



Cape Cod Bridges Program

Bourne, Massachusetts

Appendix 4.14
Air Quality and Greenhouse Gas Emissions Technical Report

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ADT	average daily traffic
CAA	Clean Air Act
CFR	Code of Federal Regulations
CH4	methane
CO	carbon monoxide
CO2	carbon dioxide
CO_2e	carbon dioxide equivalents
EEA	Executive Office of Energy and Environmental Affairs
EPA	U.S. Environmental Protection Agency
FHWA	Federal Highway Administration
GHG	greenhouse gas
GWSA	Global Warming Solutions Act
HEI	Health Effects Institute
ICE	Infrastructure Carbon Estimator

Acronym/Abbreviation	Definition
IWG	Interagency Working Group
LOS	level of service
LRTP	Long-Range Transportation Plan
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MEPA	Massachusetts Environmental Policy Act
MOVES	Motor Vehicle Emissions Simulator
MRER/EA	Major Rehabilitation Evaluation Report/Environmental Assessment
MSAT	Mobile Source Air Toxic
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NOx	oxides of nitrogen
NO2	nitrogen dioxide
PM	particulate matter
ppm	parts per million
SC-CO_2e	social cost of carbon dioxide equivalents
SC-GHG	social cost of greenhouse gas
SO2	sulfur dioxide
SUP	share-use path
USACE	U.S. Army Corps of Engineers
VMT	Vehicle Miles Traveled
VOC	volatile organic compound

1 Introduction

This Air Quality and Greenhouse Gas Emissions Technical Report has been prepared in support of the Draft Environmental Impact Report for the Cape Cod Bridges Program (the Program), in accordance with the following federal and state statutes, regulations, and guidance:

- Certificate of the Secretary of the Office of Energy and Environmental Affairs on the Environmental Notification Form for the Cape Cod Bridges Program (July 7, 2023)
- Massachusetts Environmental Policy Act (MEPA) regulations, 301 Code of Massachusetts Regulation (CMR) 11.00 (as amended, January 6, 2023)
- MEPA Greenhouse Gas Emissions Policy and Protocol (Massachusetts General Law [MGL] Chapter 30, Sections 61-62I)

2 Summary of Findings

The proposed improvements were assessed for potential air quality impacts and compliance with all applicable air quality regulations and guidance. All models, methods and assumptions applied in modeling and analyses were made consistent with those provided or specified by the Massachusetts Department of Environmental Protection (MassDEP), the U.S. Environmental Protection Agency (EPA) and the Federal Highway Administration (FHWA). Based on the assessment, the Program would meet all applicable federal and state transportation conformity regulatory requirements as well as air quality guidance under NEPA and MEPA. As such, the Program would not cause or contribute to a new violation of the National Ambient Air Quality Standards (NAAQS) established by the EPA.

2.1 Attainment Status

The Study Areas for this assessment are in Plymouth and Barnstable Counties where the EPA's Green Book shows that these counties are designated as an attainment area for all criteria pollutants with the EPA NAAQS.[1]

2.2 Microscale Carbon Monoxide (CO) Analysis

EPA project-level ("hot-spot") transportation conformity requirements for CO do not apply as the project is in a region that is in attainment of the NAAQS. However, a qualitative analysis was conducted to evaluate potential CO impacts from the Build Alternative compared to the No Build Alternative. Consistent with the traffic operations analysis for the project, a comparison of the No Build and Build Alternatives was completed for the peak- hour AM and Fall Weekday PM period travel times to assess changes in delay. In summary, the Build Alternative will result in significant improvements in traffic

[1] https://www3.epa.gov/airquality/greenbook/anayo_ma.html

operations compared to the No Build Condition. Study area intersections and expressway mainline, and merging-diverging segments are expected to operate at improved Level of Service (LOS) during the weekday fall PM design periods. In addition, the study network is anticipated to see significant reductions in vehicle delay and travel times for the Build Alternative compared to the No Build Alternative.

Therefore, based on the overall weight-of-evidence, it may reasonably be concluded that the CO NAAQS will be met given the following:

- Measured CO concentrations are well below the NAAQS
- Continued implementation of effective emission control technology leading to lower pollutant vehicle emissions
- Increasingly more stringent motor vehicle emission and fuel quality standards implemented over the past few decades by the EPA.

2.3 Mesoscale Analysis

The Massachusetts Department of Transportation (MassDOT) performed a mesoscale analysis to evaluate the potential regional air quality impact of the Build Alternative from motor vehicles within the mesoscale Traffic Study Area as a measure of the total daily emissions of volatile organic compounds (VOC), nitrogen oxides (NOx), carbon monoxide (CO), particulate matter (PM10 and PM2.5), and sulfur dioxides (SO2). MassDOT performed calculations to compare area-wide emissions for the existing conditions and the No Build Alternative and Build Alternative.

The mesoscale results illustrate the corresponding air quality reductions associated with the Build Alternative compared to the No Build Alternative. Vehicle miles traveled (VMT), vehicle hours traveled (VHT), daily trips, and vehicle speeds are expected to decrease with the Build Alternative when compared to the No Build Alternative due to more efficient flow of traffic expected with the Build Alternative. Correspondingly, emissions are also expected to decrease with fewer VMT and higher speeds for the Build Alternative compared to the No Build Alternative. In summary, VMT, VHT, speeds, and emissions are expected to decrease for the Build Alternative compared to the No Build Alternative within the regional mesoscale study area.

2.4 Greenhouse Gases

Although no federal standards have been set for greenhouse gas (GHG) emissions, it is well established that GHG emissions can affect climate.

GHG emissions were estimated for the No Build Alternative and Build Alternative consistent with the mesoscale analysis and included emissions from on-road vehicles (light-duty vehicles, trucks, and buses); upstream emissions associated with production and transport of fuels consumed by on-road vehicles; and life-cycle emissions associated with construction and maintenance of the proposed project.

MassDOT estimated GHG emissions for the No Build Alternative and Build Alternative consistent with the mesoscale analysis discussed previously and included the following:

- Emissions from on-road vehicles (light-duty vehicles, trucks, and buses)
- Upstream emissions associated with production and transport of fuels consumed by on-road
- Life-cycle emissions associated with construction and maintenance of the Build Alternative

VMT, VHT, daily trips, and vehicle speeds are expected to decrease with the Build Alternative when compared to the No Build Alternative due to more efficient flow of traffic expected with the Build Alternative. Correspondingly, GHG emissions are also expected to decrease with fewer VMT and higher speeds for the Build Alternative compared to the No Build Alternative.

In summary, when evaluating the regional mesoscale study area, VMT, speeds and GHG emissions are expected to decrease for the Build Alternative compared to the No Build Alternative.

2.5 Mobile Source Air Toxics

FHWA updated its guidance for the assessment of mobile source air toxics (MSAT) for highway projects in 2023, which was reviewed for this Program.[2] Based on the traffic forecast average annual daily traffic below 140,000 per year, the Build Alternative may therefore be categorized as one with "low potential MSAT effects."

3 Proposed Action and Alternatives

3.1 Purpose and Need

In partnership with the FHWA and the New England District of the U.S. Army Corps of Engineers (USACE), MassDOT proposes advancing the Program in the town of Bourne, Barnstable County, Massachusetts.

The purpose of the Program is to improve cross-canal mobility and accessibility between Cape Cod and mainland Massachusetts for all road users and to address the increasing maintenance needs and functional obsolescence of the aging Sagamore and Bourne Bridges. The needs for the Program are as follows:

- Address the deteriorating structural condition and escalating maintenance demands of the Sagamore and Bourne Bridges.
- Address the substandard design elements of the Sagamore and Bourne Bridges, the immediate mainline approaches, and their adjacent interchanges and intersections.
- Improve vehicular traffic operations.
- Improve accommodations for pedestrians and bicyclists.

