a similar milestone. Residents in urban areas face multiple climate hazards, including temperature extremes, episodes of poor air quality, recurrent waterfront and coastal flooding, and intense precipitation events that can lead to increased flooding on urban streams. These physical changes may lead to large numbers of evacuated and displaced populations and damaged infrastructure; sustaining communities may require significant investment and planning to provide emergency response efforts, a long-term commitment to rebuilding and adaptation, and support for relocation. Underrepresented communities, such as the poor, elderly, language-isolated, and recent immigrants, are more vulnerable due to their limited ability to prepare for and cope with extreme weather and climate events (USGCRP 2018).

3. Delaware

In Delaware, the most significant impacts include rising sea levels, escalating temperatures, and shifting precipitation patterns, which encompass extreme weather events and flooding. These changes are already being observed and are expected to intensify in the future.

Since 1900, the Lewes tide gauge has recorded a sea level rise of over one foot. Projections suggest an additional rise of 9 to 23 inches by the mid-2[1s]t century and up to 5 feet by 2100 (DNREC 2021). This rise threatens to permanently submerge low-lying areas and increase high-tide flooding, compromising infrastructure such as roads, wastewater systems, and electricity networks. It could also lead to higher salinity levels in ground and surface waters, rendering them unfit for drinking and irrigation. Furthermore, the encroachment of sea water threatens natural habitats and outdoor recreational spaces.

Delaware has warmed by approximately 2 degrees Fahrenheit since 1895, with projections indicating further increases. By mid-century, average temperatures may rise by an additional 2.5 to 4.5 degrees Fahrenheit, and by 2100, by 3.5 to 8 degrees Fahrenheit. The state is also expected to experience an increase in days with temperatures above 95 degrees Fahrenheit, jumping from an average of 5 days to more than 10 annually within two decades (DNREC 2021). Such temperature rises pose health risks, including heat exhaustion, respiratory conditions, and vector-borne diseases like West Nile virus and Lyme disease. The shifting climate also affects agriculture and natural ecosystems by altering growing seasons, increasing susceptibility to pests, and stressing wildlife and livestock. Infrastructure is at risk as well, with heightened potential for heat damage and electrical grid overloads.

By 2100, Delaware is projected to see a 10% increase in annual average precipitation. The frequency of heavy rainfall events, defined as 2 inches or more in 24 hours, is expected to rise. These changes will likely lead to more frequent flooding, exacerbated by sea level rise. Health risks may increase due to higher mold levels, waterborne diseases, and septic system failures. Additionally, more intense rainstorms will challenge water management systems and could lead to erosion and damage to infrastructure.
Delaware's response to these challenges is outlined in the State's Climate Action Plan, which seeks to mitigate and adapt to the changing climate through strategic initiatives and policies.

4. Federal Effort Addressing Climate Change Effects

Under NEPA, DelDOT is obligated to comply with all applicable federal laws, regulations, policies, and guidance. The *Fourth National Climate Assessment*, published in 2018, presents the foundational science and the "human welfare, societal, and environmental elements of climate change and variability for 10 regions and 18 national topics, with particular attention paid to observed and projected risks, impacts, consideration of risk reduction, and implications under different mitigation pathways."

The USDOT *Policy Statement on Climate Change Adaptation* committed USDOT to "integrate consideration of climate change impacts and adaptation into the planning, operations, policies, and programs of DOT in order to ensure that taxpayer resources are invested wisely, and that transportation infrastructure, services and operations remain effective in current and future climate conditions" (USDOT 2011). The *U.S. Department of Transportation Climate Adaptation Plan* followed up with a statement of policy to "accelerate reductions in greenhouse gas emissions from the transportation sector and make our transportation infrastructure more climate change resilient now and in the future," following this set of guiding principles (USDOT 2021):

- Use best available science
- Prioritize the most vulnerable
- Preserve ecosystems
- Build community relationships
- Engage globally

USDOT developed its climate action plan pursuant to EO 14008, "Tackling the Climate Crisis at Home and Abroad" (January 27, 2021). EO 14008 recognized the threats of climate change to national security and ordered federal government agencies to prioritize actions on climate adaptation and resilience in their programs and investments (White House 2021).

FHWA Order 5520, *Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events* (FHWA 2014), established FHWA policy to strive to identify the risks of climate change and extreme weather events to current and planned transportation systems. FHWA has developed guidance and tools for transportation planning that foster resilience to climate effects and sustainability at the federal, state, and local levels.

5. State Strategies Minimizing GHG Emissions

The *2021 Delaware's Climate Action Plan* identifies specific steps to take to minimize greenhouse gas emissions. The strategies in the plan aim to help Delaware meet its greenhouse gas emissions goals emphasizing the critical role of clean and renewable energy expansion as a cornerstone for long-term emissions reduction. Key initiatives include strengthening Delaware's Renewable Energy Portfolio

Standards, enhancing the deployment of on-site renewable energy systems across residential, commercial, and industrial sectors, and preparing for offshore wind energy opportunities. These efforts are supplemented by targeted actions to increase renewable energy adoption in state operations and address equity challenges in renewable energy access, promising significant environmental and economic co-benefits.

Energy efficiency and transportation sector reforms are identified as pivotal areas for immediate impact. By tightening building energy codes, expanding energy efficiency programs, and promoting industrial energy efficiency, Delaware aims to significantly lower emissions in the near term. Concurrently, the transportation sector is undergoing a transformation with a push towards electric vehicles (eVs), expanded EV charging infrastructure, and initiatives to reduce vehicle miles traveled. These measures are designed not only to cut emissions but also to spur economic growth, enhance air quality, and improve public health outcomes.

Moreover, the plan addresses the reduction of high global warming potential greenhouse gases, focusing on hydrofluorocarbons and methane, through advanced management and reduction strategies. Efforts to offset carbon emissions through enhanced natural and working land's carbon sequestration capabilities are also detailed, including best practices in agriculture, forest conservation, and urban greenspace enhancement. Collectively, these strategies form a robust framework for Delaware to achieve climate goals.

6. City Strategies Minimizing GHG Emissions

Additionally, an initiative by the Wilmington Department of Public Works, "*Resilient Wilmington: Preparing Today for Tomorrow's* low-lying topography and ongoing land subsidence. The City of Wilmington provides strategies that may be incorporated for the proposed Project:

- Elevating transportation elements according to (Federal Emergency Management Agency (FEMA) Floodplain Regulations to protect against inundation and flood-related damage. This is particularly crucial as new projections suggest an increasing frequency and severity of flooding events.
- Adherence to city requirements for new constructions in floodplains, ensuring the lowest floors are elevated to or above the base flood elevation plus 18 inches, aligning with both the 1-percent and 0.2-percent annual chance floodplain regulations. This policy is integrated into the planning for all new infrastructure within the Project study area, including roads and pedestrian pathways such as sidewalks and the Riverwalk.
- Integrating resiliency into riverfront redevelopment by exploring strategies such as seawalls or elevated shorelines. This includes modifications to existing easements and standards and considering public-private partnerships for financing and implementation.
- Increasing resilience of wastewater and stormwater systems by mapping outfall elevations and assessing the impacts of sea level rise on drainage.
- Expanding gray infrastructure to enhance stormwater storage and conveyance and adopting green infrastructure like rain gardens and bioswales to improve stormwater management.
- Implementing shoreline protection measures in priority areas to mitigate flooding risks.
- Assessing future risks to transportation from climate change, including the potential impact of sea level rise on evacuation routes and the need for rerouting.
- Promoting multi-modal transportation options through the adoption of a complete streets program, encouraging mixed-use zoning to reduce car dependency, and reducing the City's carbon footprint by expanding electric vehicle usage and charging infrastructure.

7. State Resiliency Strategies

The *2021 Delaware's Climate Action Plan* identifies specific steps to take to maximize resilience to climate change impacts. The strategies in the plan aim to help Delaware better prepare for climate change impacts the plan outlines a multifaceted approach to enhancing state resilience in the face of climate change, based on extensive input from state agency interviews and stakeholder engagement. Seven key action categories have been identified to guide state agencies in adapting to and minimizing the impacts of climate change. These include the development and revision of state regulations to protect vulnerable resources, providing support to communities through training and technical assistance, and the formulation of comprehensive management plans for natural resources, emergency response, and state facilities. Additionally, the plan emphasizes the importance of adopting future-oriented facility designs, conducting targeted research and monitoring, engaging in proactive outreach and education, and ensuring agency support to foster resilience across the state.

To address the challenges posed by outdated regulations, Delaware aims to review and update existing laws and procedures to better reflect the current understanding of climate change and its impacts. Strategies include updating regulations to reduce climate change risks, enhancing regulatory processes to consider climate impacts in permit decisions, and developing comprehensive strategies for conserving and restoring ecosystem services under future climate conditions. Support for communities and stakeholders is also a priority, with the state focusing on increasing grant opportunities for adaptation projects, assisting local governments and homeowners in building resilience, and providing essential training and resources.

Management plans are being revisited to incorporate climate impact assessments and adaptation measures, ensuring that state facilities and operations are prepared for future conditions. Facility design and operation strategies are being updated to improve resilience, and research and monitoring efforts are being expanded to provide clearer insights into effective solutions for Delaware-specific challenges. Outreach and education initiatives aim to increase community involvement and awareness, while agency support strategies focus on enhancing the capacity of state agencies to implement resilience actions effectively. Through these comprehensive measures, Delaware seeks to position itself as a leader in climate change adaptation, ensuring a more resilient future for its communities and natural resources.

8. Project Strategies and Resilience

To withstand the climate change effects, especially the effects due to increased temperature and precipitation, the design of the Build Alternative includes:

- Incorporate pedestrian and cyclist accommodations to enhance connectivity and reduce carbon footprint.
- Construct a multi-use riverwalk and two park/open space areas for increased green space and public access to riverfronts.
- Implement infrastructure improvements such as water, sanitary sewer, electric, and communications lines beneath roadways to support sustainable future development.
- Elevate transportation elements according to FEMA Floodplain Regulations to protect against flood-related damage, ensuring that new and existing roads, sidewalks, and the Riverwalk are above the 100-year flood elevation.

In addition to the design strategies, additional planning strategies would also make the proposed Project more resilient to the climate change effects. In the event of extreme storms and roadway closures, advance preparation would help the City quickly respond and recover from potential climate change hazards. Advanced preparation and planning strategies can include infrastructure assessments after storm or other climate events and the development of extreme weather risk frameworks. Planning strategies may include:

- Developing asset management and maintenance programs to ensure the new infrastructure elements are monitored and remain in good condition for the Build Alternative.
- Evaluating the resiliency of detour routes to minimize distance traveled during road closure events.

VII. Incomplete or Unavailable Information for Specific Climate Change Impacts

The GHG and climate change effects presented in this memorandum were evaluated based on the best available data; the outcomes are affected by limitations in the data available and uncertainties that limit the accuracy of the tools used.

A level of uncertainty exists in the estimation of a project’s impact on GHG emissions. Estimates of future GHG emissions can be developed using travel demand, traffic analysis, and emissions estimation tools. These tools extrapolate from observed relationships between demographics, economic activity, vehicle and transit usage, emissions under various travel conditions by different vehicle type, and available transportation facilities. All of those relationships will evolve in the future, and analysts must inevitably make reasonable assumptions about future growth, shifts in vehicle technology, and future project investments. For that reason, “forecasts” are not “predictions” in that they are always contingent on things continuing as we suppose they will, and there is always the possibility that they will not.

In addition, climate models are complex and incorporate many different assumptions. Climate projections can be affected by the limitations in the data and can limit the accuracy of the projections. Some limitations of the GHG emission scenario models are that the scenarios reflect the societal choices over the next century. Future scenarios could change based on different economic, technologic, demographic, and policies in the future.

Although there is uncertainty inherent in the analysis, the analysis was conducted using the best available information and tools and provides reasonable comparisons of the GHG and associated impacts between the Alternatives.

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Attachment 1:
Emission Summary

Table 1: Annualized CO_2e Greenhouse Gas (GHG) Emissions[1]

	Annual Operating Emissions (CO_2e)[1]		Annualized Construction and O&M Emissions (CO_2e)	
Year	**No Build**	**8-Lane Hybrid**	**No Build**	**8-Lane Hybrid**
2040	1,459	2,446	24	187
2041	1,459	2,446	24	187
2042	1,459	2,446	24	187
2043	1,460	2,447	24	187
2044	1,460	2,447	24	187
2045	1,460	2,447	24	187
2046	1,461	2,447	24	187
2047	1,461	2,447	24	187
2048	1,461	2,447	24	187
2049	1,461	2,448	24	187
2050	1,462	2,448	24	187
2051	1,462	2,448	24	187
2052	1,462	2,448	24	187
2053	1,463	2,448	24	187
2054	1,463	2,448	24	187
2055	1,463	2,449	24	187
2056	1,464	2,449	24	187
2057	1,464	2,449	24	187
2058	1,464	2,449	24	187
2059	1,464	2,449	24	187
2060	1,461	2,443	24	187
Cumulative Total	**45,265**	**75,846**	**743**	**5,796**

Notes:

NA – not applicable

1. Annualized greenhouse gas emissions for construction and O&M were taken from the Introduction to the infrastructure Carbon Estimator (ICE), Version 2.2.8 tool used for this Project. Vehicle operational emissions for 2040 and 2060 were taken from the Environmental Protection Agency (EPA) Motor Vehicle Emissions Simulator (MOVES) modeling performed for this Project. Operation emissions for years between 2040 and 2060 were estimated by linear interpolation.