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

3.2 Study Area

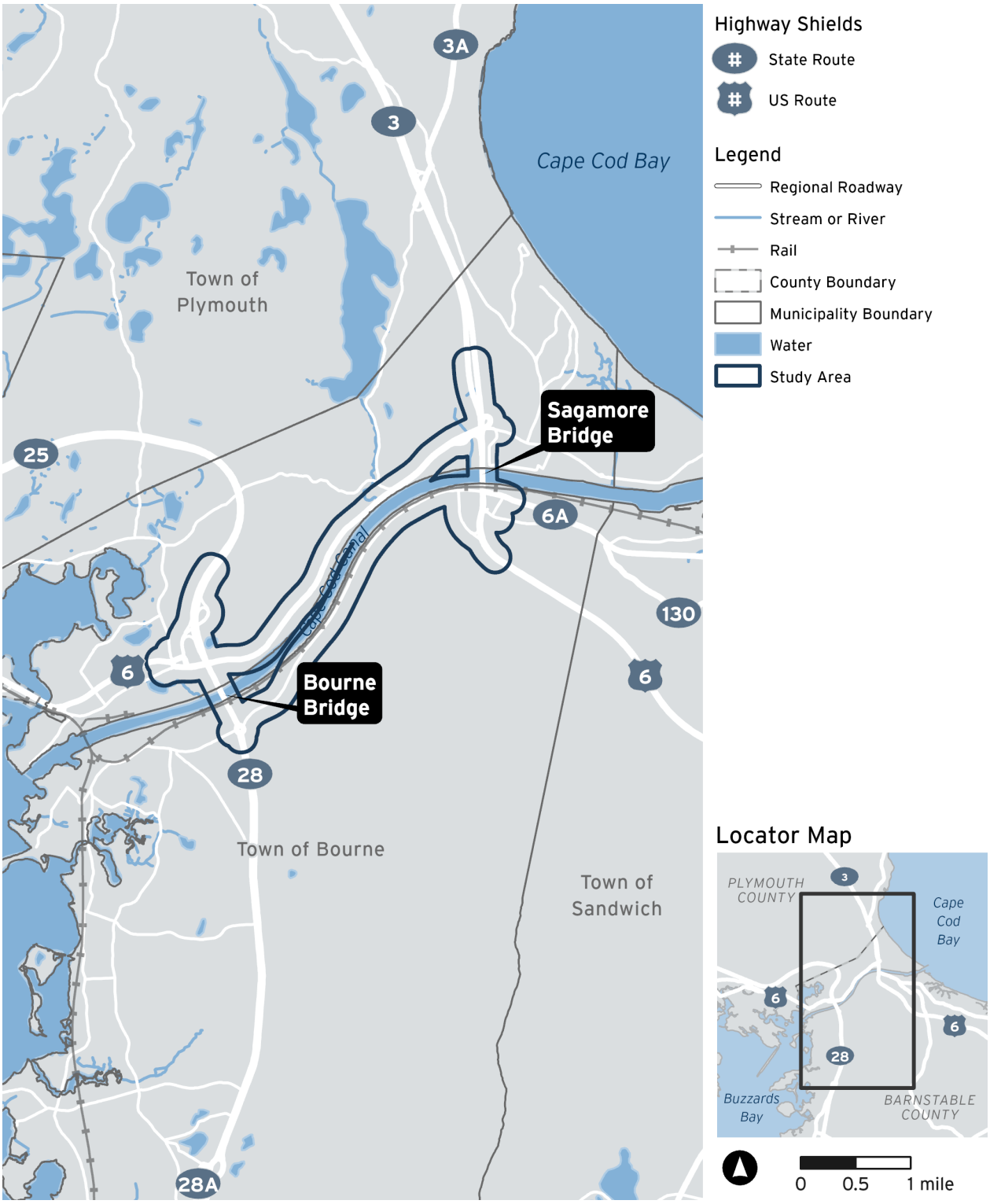
The Air Quality and Greenhouse Gas (GHG) Study Area corresponds to the Transportation and Traffic focus Study Area, which includes a 2-mile area (microscale) centered around the Sagamore and Bourne Bridges, as well as the more regional 5-mile Study Area (mesoscale) radius from the bridges. **Figure 3-1** presents the microscale study area while **Figure 3-2** presents the larger regional 5-mile mesoscale study area. Both Study Areas were considered in the analysis and form the basis for the air quality and GHG analysis and includes major regional roadways, interchanges, intersections in Plymouth, Wareham, Bourne, and Sandwich.

3.3 Build Alternative

The Program's Build Alternative would incorporate the USACE's Major Rehabilitation Evaluation Report and Environmental Assessment's (MRER/EA) preferred alternative of replacing both highway bridges with new bridges, each with four through-travel lanes and two auxiliary lanes (in-kind bridge replacement that would be updated to comply with federal and state highway and design safety standards). The Program proposes to replace the Sagamore and Bourne Bridges with parallel, twin tied-arch bridge structures that would be supported on delta frames with an approximate 700-foot mainline span length. At both the Sagamore and Bourne Bridge crossings, the replacement mainline alignment locations would be offline and inboard of the existing bridges on the side of the canal between the bridges. At both canal crossings, the Program would reconfigure the highway interchange approach networks north and south of Cape Cod Canal to align with the replacement bridges. The replacement bridges and their interchange approaches would accommodate shared-use pedestrian and bicycle paths that would connect to the local roadway network on both sides of Cape Cod Canal in the town of Bourne.

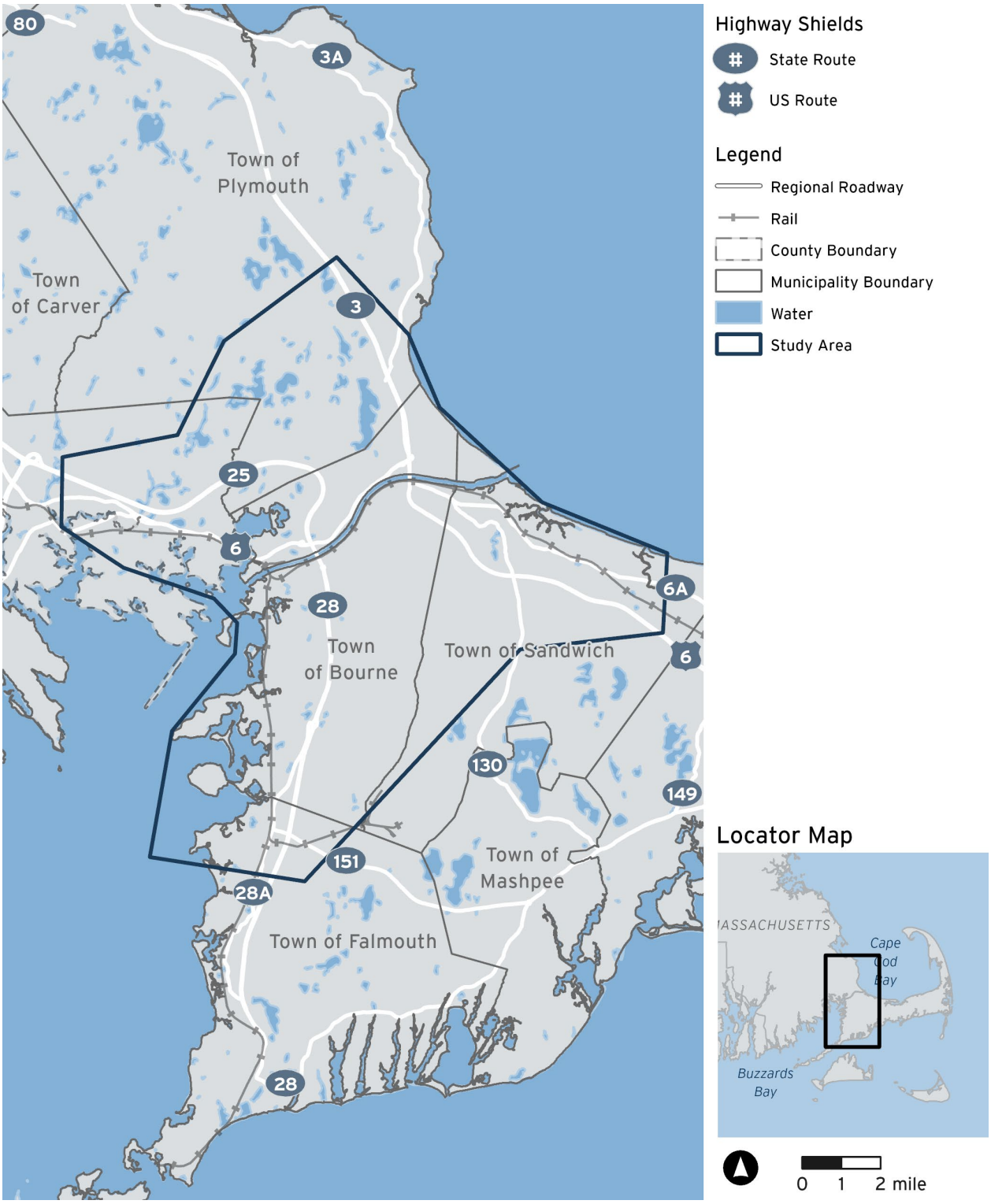
Table 3-1 presents a description of the Program elements/design parameters of the recommended Build Alternative: Replacement Highway Bridges Built to Modern Design Standards.

Figure 3-1. Microscale Study Area



Source: Massachusetts Department of Transportation, 2025

Figure 3-2. Regional 5-mile Mesoscale Study Area



Source: Massachusetts Department of Transportation, 2025

Table 3-1. Description of Design Parameters of the Recommended Build Alternative

Program Element/ Program Design Parameter	Description
Highway Bridges	Both the Sagamore and Bourne Bridges would be replaced with new bridges, with each comprising four through-travel lanes and two auxiliary lanes (i.e., an in-kind bridge replacement that would comply with federal and state highway and design safety standards).
Bridge Highway Cross-Section and Shared-Use Path	Each replacement bridge would provide four 12-foot-wide through-traffic lanes (two in each direction), two 12-foot-wide entrance/exit (auxiliary) lanes, a 4-foot-wide left shoulder, and a 10-foot-wide right shoulder. Right and left barriers would be offset an additional 2 feet beyond the limits of the shoulders.
	Each crossing location would include one bidirectional pedestrian and bicycle shared-use path (SUP), separated from vehicular traffic by the shoulder and barrier. The usable width of the SUP would be 14 feet wide on the bridge main span, 20 feet wide on the interchange approaches, and 12 feet wide on the connecting roadways.
Bridge Clearances	The replacement bridges would maintain the existing vertical clearance of 135 feet above mean high water and account for 3 feet of future sea level rise, for a total vertical clearance of 138 feet above mean high water. The replacement bridges would provide a minimum 500 feet of horizontal channel width to be consistent with existing conditions.
Main Span Length and Bridge Pier Location	The replacement bridges would have a main span length of approximately 700 feet, which would locate the bridge piers at the waterline adjacent to the service road (shoreline piers) into the riprap slope but above the low tide line.
Bridge Deck Configuration	Each replacement bridge would have two separate decks (twin structures).
Mainline Alignment	The mainline alignment locations at both crossings would be offline inboard: the main spans of each replacement bridge would be located outside the footprint of the existing bridge, approximately 10 feet apart and parallel to each other and on the side of the canal between the existing Bourne Bridge and Sagamore Bridge. At the Bourne crossing, both main spans would be located east of the existing Bourne Bridge toward Cape Cod Bay. At the Sagamore crossing, both main spans would be located west of the existing Sagamore Bridge toward Buzzards Bay.
Bridge Type	The replacement bridges would be twin tied-arch bridges with delta frames supporting an approximate 700-foot mainline span.