Table 2: Year-by-Year and Total GHG Emissions in 2040 to 2060 (CO_2e)

	Year-by-year and Total GHG Emissions in 2040 to 2060 (CO_2e)	
Year	**No Build**	**Build**
2040	1,482	2,633
2041	1,483	2,633
2042	1,483	2,633
2043	1,484	2,633
2044	1,484	2,634
2045	1,484	2,634
2046	1,485	2,634
2047	1,485	2,634
2048	1,485	2,634
2049	1,485	2,635
2050	1,486	2,635
2051	1,486	2,635
2052	1,486	2,635
2053	1,487	2,635
2054	1,487	2,635
2055	1,487	2,636
2056	1,488	2,636
2057	1,488	2,636
2058	1,488	2,636
2059	1,488	2,636
2060	1,485	2,630
Cumulative Total	**46,008**	**81,642**

Table 3: Annualized (CO_2e) Greenhouse Gas (GHG) Emissions[1]

Year	2020	2040		2060	
Scenario	Existing Condition	No Build	Build	No Build	Build
Units	Metric ton/year	Metric ton/year	Metric ton/year	Metric ton/year	Metric ton/year
Construction					
Lighting	0	0	20	0	20
Pathways	0	0	5	0	5
Roadways (Construction and O&M)	24	24	76	24	76
Signage	0	0	0	0	0
Vehicle_Ops_ConstructionDelay	0	0	86	0	86
Operation					
Vehicle_Ops_Operations[2]	2,695	1,853	3,106	1,856	3,103
Custom_Pavement	0	0	0	0	0
Total Construction and Operation	2,718	1,876	3,293	1,879	3,290
Difference Build vs No Build	NA	NA	1,417	NA	1,411
Difference Build vs No Build %	NA	NA	75.53%	NA	75.07%
Difference from Existing Condition	NA	-842	575	-839	571
Difference from Existing Condition %	NA	-31.0%	21.15%	-30.87%	21.02%

Notes:

NA – not applicable

1. Annualized greenhouse gas emissions for each activity were taken from the Introduction to the Infrastructure Carbon Estimator (ICE), Version 2.2.8 tool used for this Project, with the exception of vehicle operational emissions, which were taken from the Environmental Protection Agency (EPA) Motor Vehicle Emission Simulator (MOVES) modeling performed for this Project. Emissions from the ICE tool were annualized assuming a 35-year timespan of the proposed Project.

2. A 1.27 multiplicative factor was applied to vehicle operational emissions to obtain the total well-to-wheel emissions

Table 4: Unit Social Cost for GHG (2020 dollars per metric ton of GHG)[1]

Pollutant	Discount Rate (%)	Emissions Year		
		2020	2040	2060
CO_2	5.00%	14	25	41
CH_4	5.00%	670	1,300	2,218
N_2O	5.00%	5,800	10,000	16,900
CO_2	3.00%	51	73	99
CH_4	3.00%	1,500	2,500	3,840
N_2O	3.00%	18,000	28,000	39,000
CO_2	2.50%	76	103	131
CH_4	2.50%	2,000	3,100	4,662
N_2O	2.50%	27,000	39,000	51,923
CO_2	3% 95th Percentile	152	225	300
CH_4	3% 95th Percentile	3,900	6,700	10,056
N_2O	3% 95th Percentile	48,000	74,000	104,618

Notes:

1. Source: Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide (February 2021).

Table 5: Social Cost Due to Construction and O&M Emissions (2020 dollars)[1]

Pollutant	Discount Rate (%)	Scenario				
		2020	2040		2060	
		Existing Condition	No Build	Build	No Build	Build
CO_2	5.00%	$330	$589	$4,674	$967	$7,665
CO_2	3.00%	$1,203	$1,721	$13,648	$2,334	$18,509
CO_2	2.50%	$1,792	$2,429	$19,257	$3,089	$24,492
CO_2	3% 95th Percentile	$3,584	$5,305	$42,067	$7,074	$56,089

Notes:

1. Assumes all CO_2e emissions are CO_2 emissions.

Table 6: Social Cost Due to Vehicle Travel during Operation (2020 dollars)[1]

Pollutant	Discount Rate (%)	Scenario				
		2020	2040		2060	
		Existing Condition	No Build	Build	No Build	Build
CO_2	5.00%	$28,873	$35,711	$59,877	$58,810	$98,341
CH_4	5.00%	$116	$142	$238	$332	$555
N_20	5.00%	$1,628	$669	$1,122	$899	$1,503
CO_2	3.00%	$105,181	$104,276	$174,840	$142,004	$237,459
CH_4	3.00%	$260	$273	$459	$575	$962
N_20	3.00%	$5,052	$1,874	$3,142	$2,074	$3,468
CO_2	2.50%	$156,741	$147,129	$246,692	$187,905	$314,213
CH_4	2.50%	$347	$339	$569	$698	$1,167
N_20	2.50%	$7,578	$2,610	$4,376	$2,761	$4,617
CO_2	3% 95th Percentile	$313,482	$321,397	$538,890	$430,316	$719,571
CH_4	3% 95th Percentile	$677	$733	$1,229	$1,506	$2,518
N_20	3% 95th Percentile	$13,473	$4,952	$8,303	$5,563	$9,302

Notes:

1. Used 2020 social cost emission factors to estimate 2020 Existing Conditions social cost

Table 7: Social Cost for Construction, O&M, and Operation (2020 dollars)

Pollutant	Discount Rate (%)	Scenario				
		2020	2040		2060	
		Existing Condition	No Build	Build	No Build	Build
CH_2, CH_4, & N_20	5.00%	$30,948	$37,112	$65,911	$61,007	$108,065
CH_2, CH_4, & N_20	3.00%	$111,697	$108,144	$192,089	$146,987	$260,397
CH_2, CH_4, & N_20	2.50%	$166,459	$152,506	$270,894	$194,453	$344,489
CH_2, CH_4, & N_20	3% 95th Percentile	$331,216	$332,388	$590,489	$444,458	$787,481

Table 8: Difference in Social Cost Compared to No Build (2020 dollars)

Pollutant	Discount Rate (%)	Scenario				
		2020	2040		2060	
		Existing Condition	No Build	Build	No Build	Build
CH_2, CH_4, & N_20	5.00%	NA	$0	$28,800	$0	$47,058
CH_2, CH_4, & N_20	3.00%	NA	$0	$83,944	$0	$113,410
CH_2, CH_4, & N_20	2.50%	NA	$0	$118,388	$0	$150,037
CH_2, CH_4, & N_20	3% 95th Percentile	NA	$0	$258,101	$0	$343,023

Notes:
NA= not applicable

Table 9: Difference in Social Cost Compared to 2020 Existing Condition (2020 dollars)

Pollutant	Discount Rate (%)	Scenario				
		2020	2040		2060	
		Existing Condition	No Build	Build	No Build	Build
CH_2, CH_4, & N_20	5.00%	NA	$6,164	$34,964	$30,060	$77,117
CH_2, CH_4, & N_20	3.00%	NA	($3,553)	$80,392	$35,291	$148,701
CH_2, CH_4, & N_20	2.50%	NA	($13,952)	$104,435	$27,994	$178,031
CH_2, CH_4, & N_20	3% 95th Percentile	NA	$1,172	$259,273	$113,242	$456,265

Notes:
NA= not applicable

Table 10: Difference in Social Cost Compared to No Build (%)

Pollutant	Discount Rate (%)	Scenario				
		2020	2040		2060	
		Existing Condition	No Build	Build	No Build	Build
CH_2, CH_4, & N_20	5.00%	NA	0.0%	77.6%	0.0%	77.1%
CH_2, CH_4, & N_20	3.00%	NA	0.0%	77.6%	0.0%	77.2%
CH_2, CH_4, & N_20	2.50%	NA	0.0%	77.6%	0.0%	77.2%
CH_2, CH_4, & N_20	3% 95th Percentile	NA	0.0%	77.7%	0.0%	77.2%

Notes:
NA= not applicable

Table 11: Difference in Social Cost Compared to 2020 Existing Condition (%)

Pollutant	Discount Rate (%)	Scenario				
		2020	2040		2060	
		Existing Condition	No Build	Build	No Build	Build
CH_2, CH_4, & N_20	5.00%	NA	20%	113%	97%	249%
CH_2, CH_4, & N_20	3.00%	NA	-3%	72%	32%	133%
CH_2, CH_4, & N_20	2.50%	NA	-8%	63%	17%	107%
CH_2, CH_4, & N_20	3% 95th Percentile	NA	0%	78%	34%	138%

Notes:
NA= not applicable

Table 12: Unit Social Cost for GHG (2020 dollars per metric ton of GHG) [1,2]

Pollutant	Emissions Year	Discount Rate			
		5% Average	3% Average	2.5% Average	3% 95th Percentile
CO_2	2020	14	51	76	152
	2025	17	56	83	169
	2030	19	62	89	187
	2031	19.6	63	90.4	190.8
	2032	20.2	64	91.8	194.6
	2033	20.8	65	93.2	198.4
	2034	21.4	66	94.6	202.2
	2035	22	67	96	206
	2036	22.6	68.2	97.4	209.8
	2037	23.2	69.4	98.8	213.6
	2038	23.8	70.6	100.2	217.4
	2039	24.4	71.8	101.6	221.2
	2040	25	73	103	225
	2041	25.6	74.2	104.4	228.4
	2042	26.2	75.4	105.8	231.8
	2043	26.8	76.6	107.2	235.2
	2044	27.4	77.8	108.6	238.6
	2045	28	79	110	242
	2046	28.8	80.2	111.2	245.6
	2047	29.6	81.4	112.4	249.2
	2048	30.4	82.6	113.6	252.8
	2049	31.2	83.8	114.8	256.4
	2050	32	85	116	260
	2051	32.2	86.4	118.3	265.4
	2052	32.9	87.6	119.7	269.3
	2053	33.5	88.8	121.2	273.1
	2054	34.2	90.0	122.6	276.9
	2055	34.8	91.2	124.0	280.7
	2056	35.5	92.5	125.4	284.5
	2057	36.1	93.7	126.9	288.3
	2058	36.8	94.9	128.3	292.1
	2059	37.4	96.1	129.7	295.9
	2060	38.0	97.3	131.1	299.8
CH_4	2020	670	1,500	2,000	3,900
	2025	800	1,700	2,200	4,500
	2030	940	2,000	2,500	5,200
	2031	972	2,040	2,560	5,360
	2032	1,004	2,080	2,620	5,520
	2033	1,036	2,120	2,680	5,680
	2034	1,068	2,160	2,740	5,840

	2035	1,100	2,200	2,800	6,000
	2036	1,140	2,260	2,860	6,140
	2037	1,180	2,320	2,920	6,280
	2038	1,220	2,380	2,980	6,420
	2039	1,260	2,440	3,040	6,560
	2040	1,300	2,500	3,100	6,700
	2041	1,340	2,560	3,180	6,860
	2042	1,380	2,620	3,260	7,020
	2043	1,420	2,680	3,340	7,180
	2044	1,460	2,740	3,420	7,340
	2045	1,500	2,800	3,500	7,500
	2046	1,540	2,860	3,560	7,640
	2047	1,580	2,920	3,620	7,780
	2048	1,620	2,980	3,680	7,920
	2049	1,660	3,040	3,740	8,060
	2050	1,700	3,100	3,800	8,200
	2051	1,738	3,155	3,890	8,426
	2052	1,778	3,213	3,959	8,583
	2053	1,817	3,272	4,028	8,740
	2054	1,857	3,331	4,097	8,896
	2055	1,897	3,390	4,166	9,053
	2056	1,936	3,449	4,235	9,210
	2057	1,976	3,508	4,304	9,367
	2058	2,015	3,567	4,373	9,524
	2059	2,055	3,626	4,442	9,680
	2060	2,095	3,685	4,511	9,837
N_2O	2020	5,800	18,000	27,000	48,000
	2025	6,800	21,000	30,000	54,000
	2030	7,800	23,000	33,000	60,000
	2031	8,040	23,400	33,600	61,400
	2032	8,280	23,800	34,200	62,800
	2033	8,520	24,200	34,800	64,200
	2034	8,760	24,600	35,400	65,600
	2035	9,000	25,000	36,000	67,000
	2036	9,200	25,600	36,600	68,400
	2037	9,400	26,200	37,200	69,800
	2038	9,600	26,800	37,800	71,200
	2039	9,800	27,400	38,400	72,600
	2040	10,000	28,000	39,000	74,000
	2041	10,400	28,400	39,600	75,400
	2042	10,800	28,800	40,200	76,800
	2043	11,200	29,200	40,800	78,200
	2044	11,600	29,600	41,400	79,600
	2045	12,000	30,000	42,000	81,000
	2046	12,200	30,600	42,600	82,400

	2047	12,400	31,200	43,200	83,800
	2048	12,600	31,800	43,800	85,200
	2049	12,800	32,400	44,400	86,600
	2050	13,000	33,000	45,000	88,000
	2051	13,405	33,377	45,818	89,818
	2052	13,685	33,892	46,447	91,273
	2053	13,964	34,407	47,075	92,727
	2054	14,244	34,922	47,704	94,182
	2055	14,523	35,436	48,332	95,636
	2056	14,803	35,951	48,960	97,091
	2057	15,082	36,466	49,589	98,545
	2058	15,362	36,981	50,217	100,000
	2059	15,641	37,496	50,846	101,455
	2060	15,921	38,011	51,474	102,909

Notes:
1. Source: Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide (February 2021).
2. Italicized unit social cost emission factors were linearly interpolated because they were not available from the primary source.