Program Element/ Program Design Parameter	Description
Interchange Approach Network: Sagamore North	The Sagamore North interchange approach network would be "Direct Connection to State Road (Option SN-8A)". The interchange approach network would provide a single exit point from a relocated Route 6/Route 3. It would remove the Sagamore Bridge northbound off-ramp connection to Scenic Highway/Meetinghouse Lane eastbound and instead would connect to State Road, north of Scenic Highway/Meetinghouse Lane. The remaining ramp connections would remain similar to existing conditions. Signalized intersections along Scenic Highway and Meetinghouse Lane would be modified for new lane configurations. The intersection of State Road at Route 3 northbound would be modified to accommodate the addition of the new Route 3 northbound off-ramp with installation of a traffic signal. It would provide a SUP on the Route 6 eastbound main span that would provide connections to the south side of Scenic Highway, Canal Street, and Canal Service Road. SUPs would be provided along the southern side of Scenic Highway and Meetinghouse Lane and along the eastern side of State Road to Homestead Avenue.
Interchange Approach Network: Sagamore South	The Sagamore South interchange approach network would be "Westbound On-Ramp Under Route 6 with Sandwich Road Extension (Option SS-3.1A)." The interchange approach network would include Cranberry Highway Extension and would relocate the westbound on-ramp, so it would share the same entrance point as the eastbound on-ramp off Mid-Cape Connector. It would remove the Cranberry Highway to Sagamore Bridge westbound ramp, and it would provide a new westbound on-ramp connection from Mid-Cape Connector to Sagamore Bridge westbound. Modifications to lane arrangements at the intersections of Mid-Cape Connector with Sandwich Road and Cranberry Highway Extension would accommodate the revised traffic patterns resulting from the extension of Cranberry Highway and relocation of access to Route 6 eastbound, including modifications to the existing traffic signals. There would be a connection from Cranberry Highway Extension to Sandwich Road east of the new mainline bridge structure (Sandwich Road Extension). A traffic signal would be provided at the intersection of the Route 6 westbound off-ramp with Cranberry Highway Extension. There would be modified access to Market Basket (Factory Outlet Road) and an access driveway to the former Christmas Tree Shops area. It would provide a SUP on the Route 6 eastbound main span that would provide connections to Factory Outlet Road, Sandwich Road, and the Canal Service Road. Bicycle and pedestrian improvements would be included on Cranberry Highway. A new connection would be added through Cranberry Highway Extension to Mid-Cape Connector.

Program Element/ Program Design Parameter	Description
Interchange Approach Network: Bourne North	The Bourne North interchange approach would be "Directional Interchange (Option BN-14.4b)." The interchange approach would provide a combination of direct connection ramps between Route 25 and Route 6. The ramp connecting Route 25 eastbound to Scenic Highway would be a direct connect ramp, allowing access to Scenic Highway eastbound only. The new flyover ramp connecting Scenic Highway to Route 25 would allow vehicles to bypass Belmont Circle and would not require an additional traffic signal. This ramp would utilize one of the travel lanes on Scenic Highway and would be a free-flowing movement to reduce congestion. The existing Route 28 over the Route 25 bridge would be relocated to widen the bridge to allow for this new southbound to eastbound ramp movement. The existing southbound off-ramp would be revised to be an option lane, improving the geometry and decision sight distance for drivers. The intersection control at Route 6/Nightingale Road/Andy Oliva Drive would be either a single-lane roundabout or a signalized intersection. It would provide a SUP and a grade-separated crossing for pedestrians and bicyclists via the new flyover ramp over Scenic Highway. The Route 6 lane configuration would be reduced from four lanes to three lanes, which would provide additional space for multimodal accommodations. It would provide one continuous 12-foot-wide SUP along the south side of Route 6 connecting to Belmont Circle and a 6-foot-wide sidewalk along the north side of Route 6.
Interchange Approach Network: Bourne South	The Bourne South interchange approach network would be "Diamond Interchange (Option BS-2)." It would eliminate Bourne Rotary and replace it with a grade-separated diamond interchange, allowing through movements on Route 28 to bypass the intersections with the non-mainline roadways. Both intersections within the diamond interchange would require either a traffic signal or a roundabout for intersection control (a single-lane dogbone-shaped roundabout). Changes to the Trowbridge Road and Sandwich Road underpass in this option would consist of a roundabout at a relocated Upper Cape Cod Regional Technical High School Driveway entrance. It would provide SUP connections to Trowbridge Road, the Cape Cod Canal Service Road, and the Bourne Recreation Area.

3.4 No Build Alternative

The Sagamore and Bourne Bridges, as components of the Cape Cod Canal Federal Navigation Project, are federal assets that are managed by the USACE's New England District. The Commonwealth of Massachusetts owns the connecting major highway corridors at the bridges, which consist of the Route 3/Route 6 corridor at Sagamore Bridge and the Route 25/Route 28 corridor at Bourne Bridge.

In the No Build Alternative, the Sagamore and Bourne Bridges would retain their current configuration of four 10-foot-wide travel lanes (two in each direction) with one 6-foot sidewalk and a 2-foot safety curb. The USACE would continue to own the Sagamore and Bourne Bridges and would implement a maintenance and repair program as needed to maintain bridge operations and public safety. MassDOT would continue to own, operate, and maintain the state highway interchange approach networks at the two bridges.

The No Build Alternative would include recently completed and proposed Commonwealth of Massachusetts-sponsored and local transportation improvements projects in and near the Program as indicated in the Federal Fiscal Year 2025-2029 Transportation Improvement Program for the Cape Cod Metropolitan Planning Organization.[3] **Table 3-2** identifies the Transportation Improvement Program projects within and near the Program to be incorporated in the No Build Alternative.

Table 3-2. Transportation Improvement Program Projects, 2025–2029

Project Number	Year	Transportation Project	Project Description	Status
606900	2020	Belmont Circle Traffic and Multimodal Improvements	Traffic and multimodal improvements at Belmont Circle at U.S. Route 6 and State Route 25 and State Route 28	Completed
608422	2022	Trail Improvements – Sandwich	Shared-use path on Service Road (State Route 130 to Chase Road)	Underway
610542	2023	Bourne Rotary Improvements	• Restriping Bourne Rotary to two lanes and adding a channelized right-turn lane from State Route 28 northbound to Sandwich Road eastbound • Adding signs at Bourne Rotary • Installing flashing beacons at the Bourne Rotary approaches	Underway

[3] The TIP was endorsed on May 20, 2024, with subsequent amendments on November 18, 2024; December 16, 2024; February 24, 2025; and an adjustment on March 24, 2025.

Project Number	Year	Transportation Project	Project Description	Status
613195	2024	Bridge Systematic Maintenance	Bridge deck replacement of the Quaker Meetinghouse Road Bridge over U.S. Route 6/Mid-Cape Highway as part of an overall bridge preservation strategy	Programmed
609262	2025	Bourne Rail Trail, Phase 1	First phase of four planned phases of the Bourne Rail Trail connection to the Shining Sea Bikeway to the south in Falmouth and to the Cape Cod Canal path (Canal Service Road) in the town of Bourne; Phase 1 is approximately one-half mile long within the existing right-of-way of the Old Colony Railroad (Woods Hole branch line) from the Canal Service Road to Monument Neck Road.	Programmed
610673	—	Bourne Rail Trail, Phase 2	Phase 2 of four planned phases of the Bourne Rail Trail connection to Shining Sea Bikeway to the south in Falmouth and to the Cape Cod Canal path (Canal Service Road) in the town of Bourne; Phase 2 is approximately 2 miles long from Monument Neck Road to Monk's Park/ Valley Bars Road.	Not Programmed
	—	Bourne Rail Trail, Phase 3 and Phase 4A	Phase 3 and Phase 4A of four planned phases of the Bourne Rail Trail connection to Shining Sea Bikeway to the south in Falmouth	Not Programmed
607394/ 611998	—	Bourne Rail Trail, Phase 4B	Phase 4B of four planned phases of the Bourne Rail Trail connection to the Shining Sea Bikeway to the south in Falmouth and to the Cape Cod Canal path (Canal Service Road) in the town of Bourne; Phase 4B is approximately 1 mile long, extending the Shining Sea Bikeway from its current terminus in North Falmouth into the town of Bourne.	Not Programmed
606082	2025–2028	U.S. Route 6 Scenic Highway Median Installation	• Resurfacing • Safety improvements, including a raised center median and expanded shoulders to separate eastbound and westbound travel lanes • Drainage improvements • Traffic signal improvements at two intersections • Shared-use path	Programmed

Project Number	Year	Transportation Project	Project Description	Status
612053	2025	Bourne/Sandwich, Resurfacing and Related Work on U.S. Route 6	Improvements to pavement serviceability, condition, and roadway safety on U.S. Route 6 from Sagamore Bridge to the Sandwich town line (8.55 miles)	Programmed
613200	2026	Chase Road over U.S. Route 6 Bridge	Bridge deck replacement of Chase Road over U.S. Route 6 (Mid-Cape Highway) bridge structure in the town of Sandwich	Programmed
612063	2028	State Route 28 Resurfacing and Related Work	Improvements to pavement serviceability, condition, and roadway safety on MacArthur Boulevard (State Route 28) from Bourne Rotary to Otis Rotary	Programmed
613199	2028	U.S. Route 6 over State Route 130 Bridge	Bridge deck replacement of U.S. Route 6 (Mid-Cape Highway) bridge structure over State Route 130 in the town of Sandwich	Programmed
613271	—	Shared-use path, State Route 130 to Canal Service Road	Shared-use path from State Route 130 to Canal Service Road in the town of Sandwich	Not Programmed

Note: **Table 3-2** includes only those projects in the Study Area that are part of the No Build Alternative. It does not include Project S13144, the replacement of the Sagamore Bridge, which was added to the FFY 2025-2029 TIP as Amendment #2, December 9, 2024.