Table 13: MOVES Output – Greenhouse Gas Emissions (metric ton/year)[1]

Pollutant	Emissions Year	Scenario	
		No Build	Build
CO_2	2020	2,122	NA
	2025	NA	NA
	2030	1,696	2,845
	2031	1,662	2,786
	2032	1,628	2,730
	2033	1,598	2,679
	2034	1,569	2,631
	2035	1,544	2,588
	2036	1,521	2,551
	2037	1,502	2,518
	2038	1,483	2,486
	2039	1,470	2,464
	2040	1,459	2,446
	2041	1,448	2,428
	2042	1,440	2,414
	2043	1,433	2,403
	2044	1,428	2,394
	2045	1,424	2,387
	2046	1,420	2,382
	2047	1,419	2,380
	2048	1,418	2,377
	2049	1,418	2,377
	2050	1,418	2,378
	2051	1,419	2,380
	2052	1,421	2,383
	2053	1,424	2,388
	2054	1,428	2,394
	2055	1,431	2,400
	2056	1,436	2,407
	2057	1,441	2,416
	2058	1,447	2,427
	2059	1,454	2,438
	2060	1,461	2,443
CH_4	2020	0.17	NA
	2025	NA	NA
	2030	0.13	0.22
	2031	0.12	0.21
	2032	0.12	0.21
	2033	0.12	0.20
	2034	0.12	0.20

	2035	0.12	0.19
	2036	0.11	0.19
	2037	0.11	0.19
	2038	0.11	0.19
	2039	0.11	0.18
	2040	0.11	0.18
	2041	0.11	0.18
	2042	0.11	0.18
	2043	0.11	0.18
	2044	0.11	0.19
	2045	0.11	0.19
	2046	0.11	0.19
	2047	0.11	0.19
	2048	0.12	0.19
	2049	0.12	0.20
	2050	0.12	0.20
	2051	0.12	0.20
	2052	0.12	0.21
	2053	0.13	0.21
	2054	0.13	0.22
	2055	0.13	0.22
	2056	0.14	0.23
	2057	0.14	0.23
	2058	0.14	0.24
	2059	0.15	0.24
	2060	0.15	0.25
N_2O	2020	0.28	NA
	2025	NA	NA
	2030	0.13	0.22
	2031	0.11	0.19
	2032	0.11	0.18
	2033	0.10	0.16
	2034	0.09	0.15
	2035	0.09	0.14
	2036	0.08	0.14
	2037	0.08	0.13
	2038	0.07	0.12
	2039	0.07	0.12
	2040	0.07	0.11
	2041	0.06	0.11
	2042	0.06	0.11
	2043	0.06	0.10
	2044	0.06	0.10
	2045	0.06	0.10
	2046	0.06	0.10

	2047	0.06	0.10
	2048	0.06	0.09
	2049	0.06	0.09
	2050	0.05	0.09
	2051	0.05	0.09
	2052	0.05	0.09
	2053	0.05	0.09
	2054	0.05	0.09
	2055	0.05	0.09
	2056	0.05	0.09
	2057	0.05	0.09
	2058	0.05	0.09
	2059	0.05	0.09
	2060	0.05	0.09

Notes:

1. Annualized greenhouse gas emissions for each activity were taken from the Introduction to the Infrastructure Carbon Estimator (ICE), Version 2.2.8 tool used for this Project, with the exception of vehicle operational emissions, which were taken from the Environmental Protection Agency (EPA) Motor Vehicle Emission Simulator (MOVES) modeling performed for this Project. Emissions from the ICE tool were annualized assuming a 30-year timespan of the proposed Project.

Table 14: Cumulative Social Cost for Construction, O&M, and Operation (2020 dollars) – 5% Average Discount Rate

Emissions Year	Scenario	
	No Build	Build
2020	31,451	NA
2025	NA	NA
2030	33,392	55,991
2031	33,610	56,355
2032	33,891	56,825
2033	34,197	57,338
2034	34,509	57,862
2035	34,862	58,454
2036	35,259	59,119
2037	35,705	59,868
2038	36,138	60,594
2039	36,687	61,514
2040	37,281	62,510
2041	37,893	63,535
2042	38,545	64,628
2043	39,247	65,806
2044	39,984	67,042
2045	40,741	68,311
2046	41,787	70,064
2047	42,900	71,930
2048	43,990	73,759
2049	45,133	75,675
2050	46,300	77,631
2051	46,672	78,255
2052	47,671	79,931
2053	48,723	81,695
2054	49,786	83,477
2055	50,857	85,272
2056	51,964	87,129
2057	53,110	89,050
2058	54,300	91,045
2059	55,517	93,086
2060	56,754	94,903
Cumulative Total	1,317,406	2,208,654

Table 15: Cumulative Social Cost for Construction, O&M, and Operation (2020 dollars) – 3% Average Discount Rate

Emissions Year	Scenario	
	No Build	Build
2020	113,530	NA
2025	NA	NA
2030	108,501	181,929
2031	107,616	180,446
2032	106,986	179,384
2033	106,494	178,559
2034	106,076	177,859
2035	105,832	177,449
2036	106,091	177,884
2037	106,523	178,607
2038	106,938	179,305
2039	107,716	180,608
2040	108,639	182,157
2041	109,572	183,720
2042	110,635	185,503
2043	111,853	187,545
2044	113,177	189,765
2045	114,562	192,087
2046	116,009	194,513
2047	117,647	197,259
2048	119,225	199,905
2049	120,946	202,791
2050	122,730	205,783
2051	124,777	209,214
2052	126,697	212,434
2053	128,754	215,883
2054	130,836	219,375
2055	132,935	222,893
2056	135,126	226,566
2057	137,413	230,401
2058	139,805	234,413
2059	142,264	238,536
2060	144,765	242,076
Cumulative Total	3,677,141	6,164,852

Table 16: Cumulative Social Cost for Construction, O&M, and Operation (2020 dollars) – 2.5% Average Discount Rate

Emissions Year	Scenario	
	No Build	Build
2020	169,191	NA
2025	NA	NA
2030	155,702	261,073
2031	154,377	258,853
2032	153,420	257,240
2033	152,663	255,971
2034	152,014	254,883
2035	151,614	254,213
2036	151,476	253,981
2037	151,598	254,186
2038	151,712	254,377
2039	152,351	255,448
2040	153,205	256,880
2041	154,099	258,379
2042	155,183	260,196
2043	156,487	262,383
2044	157,942	264,823
2045	159,486	267,411
2046	160,815	269,640
2047	162,410	272,315
2048	163,925	274,854
2049	165,638	277,728
2050	167,438	280,744
2051	170,906	286,560
2052	173,182	290,377
2053	175,646	294,507
2054	178,141	298,690
2055	180,656	302,908
2056	183,295	307,333
2057	186,063	311,973
2058	188,970	316,848
2059	191,965	321,869
2060	195,013	326,099
Cumulative Total	5,107,391	8,562,743

Table 17: Cumulative Social Cost for Construction, O&M, and Operation (2020 dollars) – 3% 95th Percentile Average Discount Rate

Emissions Year	Scenario	
	No Build	Build
2020	336,680	NA
2025	NA	NA
2030	325,897	546,450
2031	324,734	544,499
2032	324,195	543,581
2033	324,011	543,272
2034	323,994	543,244
2035	324,458	544,022
2036	325,432	545,655
2037	326,912	548,136
2038	328,355	550,556
2039	330,909	554,838
2040	333,914	559,877
2041	336,391	564,031
2042	339,271	568,860
2043	342,627	574,486
2044	346,309	580,659
2045	350,176	587,144
2046	354,480	594,360
2047	359,368	602,555
2048	364,071	610,441
2049	369,215	619,066
2050	374,548	628,008
2051	382,657	641,604
2052	388,651	651,654
2053	395,067	662,412
2054	401,557	673,295
2055	408,099	684,264
2056	414,922	695,704
2057	422,046	707,649
2058	429,490	720,131
2059	437,139	732,955
2060	444,918	743,988
Cumulative Total	11,253,812	18,867,393

Table 18: Cumulative SC-GHG 2030-2060

Discount Rate	No Build	Build
5.00%	$1,317,406	$2,208,654
3.00%	$3,677,141	$6,164,852
2.50%	$5,107,391	$8,562,743
3% 95th	$11,253,812	$18,867,393

Table 19: Differences Between Build and No Build – Cumulative SC-GHG 2030-2060

Discount Rate	No Build	Build
5.00%	NA	$891,248
3.00%	NA	$2,487,711
2.50%	NA	$3,455,353
3% 95th	NA	$7,613,581

Notes:
NA= not applicable

Table 20: Differences Between Build and No Build (%) – Cumulative SC-GHG 2030-2060

Discount Rate	No Build	Build
5.00%	NA	67.65%
3.00%	NA	67.65%
2.50%	NA	67.65%
3% 95th	NA	67.65%

Notes:
NA= not applicable

Table 21: GHG Emissions Equivalency for GHG Emissions Increases From Build Alternative (Compared to No Build)

2040 GHG Emissions Increase from No Build	**987**
barrels of crude oil consumed	2,284
gasoline powered passenger vehicles driven for one year	220
Tanker truck's worth of gasoline	13.03
Natural Gas Fired Power Plan in One Year	0.00
2060 GHG Emissions Increase from No Build	**982**
barrels of crude oil consumed	2,272
gasoline powered passenger vehicles driven for one year	219
Tanker truck's worth of gasoline	12.97
Natural Gas Fired Power Plan in One Year	0.00

Note: www.epa.gov/energy/greenhouse-gas-equivalencies-caluclator

1000 MT CO_2e is equivalent to:

2313 barrels of oil consumed
223 gasoline powered passenger vehicles driven for one year
13.2 Tanker truck's worth of gasoline
0.003 Natural Gas Fired Power Plan in One Year

Table 22: MOVES Output- Greenhouse Gase Emissions (ton/year)

Pollutant	Scenario				
	2020	2040		2060	
	Existing Condition	No Build	Build	No Build	Build
CO_2	2336.71	1606.47	2693.59	1608.99	2690.54
CH_4	0.19	0.12	0.20	0.16	0.28
N_2O	0.31	0.07	0.12	0.06	0.10
Total CO_2e	2337.21	1606.67	2693.91	1609.21	2690.91

Table 23: MOVES Output- Greenhouse Gase Emissions (metric ton/year)

Pollutant	Scenario				
	2020	2040		2060	
	Existing Condition	No Build	Build	No Build	Build
CO_2	2121.91	1458.80	2445.98	1461.08	2443.21
CH_4	0.17	0.11	0.18	0.15	0.25
N_2O	0.28	0.07	0.11	0.05	0.09
Total CO_2e	2122.37	1458.97	2446.27	1461.28	2443.55
Difference Build vs No Build	NA	NA	987.30	NA	982.26
Difference Build vs No Build %	NA	NA	68%	NA	67%
Difference from Existing Condition	NA	-663.39	323.91	-661.08	321.18
Difference from Existing Condition %	NA	-31%	15%	-31%	15%

Table 24: Vehicle Miles Traveled (VMT)

Pollutant	Scenario				
	2020	2040		2060	
	Existing Condition	No Build	Build	No Build	Build
Total VMT	4127800.00	4543900.00	7618800.00	5035600.00	8420500.00
Average Daily VMT	11309.04	12449.04	20873.42	13796.16	23069.86

Table 25: Global Warming Potentials (GWPs)

Pollutant	GWP
CO_2	1
CH_4	25
N_2O	298

Notes:
1. 100-year GWP from the Intergovernmental Panel on Climate Change's (IPCC's) Fourth Assessment Report (AR4) to be consistent with the ICE Tool.

Attachment 2: Traffic Data

South Market Street Redevelopment, Wilmington, Delaware
Area 1 and Area 2 Air Quality Analysis Traffic Data
RK&K – February 2023
Revised February 2024

Attachments

A	2020 Existing Peak Hour Volumes
B	2040 No-Build Peak Hour Volumes
C	2060 No-Build Peak Hour Volumes
D	2040 100% Build Peak Hour Volumes
E	2060 100% Build Peak Hour Volumes
F	Annual Average Hourly Distribution Factor Group for Week Days
G	Diesel Percentage Calculation

Sources, Assumptions, and Methodology

- The segment lengths, in miles, were measured from the Synchro network link lengths. The Synchro model was based on existing aerial maps and the South Market Street Master Plan dated October 15, 2019.
- Peak Hour Volume forecasts from the South Market Street Redevelopment Master Planning Traffic Operational Analysis were used as a baseline to determine Average Daily Traffic (ADT) volumes.
    - **100% Build Volumes** include 2040 volumes at the intersections within the Phase 1 development area assuming all development (Phases 1-4) is complete.
    - 2060 Volumes are as follows:
        - **2060 No-Build** includes 2040 No-Build Volumes grown by 0.5% per year for 20 years, rounded to the nearest 5 vehicles per hour
        - **2060 100% Build** includes 2040 100% Build Volumes grown by 0.5% per year for 20 years, rounded to the nearest 5 vehicles per hour
    - For all scenarios (**2020 Existing**, **2040 No-Build**, **2060 No-Build**, **2040 100% Build**, and **2060 100% Build**), DelDOT's most recent Diurnal Distribution Tables (2021) were used to estimate the Average Weekday Daily Traffic (AWDT) on each segment from the AM and PM peak hour forecasts:
        - Traffic Pattern Group (TPG) 2 was used to estimate AWDT on S Market Street: AM and PM peak hour volumes account for 5.3% and 7.63% of AWDT, respectively.
        - TPG 3 was used to estimate AWDT on all other roadways: AM and PM peak hour volumes account for 7.24% and 8.80% of AWDT, respectively.
        - The AWDT was assumed to be the maximum of either:
            a) AWDT calculated from the combined AM and PM peak hour volumes, or
            b) The average of the AWDT calculated from the AM peak hour volumes and the PM peak hour volumes, separately.
        - The AWDT volumes were rounded to the nearest 100 vehicles per day.
    - AWDT was converted to ADT using a factor of 0.863.
        - This factor is the ratio of average weekday daily traffic to average daily traffic from a nearby 7-day tube count on the S Head St Off Ramp to New Castle Ave conducted in late November and early December 2018.
        - ADT volumes were rounded to the nearest 100 vehicles per day.
- Geometric improvements identified in the 100% Build analysis include:
    - The intersection of South Market Street and New Sweden Street will remain the same as existing/No-Build conditions.

  - The intersection of New Sweden Street and S Orange Street will be a one-lane roundabout.
- The diesel percentages were based on a February 2008 classification count on New Castle Avenue, just south of A Street and the gasoline vs. diesel breakdown used by MDOT SHA
  - Out of the existing classification data that was available from past studies and on the DelDOT TMC count database, this location is the most similar to the proposed land use of the South Market Street redevelopment, including a mix of residential and non-residential uses.
  - The MDOT SHA Travel Forecasting Reference Manual includes the following breakdown:

Air Quality Analysis Vehicle Classification	**FHWA Vehicle Classification**	**Gasoline Powered**	**Diesel Powered**
Light Trucks	Class 4 & 10% of Class 5	50%	50%
Medium Trucks	90% of Class 5	50%	50%
Heavy Trucks	Class 6-13	5%	95%

  - The resulting network-wide diesel percentage is **5.3%**.
  - The fraction of ADT by diesel vehicles is rounded to the nearest 10 vehicles per day.
- For each scenario, the network-wide Annual Vehicle Miles Traveled (VMT) was assumed to equal the sum of all segment VMTs in the network.
  - VMT = Segment Length x AADT x 365 days/year
  - All VMTs were rounded to the nearest 100

South Market Street Redevelopment
Air Quality Analysis Traffic Data

February 2024

2020 Existing

#	Roadway	Start	End	Segment Length (Miles)	AADT (vpd)	VMT (veh-mi/year)	Percent Diesel	Diesel AADT (vpd)	Diesel VMT veh-mi/year
1	SB Market St	A St	Howard St	0.16	19,300	1,142,100	5.3%	1,020	60,400
2	SB Market St	Howard St	U-Turn	0.26	18,500	1,775,100	5.3%	980	94,000
3	SB Market St	U-Turn	New Sweden St	0.07	17,300	462,800	5.3%	920	24,600
4	New Sweden St	US 13	Delmarva Ln	0.50	4,400	795,100	5.3%	230	41,600
			Total	-	-	4,175,100	-	-	220,600

2040 No-Build

#	Roadway	Start	End	Segment Length (Miles)	AADT (vpd)	VMT (veh-mi/year)	Percent Diesel	Diesel AADT (vpd)	Diesel VMT veh-mi/year
1	SB Market St	A St	Howard St	0.16	21,300	1,243,900	5.3%	1,130	66,000
2	SB Market St	Howard St	U-Turn	0.26	20,400	1,936,000	5.3%	1,080	102,500
3	SB Market St	U-Turn	New Sweden St	0.07	19,100	488,000	5.3%	1,010	25,800
4	New Sweden St	US 13	Delmarva Ln	0.50	4,800	876,000	5.3%	250	45,600
			Total	-	-	4,543,900	-	-	239,900

2060 No-Build

#	Roadway	Start	End	Segment Length (Miles)	AADT (vpd)	VMT (veh-mi/year)	Percent Diesel	Diesel AADT (vpd)	Diesel VMT veh-mi/year
1	SB Market St	A St	Howard St	0.16	23,600	1,378,200	5.3%	1,250	73,000
2	SB Market St	Howard St	U-Turn	0.26	22,500	2,135,300	5.3%	1,190	112,900
3	SB Market St	U-Turn	New Sweden St	0.07	21,000	536,600	5.3%	1,110	28,400
4	New Sweden St	US 13	Delmarva Ln	0.50	5,400	985,500	5.3%	290	52,900
			Total	-	-	5,035,600	-	-	267,200

South Market Street Redevelopment
Air Quality Analysis Traffic Data

February 2024

2040 100% Build

#	Roadway	Start	End	Segment Length (Miles)	AADT (vpd)	VMT (veh-mi/year)	Percent Diesel	Diesel AADT (vpd)	Diesel VMT veh-mi/year
5	SB Market St	A St	1st St	0.08	27,700	808,800	5.3%	1,470	42,900
6	SB Market St	1st St	Howard St	0.08	27,100	791,300	5.3%	1,440	42,000
7	SB Market St	Howard St	2nd St	0.07	29,200	746,100	5.3%	1,550	39,600
8	SB Market St	2nd St	3rd St	0.07	29,000	741,000	5.3%	1,540	39,300
9	SB Market St	3rd St	4th St	0.07	29,100	743,500	5.3%	1,540	39,300
10	SB Market St	4th St	5th St	0.07	28,500	728,200	5.3%	1,510	38,600
11	SB Market St	5th St	New Sweden St	0.06	30,000	657,000	5.3%	1,590	34,800
12	New Sweden St	US 13	Middle St	0.09	10,100	331,800	5.3%	540	17,700
13	New Sweden St	Middle St	Orange St	0.07	7,300	186,500	5.3%	390	10,000
14	Howard St	Orange St	S Market St	0.07	6,500	166,100	5.3%	340	8,700
15	A St	S Market St	Orange St	0.08	4,400	128,500	5.3%	230	6,700
16	1st St	S Market St	Orange St	0.07	3,400	86,900	5.3%	180	4,600
17	2nd St	S Market St	Orange St	0.09	4,100	134,700	5.3%	220	7,200
18	3rd St	S Market St	Middle St	0.06	5,600	122,600	5.3%	300	6,600
19	3rd St	Middle St	Orange St	0.05	4,600	84,000	5.3%	240	4,400
20	4th St	S Market St	Middle St	0.07	500	12,800	5.3%	30	800
21	5th St	S Market St	Middle St	0.10	1,900	69,400	5.3%	100	3,700
22	5th St	Middle St	Orange St	0.06	2,800	61,300	5.3%	150	3,300
23	Middle St	3rd St	4th St	0.07	2,200	56,200	5.3%	120	3,100
24	Middle St	4th St	5th St	0.06	2,700	59,100	5.3%	140	3,100
25	Middle St	5th St	New Sweden St	0.06	3,100	67,900	5.3%	160	3,500
26	Orange St	A St	1st St	0.08	2,400	70,100	5.3%	130	3,800
27	Orange St	1st St	Howard St	0.09	3,500	115,000	5.3%	190	6,200
28	Orange St	Howard St	2nd St	0.07	5,600	143,100	5.3%	300	7,700
29	Orange St	2nd St	3rd St	0.09	4,100	134,700	5.3%	220	7,200
30	Orange St	3rd St	4th St	0.06	5,600	122,600	5.3%	300	6,600
31	Orange St	4th St	5th St	0.06	5,800	127,000	5.3%	310	6,800
32	Orange St	5th St	New Sweden St	0.07	4,800	122,600	5.3%	250	6,400
			Total	-	-	7,618,800	-	-	404,600