— No date available.

The No Build Alternative represents the "Fix as Fails" Base Condition of the USACE's MRER/EA. In the No Build Alternative, the USACE would implement an ongoing program of continued inspections and maintenance and repair of both existing bridges as needed to maintain safety. No major rehabilitation efforts involving extensive repairs and replacement of major bridge components would occur. Structural components would be repaired, and critical elements would be replaced only when inspections indicate unsatisfactory reliability ratings. The MRER/EA indicates that both the Sagamore and Bourne Bridges are in deteriorated condition and well beyond the state in which actions and funding from the USACE's operations and maintenance program could correct the deficiencies and restore and sustain reliability. The USACE has indicated that as the bridges continue to age, routine maintenance and minor component replacement would result in an unacceptable structural condition. As a result, it is likely that lower vehicle weights, traffic volume restrictions, and speed limits would be required and posted to maintain continued bridge safety.

The No Build Alternative would not meet any of the Program's identified needs:

- It would not address the deteriorating structural condition and escalating maintenance demands of the existing bridges.
- It would not address the substandard design elements of the bridges, the immediate mainline approaches, and their adjacent interchanges and intersections.
- It would not improve vehicular traffic operations.
- It would not improve accommodations for pedestrians and bicyclists.

Per NEPA requirements, the No Build Alternative is included in the DEIR as the base condition against which the Build Alternative is compared and evaluated. In accordance with MEPA, the No Build Alternative is the alternative of not undertaking a project, for the purpose of establishing a future baseline in relation to which a project can be described and analyzed, and its potential environmental impacts and mitigation measures can be assessed.

4 Methods for Effect Evaluation

4.1 Regulatory Framework

The following provides the regulatory context and guidance for this analysis:

- Federal Clean Air Act (CAA) of 1970 and Amendments
- Transportation Conformity Rule (40 CFR Parts 51 and 93)
- FHWA Updated Interim Guidance on Mobile Source Air Toxic Analysis in NEPA Documents, January 18, 2023
- MassDEP, Global Warming Solutions Act Requirements for the Transportation Sector and the Massachusetts Department of Transportation (310 CMR 60.05)
- MassDEP Guidelines for Performing Mesoscale Analysis of Indirect Sources, May 1991
- MEPA Greenhouse Gas Emissions Policy and Protocol (2015 update of the Clean Energy and Climate Plan for 2020)
- Massachusetts Clean Air Act (MGL Chapter 111, Sections 142A-142M) and Air Quality regulations: 310 CMR 6.00: Ambient Air Quality Standards; 310 CMR 7.00: Air Pollution Control, 310 CMR 8.00: Prevention & Abatement of Air Pollution Control Episodes & Emergencies; 310 CMR 60.00: Air Pollution Control for Mobile Sources

4.2 Methodology

This section includes methodology for conducting the operational and construction-period air analyses for the alternatives to be retained for study in the DEIR.

4.2.1 Carbon Monoxide Microscale (Localized) Analysis

Consistent with the traffic operations analysis for the Program, a comparison of the No Build and Build Alternatives was completed for the peak-hour AM and Fall Weekday PM period travel times to assess changes in delay. Key travel routes within the study area were evaluated to qualitatively assess air quality impacts within the microscale study area.

4.2.2 Mesoscale (Regional) Emission Analysis

MassDOT performed a mesoscale analysis to evaluate the potential regional air quality impact of the Build Alternative from motor vehicles within the mesoscale study area as a measure of the total daily emissions of VOCs, oxides of nitrogen (NOx), CO, PM10 and PM2.5, and sulfur dioxides (SO2). MassDOT performed calculations to compare area-wide emissions between the No Build Alternative and Build Alternative.

MassDOT used affected traffic segment links from the larger mesoscale study area, including segment length and average daily traffic, to estimate vehicle miles traveled (VMT) for the No Build Alternative and Build Alternatives. Average vehicle speeds were estimated for the overall study area for each condition to obtain the appropriate emission factors from the EPA Motor Vehicle Emission Simulator (MOVES model version 4). The EPA MOVES4 model is a state-of-the-science emission modeling system that estimates emissions for a variety of vehicle types including but not limited to passenger vehicles, trucks, bulldozers, cranes, etc. The VMT and the average MOVES4 emission factors were used to estimate daily emission in tons per day over the mesoscale study area. MassDOT estimated daily emissions for No Build Alternative and Build Alternative.

4.2.3 Greenhouse Gas Analysis

An analysis was also performed to evaluate the potential regional air quality impact of the Project from motor vehicles within the mesoscale study area as a measure of the total annual emissions of greenhouse gases including carbon dioxide (CO2), methane (CH4) and nitrous oxides (N2O). Calculations were performed using the traffic data and the USEPA Motor Vehicle Emissions Simulator (MOVES Version 4) consistent with the mesoscale methodology to compare area-wide emissions for the existing conditions and future Build and No Build Alternative. The GHG mesoscale analysis includes direct emissions from vehicles, indirect emissions from the full life-cycle of emissions (i.e., fuel consumption, upstream emissions, etc.), and construction and maintenance operations.

In order to account for the full life-cycle of emissions from fuel consumption, upstream operations were incorporated as part of this analysis. Upstream emissions include those from the extraction, refining, and transportation of the fuel used in the vehicle. The Argonne National Laboratory's GREET model (v.2021) provides fuel-cycle multipliers of 1.24 for gasoline and 1.21 for diesel (ratio of pump-to-wheel to well-to-wheel GHG emissions). Data from the U.S. Department of Energy Annual Energy

Outlook indicates that nearly all light-duty vehicles are gasoline-powered, heavy-duty trucks are diesel-powered, and medium-duty trucks are split with 65% diesel use and 35% gasoline use. The following weighted multipliers[4] were applied to emissions from each vehicle type:

- Light-duty cars and trucks: 1.24
- Medium-duty trucks: 1.22
- Heavy-duty trucks: 1.21
- Diesel buses: 1.29

Emissions resulting from the construction and maintenance of transportation and infrastructure were estimated using the ICE tool version 2.0, which calculates life-cycle emissions for projects ranging from construction, roadway maintenance and bridge repair. For this analysis, the ICE model was run for the Program including materials, transportation, construction and operations and maintenance to estimate the GHG emissions for the 2019 baseline, and 2050 No Build and Build Alternatives. The ICE model results are presented in **Attachment 4**.

4.2.3.1 Social Costs of Carbon

SC-CO_2e is an estimate of the economic costs of emitting one additional ton of CO_2 into the atmosphere, and thus the benefits of reducing emissions. It provides a monetary measure (in U.S. dollars) of the future damages (e.g., changes in net agricultural productivity, human health impacts, property damage from increased flood risk natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services) associated with specified quantities of GHG resulting from the Build Alternative.

4.2.4 Qualitative Assessment of Mobile Source Air Toxics

The FHWA most recently updated its guidance for the assessment of MSATs for highway projects in 2023. It states the following:

> "…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).[5] These are 1,3-butadiene, acetaldehyde, acrolein, benzene, diesel particulate matter (diesel PM), ethylbenzene, formaldehyde, naphthalene, and polycyclic organic matter."

It also specifies three possible categories or tiers of analysis:

1. Projects with no meaningful potential MSAT impacts, or exempt projects (for which MSAT analyses are not required)
2. Projects with low potential MSAT impacts (requiring only qualitative analyses)
3. Projects with higher potential MSAT impacts (requiring quantitative analyses)

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[4] U.S. Energy Information Administration. 2020. Annual Energy Outlook 2020 Reference Case. https://www.eia.gov/outlooks/aeo/

[5] https://www.epa.gov/national-air-toxics-assessment

The forecast average daily traffic (ADT) volumes for the Build Alternative were compared to the FHWA criteria to determine the level of analysis for MSATs.

4.2.5 Construction Emissions

A qualitative assessment of construction-related air quality impacts of the Build Alternative was conducted to identify potential exposures to sensitive populations, including EJ populations. Anticipated construction travel routes for trucks and vessels were also evaluated to determine if they would extend through or pass by EJ populations.

5 Existing Conditions

5.1 National Ambient Air Quality Standards

Pursuant to the CAA of 1970, the EPA established NAAQS for major pollutants known as "criteria pollutants." **Table 5-1** presents the NAAQS established by the EPA for criteria air pollutants, namely CO, sulfur dioxide (SO_2), ozone, particulate matter, nitrogen dioxide (NO_2), and lead (Pb).