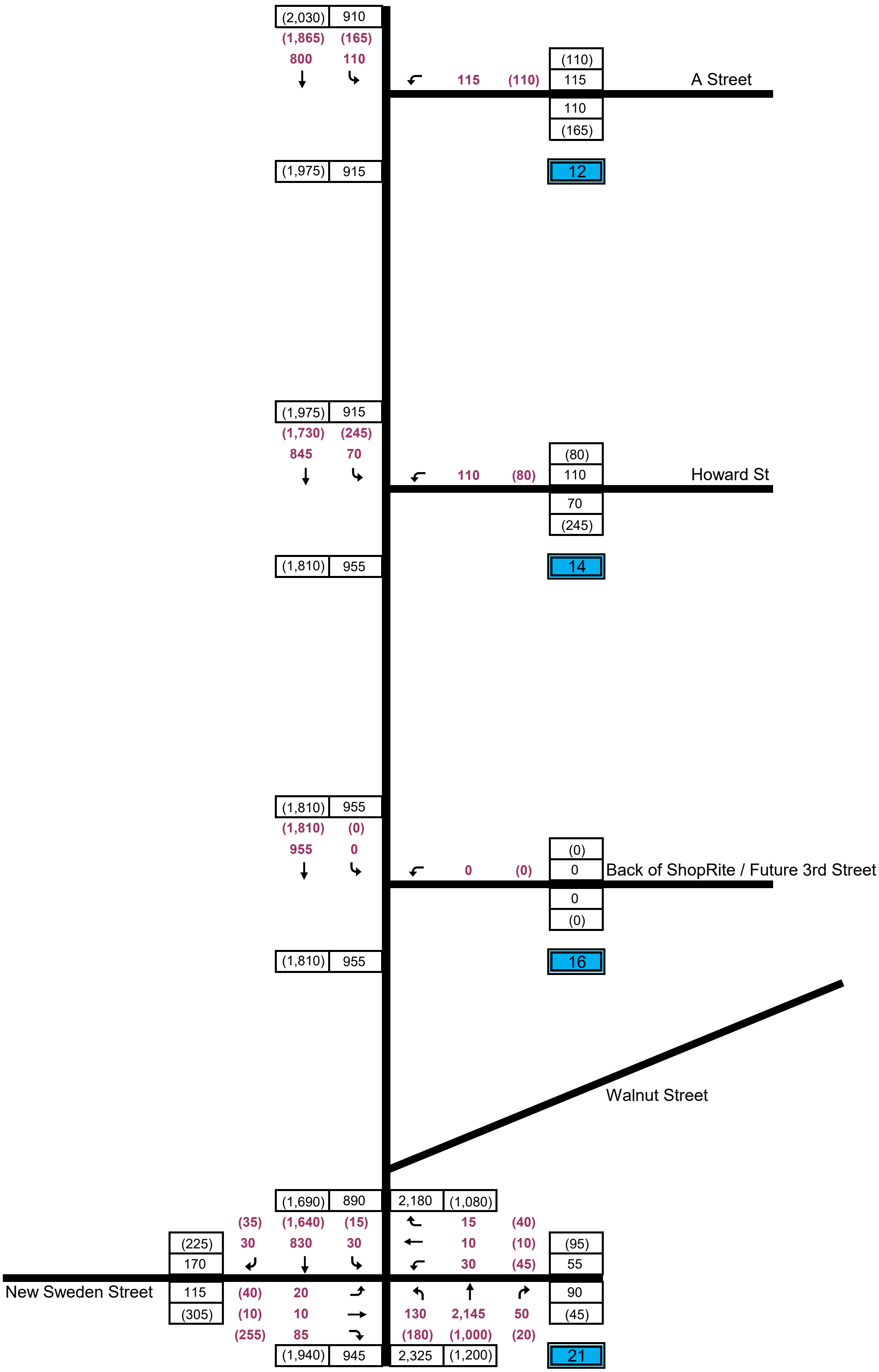
2060 100% Build

#	Roadway	Start	End	Segment Length (Miles)	AADT (vpd)	VMT (veh-mi/year)	Percent Diesel	Diesel AADT (vpd)	Diesel VMT veh-mi/year
5	SB Market St	A St	1st St	0.08	30,600	893,500	5.3%	1,620	47,300
6	SB Market St	1st St	Howard St	0.08	30,000	876,000	5.3%	1,590	46,400
7	SB Market St	Howard St	2nd St	0.07	32,300	825,300	5.3%	1,710	43,700
8	SB Market St	2nd St	3rd St	0.07	32,000	817,600	5.3%	1,700	43,400
9	SB Market St	3rd St	4th St	0.07	32,100	820,200	5.3%	1,700	43,400
10	SB Market St	4th St	5th St	0.07	31,500	804,800	5.3%	1,670	42,700
11	SB Market St	5th St	New Sweden St	0.06	33,200	727,100	5.3%	1,760	38,500
12	New Sweden St	US 13	Middle St	0.09	11,100	364,600	5.3%	590	19,400
13	New Sweden St	Middle St	Orange St	0.07	8,100	207,000	5.3%	430	11,000
14	Howard St	Orange St	S Market St	0.07	7,200	184,000	5.3%	380	9,700
15	A St	S Market St	Orange St	0.08	4,800	140,200	5.3%	250	7,300
16	1st St	S Market St	Orange St	0.07	3,600	92,000	5.3%	190	4,900
17	2nd St	S Market St	Orange St	0.09	4,600	151,100	5.3%	240	7,900
18	3rd St	S Market St	Middle St	0.06	6,200	135,800	5.3%	330	7,200
19	3rd St	Middle St	Orange St	0.05	5,100	93,100	5.3%	270	4,900
20	4th St	S Market St	Middle St	0.07	600	15,300	5.3%	30	800
21	5th St	S Market St	Middle St	0.10	2,100	76,700	5.3%	110	4,000
22	5th St	Middle St	Orange St	0.06	3,100	67,900	5.3%	160	3,500
23	Middle St	3rd St	4th St	0.07	2,400	61,300	5.3%	130	3,300
24	Middle St	4th St	5th St	0.06	3,000	65,700	5.3%	160	3,500
25	Middle St	5th St	New Sweden St	0.06	3,500	76,700	5.3%	190	4,200
26	Orange St	A St	1st St	0.08	2,700	78,800	5.3%	140	4,100
27	Orange St	1st St	Howard St	0.09	3,800	124,800	5.3%	200	6,600
28	Orange St	Howard St	2nd St	0.07	6,100	155,900	5.3%	320	8,200
29	Orange St	2nd St	3rd St	0.09	4,600	151,100	5.3%	240	7,900
30	Orange St	3rd St	4th St	0.06	6,200	135,800	5.3%	330	7,200
31	Orange St	4th St	5th St	0.06	6,400	140,200	5.3%	340	7,400
32	Orange St	5th St	New Sweden St	0.07	5,400	138,000	5.3%	290	7,400
			Total	-	-	8,420,500	-	-	445,800

Attachment A

2020 Existing Peak Hour Volumes

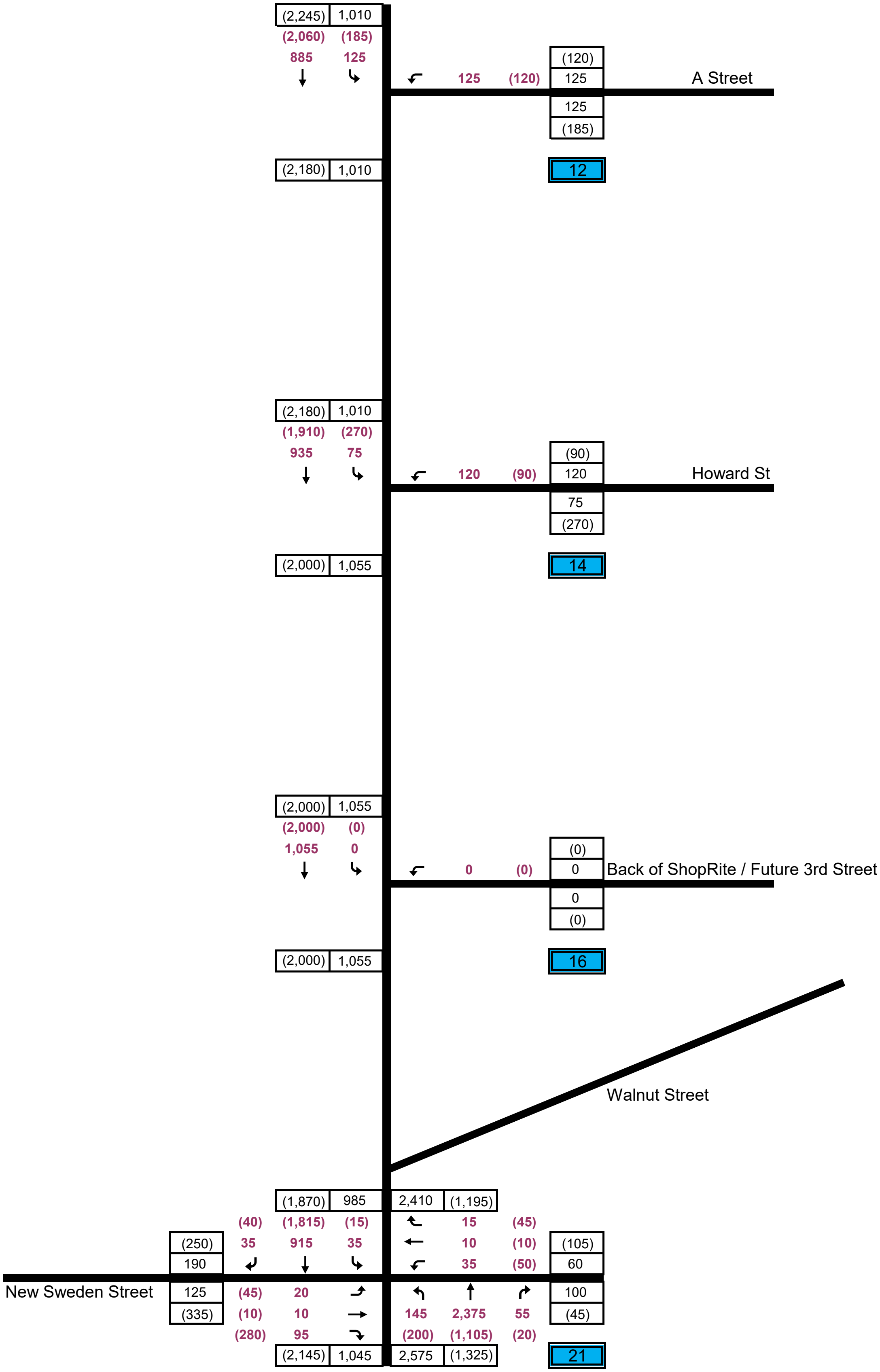
2020 Existing Volumes
xx AM Peak Hour
(xx) PM Peak Hour



Attachment B

2040 No-Build Peak Hour Volumes

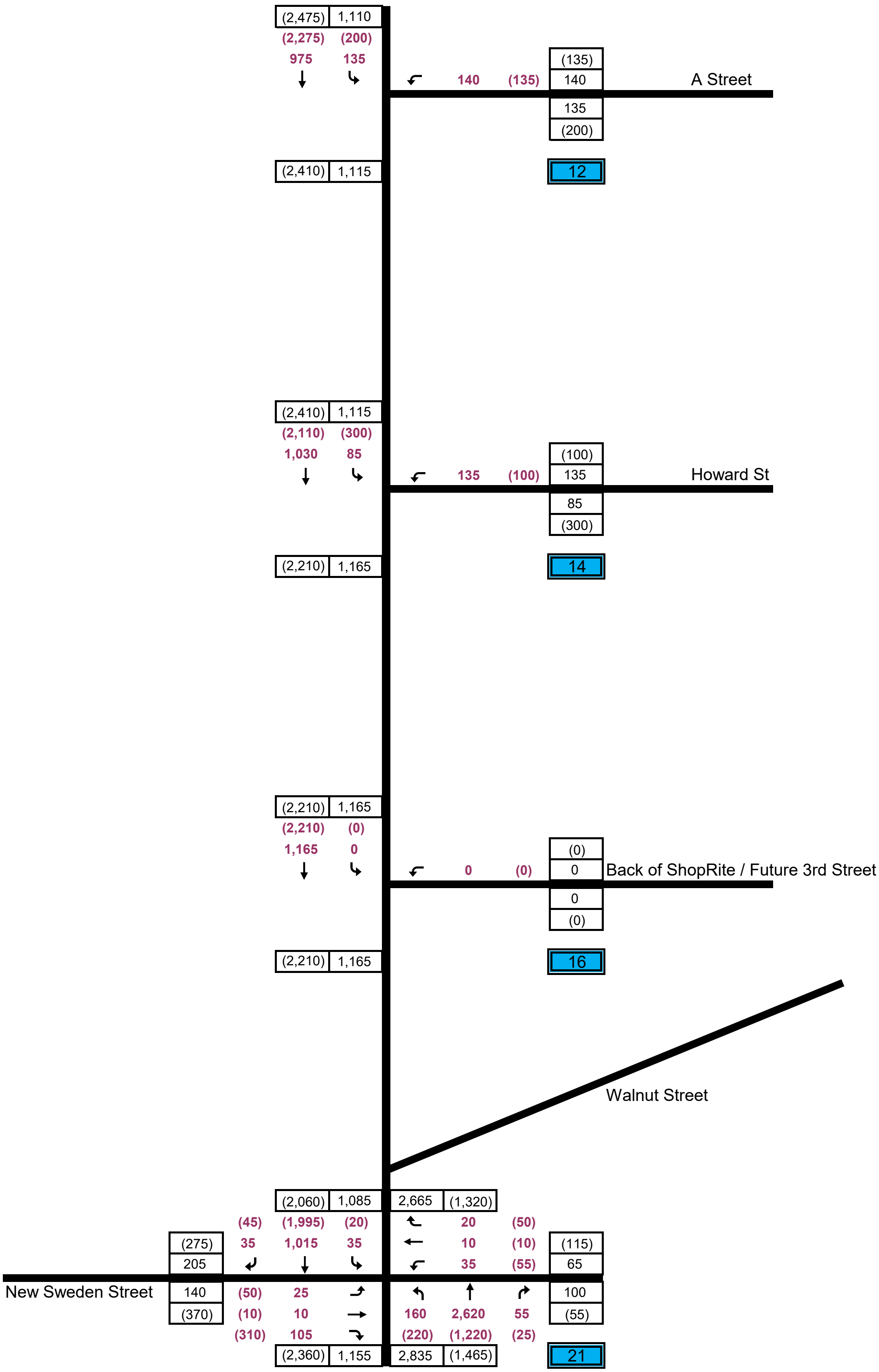
2040 No-Build Volumes
xx AM Peak Hour
(xx) PM Peak Hour



Attachment C

2060 No-Build Peak Hour Volumes

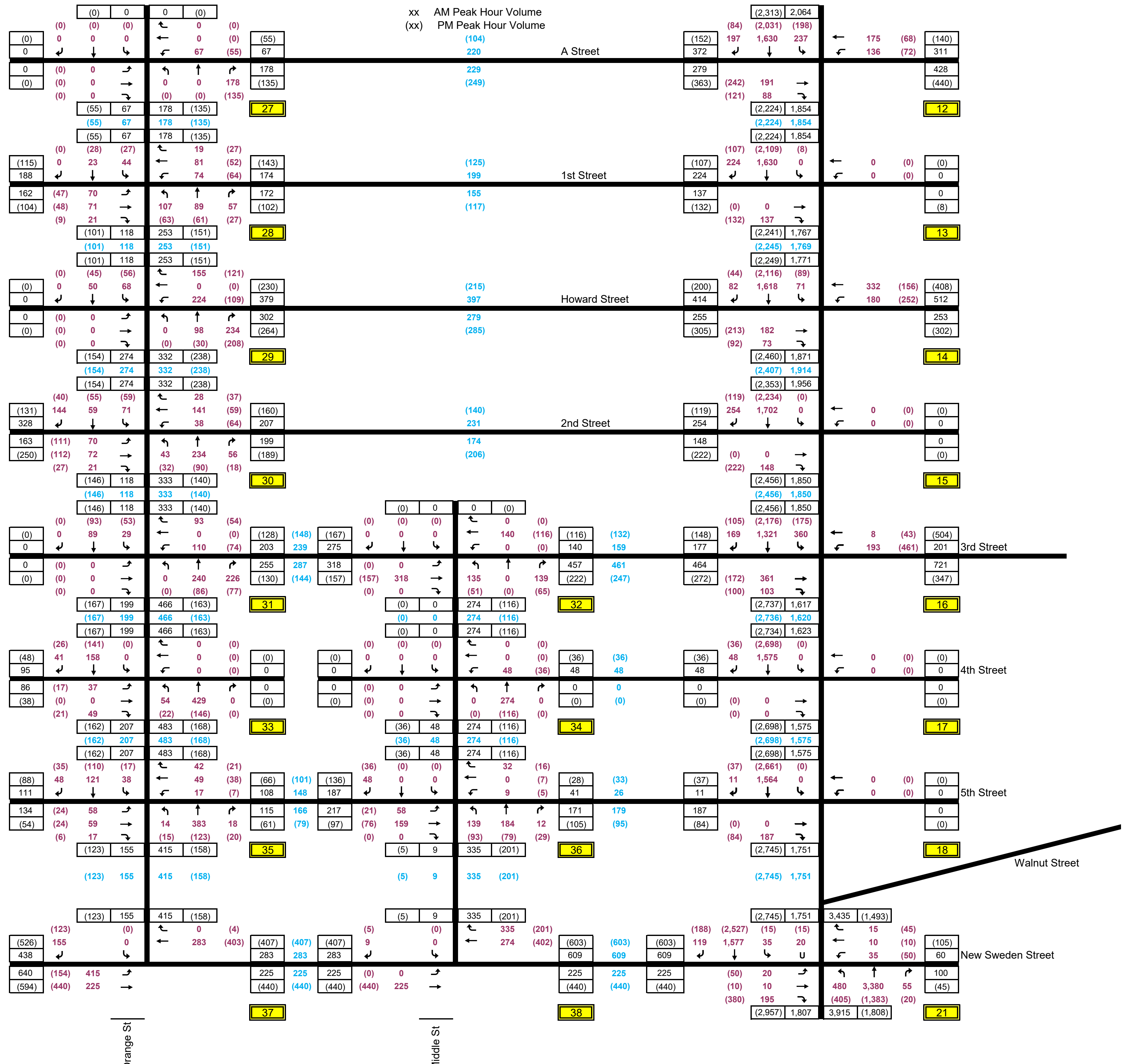
2060 No-Build Volumes
xx AM Peak Hour
(xx) PM Peak Hour



Attachment D

2040 100% Build Peak Hour Volumes

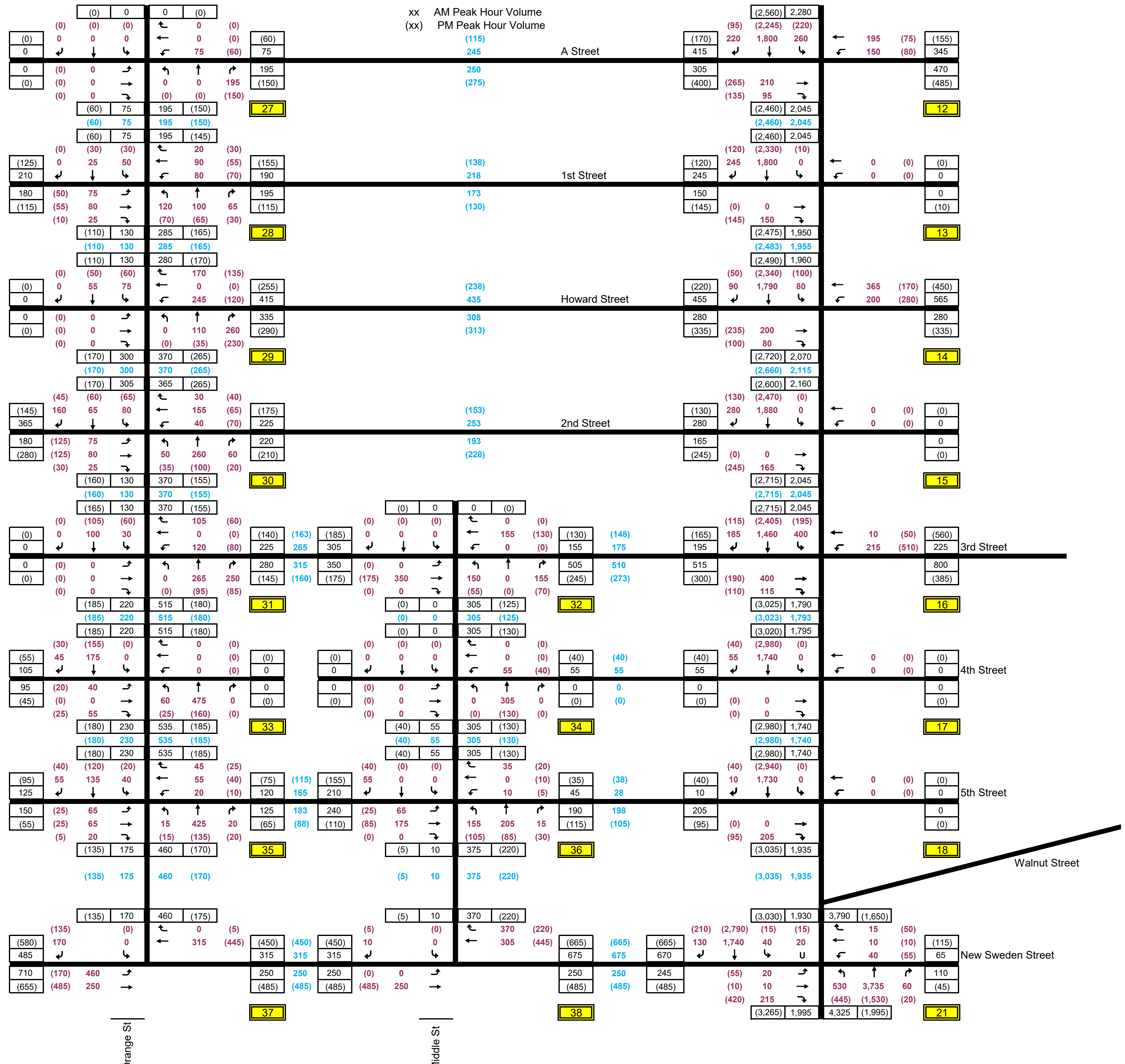
2040 100% Build Volumes



Attachment E

2060 100% Build Peak Hour Volumes

2060 100% Build Volumes



Attachment F
Delaware DOT
Annual Average Hourly Distribution Factor Group for Week Days

Delaware DOT

Annual Average Hourly Distribution By Factor Group for Week Days

2021

	1	2	3	5	6	7	8
0	1.14	0.71	0.61	0.68	1.28	0.61	0.64
1	0.82	0.46	0.38	0.51	1.17	0.40	0.45
2	0.74	0.40	0.29	0.52	1.25	0.43	0.38
3	0.85	0.53	0.32	0.68	1.93	0.65	0.41
4	1.38	0.97	0.68	1.03	2.46	1.28	0.77
5	2.76	1.93	1.75	2.11	3.50	3.13	1.66
6	4.91	3.63	4.11	4.57	5.59	4.97	4.17
7	6.19	5.30	7.24	6.58	6.63	6.64	6.44
8	5.81	5.31	5.89	5.84	5.32	6.02	5.93
9	5.23	5.08	4.65	5.60	4.74	5.17	5.71
10	5.30	5.61	4.75	5.94	4.92	5.01	6.10
11	5.55	6.34	5.13	6.32	5.14	5.16	6.33
12	5.76	6.88	5.80	6.53	5.46	5.53	6.53
13	5.89	6.78	5.94	6.64	5.72	5.78	6.58
14	6.36	7.11	7.03	6.97	6.23	6.25	7.03
15	6.94	7.64	7.96	7.53	6.67	7.30	7.76
16	7.17	8.08	9.12	7.88	7.27	8.63	7.87
17	6.85	7.63	8.80	7.10	6.93	8.46	7.14
18	5.52	5.95	6.13	5.10	5.14	6.26	5.11
19	4.42	4.68	4.53	3.82	3.67	4.31	4.25
20	3.63	3.54	3.51	3.04	3.05	3.29	3.26
21	2.87	2.52	2.44	2.27	2.42	2.36	2.52
22	2.21	1.72	1.77	1.61	1.95	1.47	1.83
23	1.69	1.20	1.17	1.13	1.55	0.89	1.10

Attachment G

Diesel Percentage Calculations

Diesel Percentages

NOTE: The vehicle classifications shown in the table below are assumed for all roads within the project area under 2040 No-Build and 2040 100% Build conditions

Autos	91.6%
Medium	3.3%
Heavy	2.5%
Buses	2.4%
Cycles	0.1%

	% of Volume	% Diesel by Type	Total % Diesel
Light Trucks	2.8%	50%	1.4%
Medium Trucks	3.0%	50%	1.5%
Heavy Trucks	2.5%	95%	2.4%
			5.3%

Data Source: February 2008 Classification Count - New Castle Avenue just South of A Street

Class 1	17	0.1%
Class 2	9626	79.7%
Class 3	1431	11.9%
Class 4	294	2.4%
Class 5	396	3.3%
Class 6	142	1.2%
Class 7	20	0.2%
Class 8	34	0.3%
Class 9	75	0.6%
Class 10	20	0.2%
Class 11	0	0.0%
Class 12	1	0.0%
Class 13	6	0.0%
Class 14	0	0.0%
Class 15	9	0.1%
Total	12071	100%

Attachment 3: ICE Model

Introduction to the Infrastructure Carbon Estimator (ICE), version 2.2

Infrastructure Carbon Estimator (ICE) version 2.2.8. Final Tool. 5/17/2023.

Note: This tool is designed to allow users to create screening-level estimates of energy and GHG emissions using limited data inputs. It asks for limited data to estimate lifecycle energy use emissions from a single or group of projects. <u>The tool is not appropriate to inform engineering analysis, including for pavement selection</u>. Other tools should be consulted for those purposes. More details about suggested uses for the tool are provided in the accompanying ICE User's Guide.

Project Inputs Page (On)

Summary Results Page (On)

OVERVIEW

The Infrastructure Carbon Estimator (ICE) estimates the lifecycle energy and greenhouse gas (GHG) emissions from the construction and maintenance of transportation facilities. The ICE tool was created to solve the problem of “planning level” estimation of embodied carbon emissions in transportation infrastructure. Without the need for any engineering studies, ICE helps answer this question: How much carbon will be embodied in the building, modification, maintenance, and/or use of this transportation project (or group of projects)?

ICE evaluates energy use and greenhouse gas emissions at the project- or planning-level. The tool uses the term “project-level” to generally refer to a single project type, with access to some additional details and project customization. “Planning-level” analyses are designed to support a suite of projects together, but with limited customization.

The tool estimates emissions for the following types of facilities and projects:

1. Bridges and Overpasses
2. Bus Rapid Transit (BRT)
3. Culverts
4. Interchanges
5. Light Rail
6. Lighting
7. Heavy Rail
8. Parking
9. Pathways
10. Roadways
11. Signage
12. Vehicle Operations
13. Standalone Maintenance Projects on Existing Roadways (Roadway Rehabilitation)
14. Custom Pavement Projects with Data Imported from External Tools

(Please note Types 13 and 14 address specific and limited applications. These are discussed in the individual tabs and the User's Guide.)

For each type of facility, the tool calculates both mitigated results that take into account the effect of various energy/GHG reduction strategies and unmitigated results.

USER'S GUIDE

Refer to the accompanying User's Guide for further instructions, detailed descriptions of factors, and assumptions regarding this tool.

Find the current version of the users guide here: https://edocs-public.dot.state.mn.us/edocs_public/DMResultSet/download?docId=11949837

USING THE TOOL

Color Scheme

ICE uses the following color scheme to describe the function of each cell:

Description Cells
Computed Value Cells
Cell value is not relevant (Cell is NA)
Data Entry Cells
Action Cell
Command button - on
Command button - off
Command button - disabled

The tool provides users the ability to display results in 508 compliant format, which among other features, will add data labels to all results charts. The color scheme when 508 compliant is activated deviates slightly from when the format is turned off.

Analysis Mode

The tool can be used in either *Planning* or *Project* mode. This is set at the top of the *Project Inputs* page.

Planning mode allows multiple infrastructure types to be analyzed together. Planning Mode reveals all facility types on one page. Using the buttons at the top of the screen allows you to add or remove facilities from your analysis. Individual facility details can be viewed via the links below the input table or by navigating the separate tabs for each infrastructure type. Clicking the hyperlinks above and below each infrastructure type's inputs in the Project Inputs page navigates to the various sections in each analysis page for that infrastructure type. The relevant analysis page(s), Mitigation Strategies page, and the Summary Results page will be shown when an infrastructure type is selected. Buttons on the analysis pages carry the user to specify mitigation measures and back to the analysis pages. Most uses of the tool use *Planning* mode.

The *Project mode* allows additional details but is limited to a single infrastructure type. It operates similarly, but for a single infrastructure type. In the Project mode, the user has the option to view all inputs or have ICE walk the user through each step. In walkthrough mode, green action cells direct the user through each step.

TABS & NAVIGATION

The tool can be navigated in multiple ways. Users will start by describing their project on the *Project Inputs* page. This includes the infrastructure type(s), analysis lifetime, location, and analysis mode. Hyperlinks carry users through the various tabs. Three comment boxes allow the user to input descriptive text that will be carried through to the output pages. This could include analysis date, analyst, project descriptions, or other information the analyst may want to include in their report.

First, select your level of analysis (Project or Planning) and input the requested information for your project on the *Project Inputs* page. Input the US state for your analysis, the project analysis lifetime (in years), and whether the impacts of a custom electricity emission program, such as a state Renewable Portfolio Standard (RPS), are to be included. Answering "yes" on the latter will open the *Annual Electricity Emissions* tab for populating. Note that due to data limitations, 2060 emissions factors are used for all calculations after 2060.