There are two types of NAAQS: primary and secondary. Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings."[6]

As a requirement of the CAA, EPA periodically reviews the NAAQS and revises them as needed (for example, to make them more stringent and/or, on occasion, to revoke previous standards that were less stringent).[7] For instance, EPA revoked the 1997 annual primary PM2.5 NAAQS effective October 24, 2016, with the implementation of the more stringent 2012 PM2.5 NAAQS.[8] Most recently in February 2024, the EPA strengthened the primary annual PM2.5 standard to 9 microgram per cubic meter from 12 microgram per cubic meter.[9]

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[6] From the preamble to the USEPA NAAQS table: https://www.epa.gov/criteria-air-pollutants/naaqs-table

[7] On January 27, 2023, the EPA issued a proposed rule for "Reconsideration of the National Ambient Air Quality Standards for Particulate Matter" (18 Federal Register 5558). At the time of preparation of this report, that rule has not been finalized. The NAAQS table presented here may be updated for particulate matter when the rule is finalized.

[8] On August 24, 2016, EPA issued a final rule (81 Federal Register 58010), effective October 24, 2016, on "Fine Particulate Matter National Ambient Air Quality Standards: State Implementation Plan Requirements" that stated, in part: "Additionally, in this document the EPA is revoking the 1997 primary annual standard for areas designated as attainment for that standard because the EPA revised the primary annual standard in 2012." https://www.gpo.gov/fdsys/pkg/FR-2016-08-24/pdf/2016-18768.pdf. Note the revocation of the 1997 annual primary NAAQS for PM2.5 also eliminated the associated conformity requirements. For example, conformity requirements for that NAAQS were eliminated for northern Virginia, which until then had been in attainment (maintenance) for that standard.

[9] U.S. Environmental Protection Agency. 2024. Final Reconsideration of the National Ambient Air Quality Standards for Particulate Matter (PM). February. https://www.epa.gov/pm-pollution/final-reconsideration-national-ambient-air-quality-standards-particulate-matter-pm

Table 5-1. National Ambient Air Quality Standards

Pollutant		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 (NO2)		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 (O3)		Primary and Secondary	8 hours	0.070 ppm[3]	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	PM2.5	Primary[5]	1 year	9.0 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
	PM10	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 (SO2)		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

Source: U.S. Environmental Protection Agency. NAAQS Table (https://www.epa.gov/criteria-air-pollutants/naaqs-table) (accessed February, 2025)

ppm = parts per million by volume; ppb = parts per billion by volume; µg/m^3 = micrograms per cubic meter of air

[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 (1.5 µg/m^3 as a calendar quarter average) also remain in effect.

[2] The level of the annual NO_2 standard is 0.053 ppm. 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 call under the previous SO_2 standards (40 CFR 50.4(3)). A State Implementation Plan call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the required NAAQS.

[5] On January 27, 2023, the EPA issued a proposed rule for "Reconsideration of the National Ambient Air Quality Standards for Particulate Matter" (18 Federal Register 5558). At the time of preparation of this report, that rule has not been finalized. The NAAQS table presented here may be updated for particulate matter when the rule is finalized.

Areas that are not currently designated by the EPA as nonattainment for one or more of the NAAQS are classified as attainment areas, while areas that do not meet one or more of the NAAQS may be designated by the EPA as nonattainment areas for that or those criteria pollutants. Areas that have failed to meet the NAAQS in the past but have since re-attained them may be re-designated as attainment (maintenance) areas, which are commonly referred to as maintenance areas.

5.2 Air Quality Attainment Status

The microscale and mesoscale study areas are in the counties of Plymouth and Barnstable where the EPA's Green Book shows that these counties are designated as an attainment area for all criteria pollutants with the EPA NAAQS.[10] Federal conformity requirements at 40 CFR 93.114[11] and 40 CFR 93.115[12] (as incorporated by reference into the Massachusetts conformity State Implementation Plan [SIP]) apply as the area in which the Program is located is an area under a federal court decision affecting former maintenance areas nationwide for the 1997 ozone NAAQS.[13] Accordingly, there must be a currently conforming transportation plan (i.e. Transportation Improvement Plan and a Long Range Transportation Plan) at the time of issuance of the NEPA Record of Decision, and the Program must come from a conforming plan or otherwise meet the criteria specified in 40 CFR 93.109(b).[14] As of the date of preparation of this analysis, Phase 1 of the Program (Replacement of Sagamore Bridge) is currently included in the FY 2025-2029 Transportation Improvement Program (TIP) Amendment 2.[15] The Program is also included in the Draft FY 2026-2030 TIP currently being reviewed by the Cape Cod Metropolitan Planning Organization (Cape Code MPO) as of April 2025.[16] The Program is also included in the Regional Air Conformity Assessment for the Cape Cod 2024 Regional Transportation Plan 2024-2044, which received approval by the Cape Cod MPO dated July 24, 2023.[17]

5.3 Ambient Air Quality Data and Trends

MassDEP issues an annual report summarizing air quality monitoring data collected at monitoring stations across the state for the previous year, covering criteria pollutants (those for which the EPA has

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[10] https://www3.epa.gov/airquality/greenbook/anayo_ma.html

[11] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-93#93.114

[12] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-93#93.115

[13] Per a February 16, 2018, court decision (South Coast Air Quality Management District v. EPA), all areas in the country that were in nonattainment or maintenance for the 1997 eight-hour ozone NAAQS before its revocation by the EPA in 2015 were again made subject to conformity for that standard. This decision in part affects "orphan areas" (as defined in the ruling), which in Virginia includes Fredericksburg, Richmond/Tri-Cities, and Hampton Roads. https://law.justia.com/cases/federal/appellate-courts/cadc/15-1115/15-1115-2018-02-16.html

[14] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-93#93.109

[15] https://www.capecod.gov/2024/11/19/public-review-notice-transportation-improvement-program/)

[16] https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/tr/ccmpo/Outreach/OUTREACH%202025/Documents%20for%20Public%20Review/Cape_Cod_2026%202030_Transportation_Improvement_Program_draft%20for%20CCMPO%20review.pdf

[17] https://www.capecodcommission.org/resource-library/file/?url=/dept/commission/team/tr/Transportation%20Plans/RTP/2024_RTP/Report/FINAL%20PDF/Cape%20Cod%202024%20Regional%20Transportation%20Plan_Endorsed%200724 2023%20With%20Appendix.pdf

established NAAQS) and other pollutants including air toxics.[18] Excerpts of the latest annual air quality monitoring report are presented below.

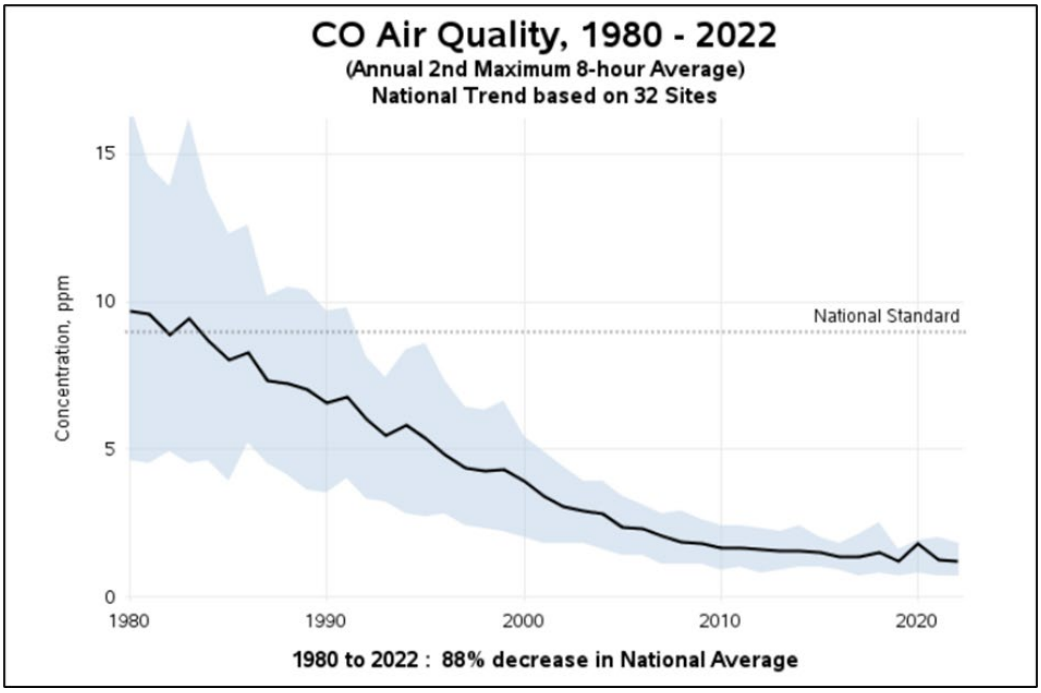
5.3.1 Carbon Monoxide

The EPA provides the following background information on CO:[19]

> "CO is a colorless, odorless gas that can be harmful when inhaled in large amounts. CO is released when something is burned. The greatest sources of CO to outdoor air are cars, trucks and other vehicles or machinery that burn fossil fuels. A variety of items in your home such as unvented kerosene and gas space heaters, leaking chimneys and furnaces, and gas stoves also release CO and can affect air quality indoors."