If using the Planning level of analysis, "turn on" all infrastructure types to be analyzed on the *Project Inputs* page. If using the *Project* level of analysis, then select the single infrastructure type to analyze.

Hyperlinks from the *Project Inputs* page will take you to the *analysis page* for your project type(s). (The project analysis pages are titled according to the infrastructure type.) Here some additional inputs for your project may be requested. At the top of each analysis page is a hyperlink that carries you to the *Mitigation Strategies* page.

Each *analysis page* includes the following sections:

- Specifications – Fixed and input values describing the project
- Baseline Energy Use and GHG Emissions – Total energy use and GHG emissions over the project's lifetime
- Mitigated Results – Annualized energy use and GHG emissions for the project without (baseline) and with (both business as usual and control scenario) mitigations applied.
- Results - Charts – Summary charts and tables of the mitigated and unmitigated energy use and emissions by emission category, material, and individualized mitigation effects. Results can be viewed for GHG emissions or energy consumption either as annualized values or cumulative over the analysis period.

On the *Mitigation Strategies* page, you have the option to input certain strategies that reduce energy and GHG emissions for your project. Only relevant strategies are shown. Hyperlinks at the top return you to the *analysis page* for your project type.

Below the project specifications in each *analysis page,* the calculated, annualized baseline, business-as-usual (BAU), and mitigated levels of energy or GHG emissions for your project type(s) are displayed. This shows results by the five emission categories and by material for both mitigated and unmitigated cases. It also shows emission or energy reductions by mitigation measure.

The *Summary Results* page displays a summary of results for all infrastructure types analyzed. If the analysis is at the *Project* level, this display is nearly identical to that on the *analysis page.* For *Planning* level, buttons appear allowing the user to turn on or off the different project types included in the combined results. The "Show" dropdown menu selects the results displayed: Annualized Greenhouse Gas Emissions, Annualized Energy Use, Cumulative Greenhouse Gas Emissions, and Cumulative Energy Use. An additional chart in the *Summary Results* page, not available in the individual *analysis pages*, displays values by infrastructure type.

If the use phase of vehicles is considered in your project, you must include the *Vehicle Operations* project type. Resulting energy and emissions from project use will be added to the summary charts on the *Summary Results* page. Note this is limited to roadway infrastructure. This project type also includes the ability to estimate additional emissions related to construction delay and to directly use results computed in a seperate analysis.

Similarly, ICE remains pavement material neutral. In order to consider lifecycle implications of specific pavement configurations, you must use another tool, such as FHWA's LCA PAVE. Emission factors from such an analysis may be input directly into ICE via the *Custom Pavements* infrastructure type.

At any time, the user can view overall results in the *Summary Results* page or enter a custom mitigation approach for energy and GHG emissions on the *Mitigation Strategies* page. The user can switch directly between various pages indicated in Excel tabs at any time. The *Print Results* tab collects outputs and formats them for standard printing, either to an electronic or paper copy for archiving the outputs of your simulation. This can be used to compare multiple simulations, such as for a Build vs. No-Build analysis.

Units and Time Periods

ICE requests the analysis timeframe (in years) from the user. It produces lifecycle (to end-of-life) estimates of energy use and/or GHG emissions. Both values can be reported on an annualized or total lifespan basis. The standard reporting unit for energy is "mmBTU", or millions of British Thermal Units. The standard reporting unit for greenhouse gas emissions is "MT CO2e", or metric tons of CO2-equivalent gases. 1 metric ton = 1,000 kg. CO2 equivalency is defined by a global-warming potential basis.

A Note about Energy and Emission Factors

It is important to note that ICE uses MOVES for projections of the vehicle fleet mix and downstream (tank to wheels) energy consumption rates along with fuel-vehicle full lifecycle energy and emission factors from GREET. These are combined to deiver full lifecycle (well to wheels) fuel energy and emission rates. ICE2.2 uses rates from MOVES3, which is the current version of the tool as of the time of ICE2.2 release.

It is important to note that MOVES3 includes the SAFE rule what has been repealed resulting in more stringent GHG reductions for future vehicle model years, does not account for expected future Heavy-Duty Vehicle rulemakings, and assumes negligible electric vehicle penetration in the fleet, among other limitations. ICE may be updated at a future date when improved vehicle energy rate projections are available. See the User's Guide for more information.

ESTIMATED EMISSIONS SOURCES

Construction and maintenance activities covered by the tool are broken into five categories:

Materials

Upstream Energy and Emissions associated with project materials:

1. Energy and fuel used in raw material extraction
2. Energy and fuel used in material production*
3. Chemical reactions in material production**
4. Energy and fuel used in raw material transportation

Transportation

Upstream Energy and Emissions associated with:

1. Fuel used in transportation of materials to site

Construction

1. Energy and fuel used in construction equipment

Operations and Maintenance (O&M)

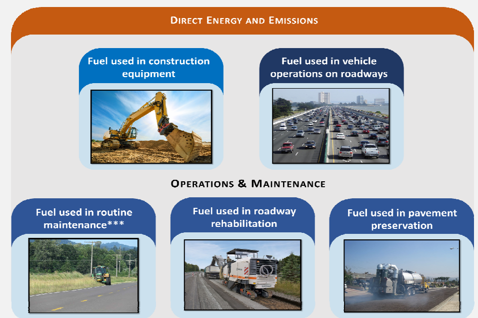
Routine Maintenance, including:

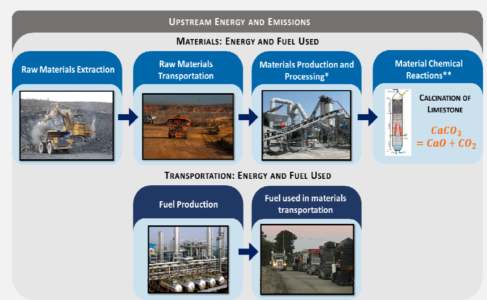
1. Fuel used in snow removal equipment
2. Fuel used in vegetation management equipment
3. Fuel used in other routine maintenance***
4. Energy and emissions from roadway repair and rehabilitation
5. Net energy and emissions from pavement preservation activities (optional)

Usage

Energy and Emissions associated with:

1. Vehicle operations on roadways, including delay during construction





*e.g. crushing of aggregate, asphalt batch plants
**e.g CO2 emitted from calcination of limestone
***activities include sweeping, stripping, bridge deck repair, litter pickup, and maintenance of appurtenances

ICE does not include energy or emissions associated with land use change from the project.

Project Inputs

Planning Summary of Inputs - See Individual Tabs for Details

Display result in 508 compliant format:	Yes
Hide Instructions	No

Clear All User Data

INSTRUCTIONS

1. Populate location (state) and lifetime (years) for your analysis.
2. Select operating mode (*Project* or *Planning*) for your analysis. (The tool can analyze individual projects (*Project* mode) or a suite of projects in a comprehensive plan (*Planning* mode). Most analyses using *Planning* mode.
3. Select the infrastructure type(s) to analyze. Input all requested data using information from the project or plan you want to analyze. Then navigate to the relevant *analysis page(s)* for your project or the individual project(s) in your plan and complete the analysis for each infrastructure type by entering information in all cells that are shaded yellow. Blue and gray cells display fixed values and results; do not change the information in these cells.
4. Apply any selected mitigation measures on the *Mitigation Strategies* tab.
5. Review outputs on the *Summary Results* tab.
6. For further instructions, refer to the accompanying User Guide for detailed descriptions of factors and assumptions used in this tool.

Infrastructure location (state)	DE
Analysis period of your plan or project (years)	35
Year construction starts	2025
Use custom electric emission profile (RPS)?	No

Tool Use	Planning

Infrastructure Types

Roadways (On) | BRT (Off) | Heavy Rail (Off) | Light Rail (Off) | Parking (Off) | Signage (On)

Bridges & Overpasses (Off) | Culverts (Off) | Interchanges (Off) | Lighting (On) | Pathways (On) | Vehicle Operations (On) | Custom Pavement (Off)

Stand-Alone Infrastructure Type

Roadway Rehabilitation (Off)

Note: This project type cannot be combined with other infrastructure types and is designed solely for short-term projects, such as one-time resurfacing events.

Enter comments and comment titles. These will be displayed on the Summary Results worksheet.	Title: Wilmington Waterfront Transportation Infrastructure F	Title: Build	Title:
	City of Wilmington New Castle County, Delaware		

Roadways

Roadways

The Roadways module in ICE accounts for the full roadway lifespan, including construction, rehabilitation, routine maintenance, and preventive maintenance for new and existing roadways. Separate inputs are required for construction, rehabilitation, and effects of preventative maintenance. Module inputs include those for both the existing and new construction. As noted, some inputs are lane miles; some are centerline miles. See the Roadways sheet and User's Guide for more information.

Source: https://commons.wikimedia.org/wiki/File:Veterans_Memorial_Parkway,_London,_Ontario.jpg

Roadway System

Total existing centerline miles	0.99
Total newly constructed centerline miles	2.02

Roadway Projects

Facility type	Roadway System	Roadway Construction				
	Existing Roadway (lane miles)	New Roadway (lane miles)	Construct Additional Lane (lane miles)	Realignment (lane miles)	Lane Widening (lane miles)	Shoulder Improvement (centerline miles)
Rural Interstates						
Rural Principal Arterials						
Rural Minor Arterials						
Rural Collectors						
Urban Interstates / Expressways						
Urban Principal Arterials						
Urban Minor Arterials / Collectors	2.47	2.71				

Include roadway rehabilitation activities (reconstruct and resurface)	Yes
% roadway construction on rocky / mountainous terrain	0%

Specification
Baseline Energy Use and GHG Emissions
Mitigated Results
Results - Charts

Lighting

Lighting

The Lighting module estimates the energy and GHG emissions associated with roadway lighting projects. ICE considers LED and HPS type lights and state-specific energy factors. See the Lighting sheet and User's Guide for more information. Module inputs include average number of lights per roadway mile by type and luminosity.

Source: http://www.sanengineeringllc.com/Projects/Structural-Engineering-NMDOT.php

Number of roadway miles	2.02

Lighting Structures Support Structure Type	Lumen Range	Ave. number of HPS lights per roadway mile	Ave. number of LED lights per roadway mile
Vertical	4000-5000		107
Vertical	7000-8800		
Vertical	8500-11500		
Vertical	11500-14000		
Vertical	21000-28000		
Vertical and Vertical with 8' Arm	4000-5000		
Vertical and Vertical with 8' Arm	7000-8800		
Vertical and Vertical with 8' Arm	8500-11500		
Vertical and Vertical with 8' Arm	11500-14000		
Vertical and Vertical with 8' Arm	21000-28000		
High Mast	28800 - 42000		
High Mast	46500-52800		
High Mast	52500-58300		

Specification
Baseline Energy Use and GHG Emissions

Mitigated Results
Results - Charts

Pathways

Pathways

The Pathways module in ICE characterizes the new construction, resurfacing, and restriping of off-street bicycle or pedestrian paths, on-street bicycle lanes, and on-street pedestrian sidewalks. See the Pathways sheet and User's Guide for more infromation. Module inputs include length of pathway by type.

Source: https://altaplanning.com/separated-bike-lanes/ ; https://www.fhwa.dot.gov/publications/research/safety/pedbike/05085/pptchapt9.cfm

Bicycle and Pedestrian Facilities

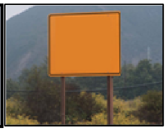
Project Type	New Construction	Resurfacing
Off-Street Bicycle or Pedestrian Path - miles	0.48	
On-Street Bicycle Lane - lane miles	2.12	
On-Street Sidewalk - miles	1.4	*N/A*

Specification
Baseline Energy Use and GHG Emissions
Mitigated Results
Results - Charts

Signage

Signage

The Signage module charaterizes small, medium, and large signs for aluminum sheet metal and directly embedded or concrete encased steel. See the Signage sheet and User's Guide for more information. Module inputs include average number of each type of sign per roadway mile and the total project roadway miles.



Source: dot.state.mn.us/trafficeng/publ/tem/2009/Chapter-06.pdf; https://www.defensivedriving.org/dmv-handbook/29-unusual-road-signs/; https://www.waaytv.com/content/news/School-bus-warning-signs-installed-on-Highway-43-463727923.html

Number of roadway miles	1.36

Signage Structures	Avg. number of signs per roadway mile
Small (3'x3') - 14 Gauge Steel Post (MDOT SIGN-150-D)	9
Medium (6'x6') - 14 Gauge Steel Posts (MDOT SIGN-150-D)	
Large (10'x14') - 8 Gauge Cantilever Arm (MDOT SIGN-300-A)	

Specification
Baseline Energy Use and GHG Emissions
Mitigated Results
Results - Charts

Vehicle Ops

Vehicle_Ops

The Vehicle Operations module estimates on roadway infrastructure from vehicle operations. It addresses both ongoing vehicle operations and additional emissions from construction delay.
ICE2.2 includes two approaches: 1) The preferred approach is for the user to enter custom emission amounts directly from a seperate calculation. ICE then combines this with any other infrastructure included. 2) The alternative approach estimates these values from user inputs of VMT, speed, and optional vehicle type. Note ICE2.2 uses MOVES3 projections of vehicle energy consumption and fleet mix.
See the Vehicle_Ops sheet and User's Guide for more information.