As shown in **Figure 5-1,** and due primarily to the implementation of more stringent vehicle emission and fuel quality standards, the national trend in ambient concentrations of CO over the past few decades has decreased to a level substantially below the current eight-hour NAAQS of 9 parts per million (ppm). The national trend is reflected in the very low ambient CO concentrations.

Figure 5-1. National Trends in Ambient Carbon Monoxide Concentrations

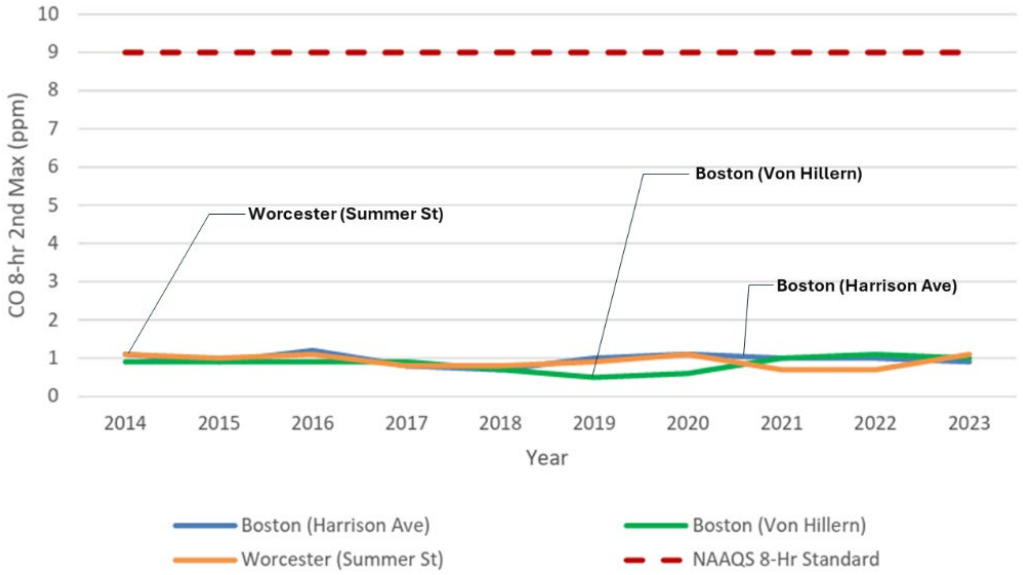


Source: U.S. Environmental Protection Agency. Carbon Monoxide Trends. https://www.epa.gov/air-trends/carbon-monoxide-trends.

[18] Massachusetts Department of Environmental Protection. 2024. Massachusetts 2023 Air Quality Report. September. https://www.mass.gov/doc/2023-annual-air-quality-report/download

[19] U.S. Environmental Protection Agency. Basic Information about Carbon Monoxide (CO) Outdoor Air Pollution. https://www.epa.gov/co-pollution/basic-information-about-carbon-monoxide-co-outdoor-air-pollution#What%20is%20CO

Figure 5-2. Carbon Monoxide Trends 2014-2023 (8-Hour Values)



Source: Massachusetts Department of Environmental Protection. 2024. Massachusetts 2023 Air Quality Report. September. https://www.mass.gov/doc/2023-annual-air-quality-report/download

5.3.2 Nitrogen Oxides

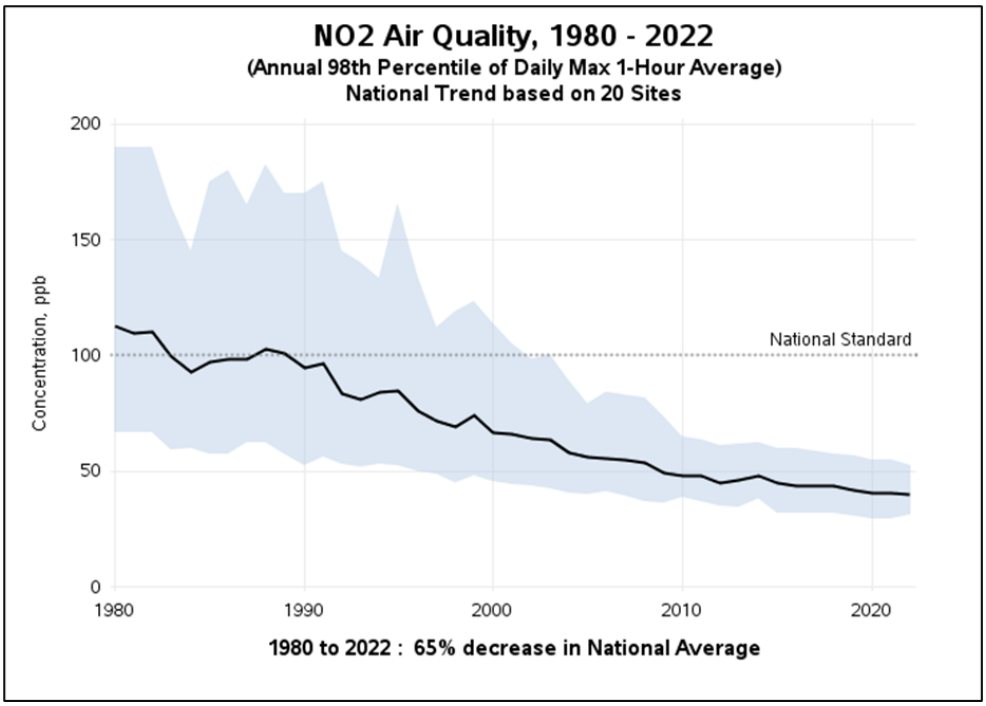
The EPA provides the following background information on NO2:[20]

> "Nitrogen Dioxide (NO2) is one of a group of highly reactive gases known as oxides of nitrogen or nitrogen oxides (NOx). Other nitrogen oxides include nitrous acid and nitric acid. NO2 is used as the indicator for the larger group of nitrogen oxides.
>
> NO2 primarily gets in the air from the burning of fuel. NO2 forms from emissions from cars, trucks and buses, power plants, and off-road equipment."
>
> and
>
> "Breathing air with a high concentration of NO2 can irritate airways in the human respiratory system. Such exposures over short periods can aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing), hospital admissions and visits to emergency rooms. Longer exposures to elevated concentrations of NO2 may contribute to the development of asthma and potentially increase susceptibility to respiratory infections. People with asthma, as well as children and the elderly are generally at greater risk for the health effects of NO2. NO2 along with other NOx reacts with other chemicals in the air to form both particulate matter and ozone. Both of these are also harmful when inhaled due to effects on the respiratory system."

[20] U.S. Environmental Protection Agency. Basic Information about NO2. https://www.epa.gov/no2-pollution/basic-information-about-no2#What%20is%20NO2

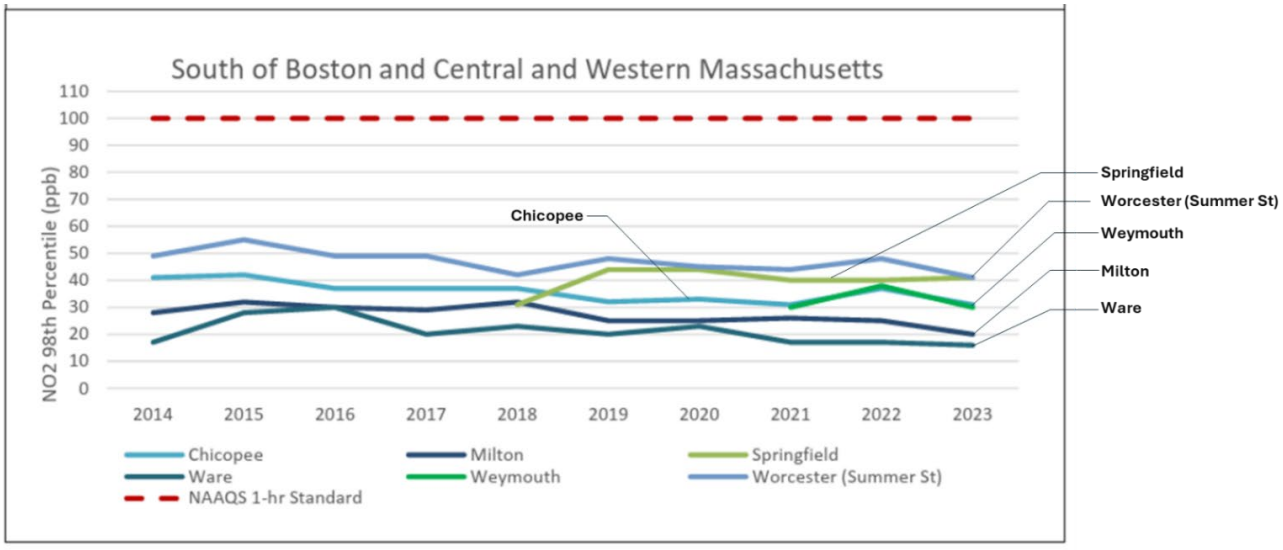
Figure 5-3 and **Figure 5-4** present the trend in levels of NO2 on a national level and for the region south of Boston including Central and Western Massachusetts, respectively. Monitored levels of NO2 in Massachusetts meet the NO2 standards.

Figure 5-3. National Trends in Nitrogen Dioxide Concentrations, 1980–2022



Source: U.S. Environmental Protection Agency. Nitrogen Dioxide Trends. https://www.epa.gov/air-trends/nitrogen-dioxide-trends.