Source: https://www.greencarreports.com/news/1093560_1-2-billion-vehicles-on-worlds-roads-now-2-billion-by-2035-report

Enter results from external model?	No
Use separate entry for light-duty and heavy-duty vehicles?	No

Vehicle Operating Emissions

	Year		All Vehicles	
	Default	Custom	Avg Daily VMT on project	Average Daily Speed (mph) (or NA)
Project Opening Year	2025	2040	0	NA
Project Design/Horizon Year	2075	2060	0	NA

Construction Delay, Additional Emissions

	Year	
	Default	Custom
Construction start year	2025	2025
Project Opening Year	2040	2029

	All Vehicles
Avg Daily VMT impacted by project	11446.84932
Congested Speed (mph or NA)	15
Speed without congestion (mph or NA)	25

Specification
Baseline Energy Use and GHG Emissions
Mitigated Results
Results - Charts

Summary Results

Roadways (On) | BRT (Disabled) | Heavy Rail (Disabled) | Light Rail (Disabled) | Parking (Disabled) | Signage (On)

Bridges & Overpasses (Disabled) | Culverts (Disabled) | Interchanges (Disabled) | Lighting (On) | Pathways (On) | Vehicle Operations (On) | Custom Pavement (Disabled)

Show	Annualized Greenhouse Gas Emissions	Units	MT CO2e

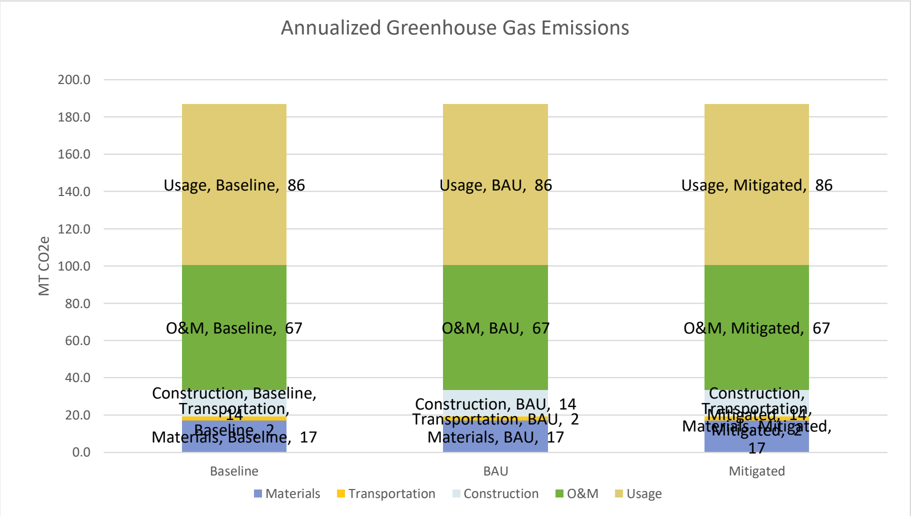
Wilmington Waterfront Transportation Infranstructure Project

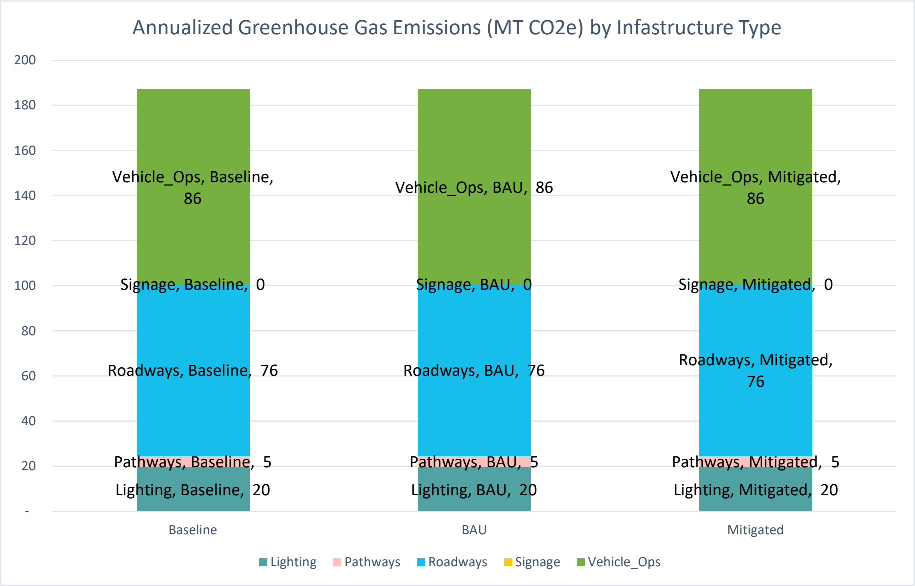
City of Wilmington
New Castle County, Delaware

Build

	Annualized Greenhouse Gas Emissions (MT CO2e) by Infastructure Type		
	MT CO2e Baseline	MT CO2e BAU	MT CO2e Mitigated
Lighting	20	20	20
Pathways	5	5	5
Roadways	76	76	76
Signage	0	0	0
Vehicle_Ops	86	86	86
Total	**187**	**187**	**187**

Summary Results - Charts





Summary Results - Tables

	Annualized Greenhouse Gas Emissions		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Materials	17	17	17
Transportation	2	2	2
Construction	14	14	14
O&M	67	67	67
Usage	86	86	86
Total	**187**	**187**	**187**

	Annualized Greenhouse Gas Emissions Per Material Type		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Aggregate	2	2	2
Aluminum	0	0	0
Bitumen (Asphalt Binder)	3	3	3
Cement	6	6	6
Steel	6	6	6
Water	0	0	0
Transportation Fuel	2	2	2
Construction Fuel	14	14	14
O&M Electricity (kWh)	16	16	16
O&M fuel (DGEs)	12	12	12

O&M Roadway Rehabilitation	39	39	39
Usage	86	86	86
Total	**187**	**187**	**187**

	Annualized Greenhouse Gas Emissions Reductions Relative to BAU				
	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e
	Materials	Transportation	Construction	O&M	TOTAL
Total	-	-	-	-	-

	Annualized Greenhouse Gas Emissions (MT CO2e) by Infastructure Type		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Lighting	20	20	20
Pathways	5	5	5
Roadways	76	76	76
Signage	0	0	0
Vehicle_Ops	86	86	86
Total	**187**	**187**	**187**

Project Inputs

Planning Summary of Inputs - See Individual Tabs for Details

Display result in 508 compliant format:	Yes
Hide Instructions	No

Clear All User Data

INSTRUCTIONS

1. Populate location (state) and lifetime (years) for your analysis.
2. Select operating mode (*Project* or *Planning*) for your analysis. (The tool can analyze individual projects (*Project* mode) or a suite of projects in a comprehensive plan (*Planning* mode). Most analyses using *Planning* mode.
3. Select the infrastructure type(s) to analyze. Input all requested data using information from the project or plan you want to analyze. Then navigate to the relevant *analysis page(*s) for your project or the individual project(s) in your plan and complete the analysis for each infrastructure type by entering information in all cells that are shaded yellow. Blue and gray cells display fixed values and results; do not change the information in these cells.
4. Apply any selected mitigation measures on the *Mitigation Strategies* tab.
5. Review outputs on the *Summary Results* tab.
6. For further instructions, refer to the accompanying User Guide for detailed descriptions of factors and assumptions used in

Infrastructure location (state)	DE
Analysis period of your plan or project (years)	35
Year construction starts	2025
Use custom electric emission profile (RPS)?	No

Tool Use	Planning

Infrastructure Types

Roadways (On) | BRT (Off) | Heavy Rail (Off) | Light Rail (Off) | Parking (Off) | Signage (Off)

Bridges & Overpasses (Off) | Culverts (Off) | Interchanges (Off) | Lighting (Off) | Pathways (Off) | Vehicle Operations (Off) | Custom Pavement (Off)

Stand-Alone Infrastructure Type

Roadway Rehabilitation (Off)

Note: This project type cannot be combined with other infrastructure types and is designed solely for short-term projects, such as one-time resurfacing events.

	Title:	Wilmington Waterfront Transportation Infrastructure Pr	Title:	No Build	Title:	
Enter comments and comment titles. These will be displayed on the Summary Results worksheet.	City of Wilmington New Castle County, Delaware					

Roadways

Roadways

The Roadways module in ICE accounts for the full roadway lifespan, including construction, rehabilitation, routine maintenance, and preventive maintenance for new and existing roadways. Separate inputs are required for construction, rehabilitation, and effects of preventative maintenance. Module inputs include those for both the existing and new construction. As noted, some inputs are lane miles; some are centerline miles. See the Roadways sheet and User's Guide for more information.

Source: https://commons.wikimedia.org/wiki/File:Veterans_Memorial_Parkway,_London,_Ontario.jpg

Roadway System

Total existing centerline miles	0.99
Total newly constructed centerline miles	

Roadway Projects

Facility type	Roadway System	Roadway Construction				
	Existing Roadway (lane miles)	New Roadway (lane miles)	Construct Additional Lane (lane miles)	Realignment (lane miles)	Lane Widening (lane miles)	Shoulder Improvement (centerline miles)
Rural Interstates						
Rural Principal Arterials						
Rural Minor Arterials						
Rural Collectors						
Urban Interstates / Expressways						
Urban Principal Arterials						
Urban Minor Arterials / Collectors	2.47					

Include roadway rehabilitation activities (reconstruct and resurface)	Yes

% roadway construction on rocky / mountainous terrain	0%

Specification
Baseline Energy Use and GHG Emissions
Mitigated Results
Results - Charts

Summary Results

Roadways (On) | BRT (Disabled) | Heavy Rail (Disabled) | Light Rail (Disabled) | Parking (Disabled) | Signage (Disabled)

Bridges & Overpasses (Disabled) | Culverts (Disabled) | Interchanges (Disabled) | Lighting (Disabled) | Pathways (Disabled) | Vehicle Operations (Disabled) | Custom Pavement (Disabled)

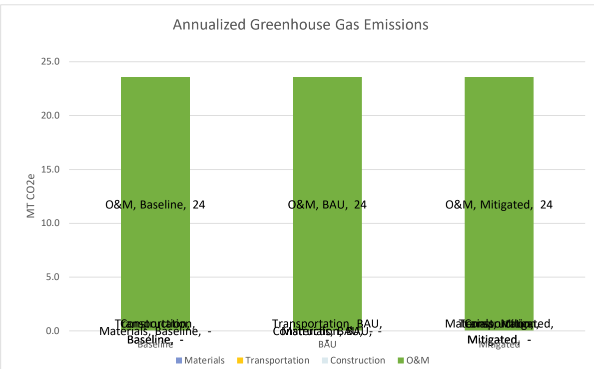
Show	Annualized Greenhouse Gas Emissions	Units	MT CO2e

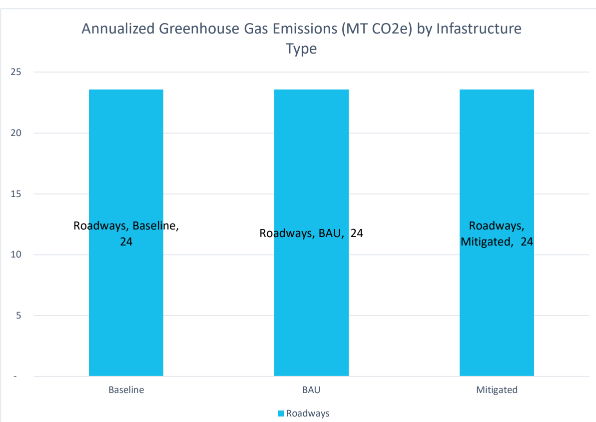
Wilmington Waterfront Transportation Infranstructure Project
City of Wilmington
New Castle County, Delaware

No Build

	Annualized Greenhouse Gas Emissions (MT CO2e) by Infastructure Type		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Roadways	24	24	24
Total	**24**	**24**	**24**

Summary Results - Charts





Summary Results - Tables

	Annualized Greenhouse Gas Emissions		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Materials	-	-	-
Transportation	-	-	-
Construction	-	-	-
O&M	24	24	24
Total	**24**	**24**	**24**

	Annualized Greenhouse Gas Emissions Per Material Type		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
O&M fuel (DGEs)	5	5	5
O&M Roadway Rehabilitation	19	19	19
Total	**24**	**24**	**24**

	Annualized Greenhouse Gas Emissions Reductions Relative to BAU				
	MT CO2e	MT CO2e	MT CO2e	MT CO2e	MT CO2e
	Materials	Transportation	Construction	O&M	TOTAL
Total	**-**	**-**	**-**	**-**	**-**

	alized Greenhouse Gas Emissions (MT CO2e) by Infastructure		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Roadways	24	24	24
Total	**24**	**24**	**24**