Figure 5-4. Nitrogen Dioxide Trends 2014-2023, 1-hour 98th Percentile (Annual Average South of Boston Including Central and Western Massachusetts)

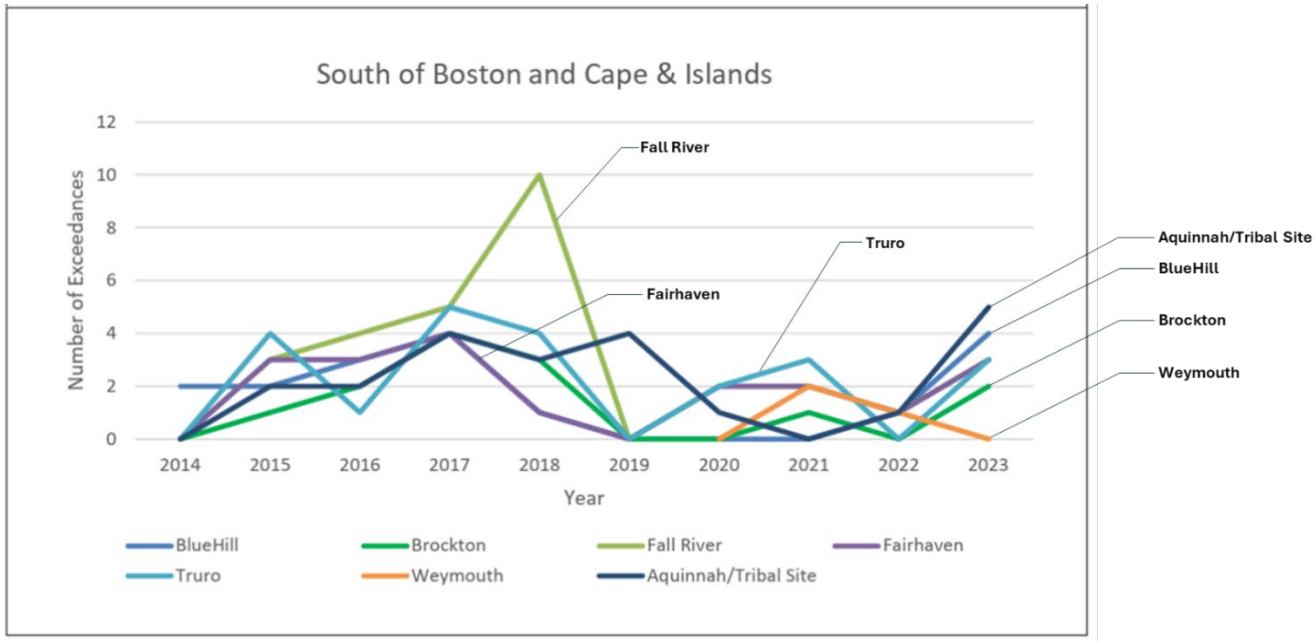


Source: Massachusetts Department of Environmental Protection. 2024. Massachusetts 2023 Air Quality Report. September. https://www.mass.gov/doc/2023-annual-air-quality-report/download

5.3.3 Ozone

Figure 5-5 presents the 8-hour ozone exceedance trends south of Boston and Cape & Islands. Based on the most recent three years of data (2021–2023), no monitoring locations violated the 0.070 ppm standard.

Figure 5-5. 8-hour Ozone Exceedance Trends, 2014-2023 (South of Boston and Cape & Islands)



Source: Massachusetts Department of Environmental Protection. 2024. Massachusetts 2023 Air Quality Report. September. https://www.mass.gov/doc/2023-annual-air-quality-report/download

5.3.4 Particulate Matter

EPA provides the following background information on particulate matter:[21]

> "PM stands for particulate matter (also called particle pollution): the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope."

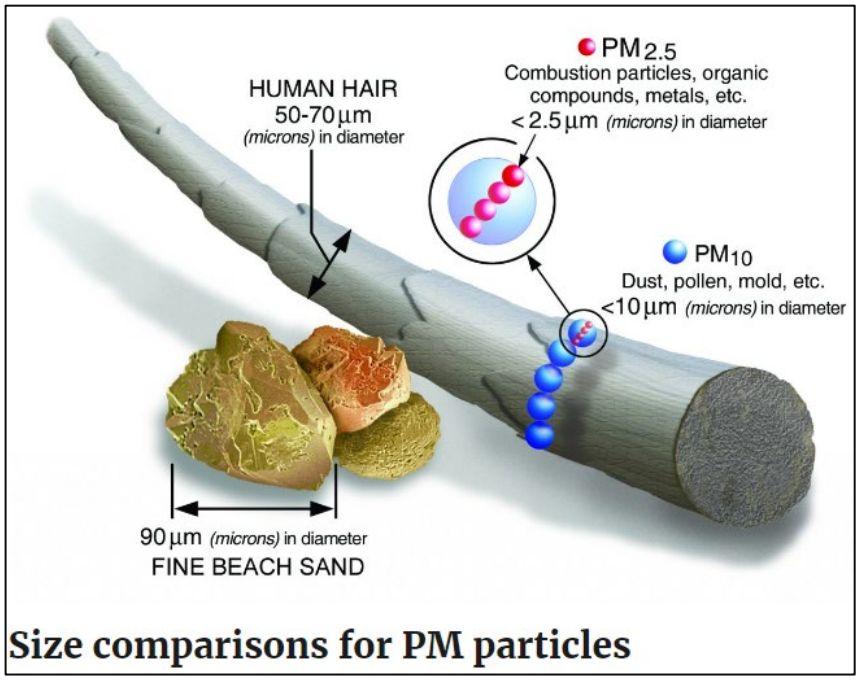
Particle pollution includes:

- PM10: inhalable particles, with diameters that are generally 10 micrometers and smaller
- PM2.5: fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller

Figure 5-6 from the EPA shows the size of $PM_{2.5}$ and PM_{10} particles relative to a human hair and to fine beach sand.

[21] U.S. Environmental Protection Agency. Particulate Matter (PM) Basics. https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

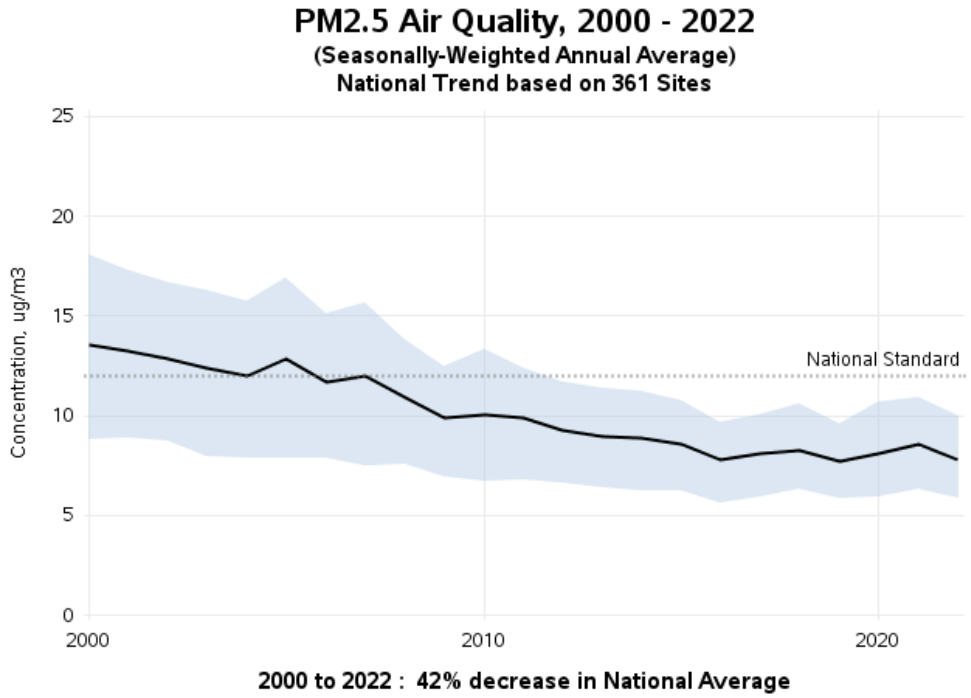
Figure 5-6. Size Comparison of Particulate Matter Particles



Source: U.S. Environmental Protection Agency. Particulate Matter (PM) Basics. https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

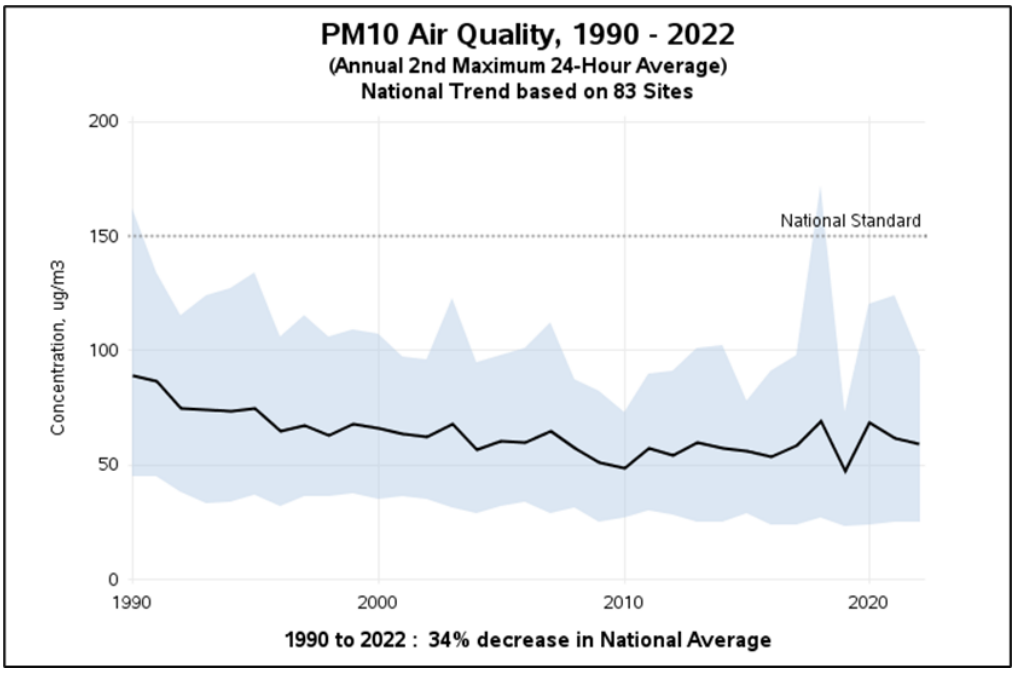
Figure 5-7 and **Figure 5-8** present the national trends in $PM_{2.5}$ and PM_{10} levels, respectively. **Figure 5-9** and **Figure 5-10** present tabulations of $PM_{2.5}$ (annual trends) South of Boston and PM_{10} (24-hour standard) concentrations, which were excerpted from the referenced MassDEP annual air quality monitoring report. As noted above, all of Massachusetts is in attainment of the NAAQS for both pollutants.

Figure 5-7. National Trends in PM2.5 Concentrations (Annual Average)



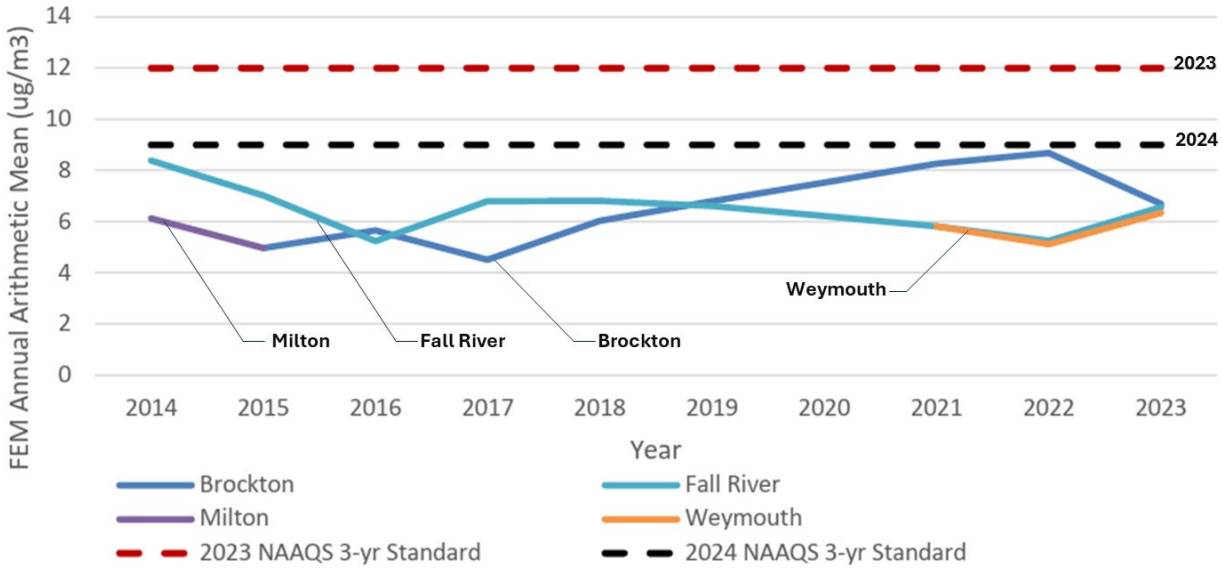
Source: U.S. Environmental Protection Agency. Particulate Matter (PM2.5) Trends. https://www.epa.gov/air-trends/particulate-matter-pm25-trends.

Figure 5-8. National Trends in PM10 Concentrations (24-hour Average)



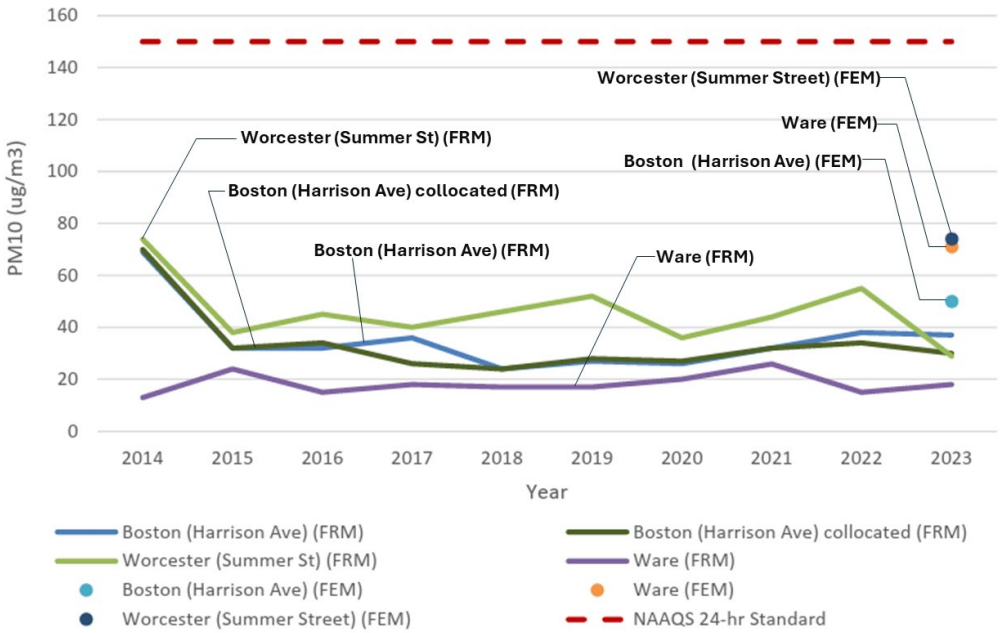
Source. U.S. Environmental Protection Agency. Particulate Matter (PM10) Trends. https://www.epa.gov/air-trends/particulate-matter-pm10-trends.

Figure 5-9. PM2.5 Annual Trends, 2014-2023, South of Boston



Source: Massachusetts Department of Environmental Protection. 2024. Massachusetts 2023 Air Quality Report. September. https://www.mass.gov/doc/2023-annual-air-quality-report/download

Figure 5-10. PM10 Trends, 2014 to 2023 (24-hour Calendar Year Maximum)



Source: Massachusetts Department of Environmental Protection. 2024. Massachusetts 2023 Air Quality Report. September. https://www.mass.gov/doc/2023-annual-air-quality-report/download

6 Program Impacts

The assessments presented in this section were conducted for purposes of the MEPA analysis. FHWA posts guidance on its website for project development,[22] and provides guidance specific to air quality (focusing on carbon monoxide) in its 1987 Technical Advisory 6640.8A, "Guidance for Preparing and Processing Environmental and Section 4(f) Documents."[23] FHWA posts separate guidance for MSATs along with responses to "Frequently Asked Questions" on its air quality webpage.[24]

6.1 Microscale (Localized) Carbon Monoxide (CO) Analysis

Based upon the design year 2050 traffic analysis, the Build Alternative is expected to substantially improve traffic operations compared to the No Build Alternative. Study area intersections, expressway mainline, and merging-diverging segments are expected to operate at improved Level of Service (LOS) during the weekday fall PM design periods. Travel times between major origin-destination points along major routes within the study area are also estimated to improve for the Build Condition compared to the No Build Condition. Despite processing more vehicles, the Build Conditions model recorded less total travel time (2,240 hours) in the network roadway than the No Build Condition (2,879). Improved traffic operations and mobility within the Study Area for the 2050 Build Alternative is anticipated to reduce CO emission rates compared to the 2050 No Build Alternative. Refer to **Section 4.2, Transportation, Traffic and Safety**, and the supporting **Appendix 4.2, Traffic Engineering Technical Report**, for detailed information on the traffic analyses conducted for the 2019 Base Year and 2050 Design Year.

In addition to the proposed traffic improvements with the Build Alternative, continued implementation of effective emission control technology, increasingly more stringent motor vehicle emissions and fuel quality standards implemented over the past few decades by the EPA strategies have had the combined effect of substantially reducing CO emission rates nationwide, resulting in long-term downward trends in emissions and near-road ambient concentrations of CO despite increasing VMT. As presented in **Figure 5-2**, the MassDEP measured air pollution for CO in the state is well below the NAAQS and the 10-year historical 8-hour concentrations have remain steady and trended down and have been well below the standards for over 20 years.

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[22] Federal Highway Administration. NEPA and Project Development. https://www.environment.fhwa.dot.gov/nepa/nepa_projDev.aspx

[23] Federal Highway Administration. NEPA Implementation, Guidance for Preparing and Processing Environmental and Section 4(f) Documents. https://www.environment.fhwa.dot.gov/projdev/impTA6640.asp

[24] Federal Highway Administration. Air Quality: Transportation & Toxic Air Pollutants. https://www.fhwa.dot.gov/environment/air_quality/air_toxics/

6.2 Mobile Source Air Toxics

6.2.1 Background

Controlling air toxic emissions became a national priority with the passage of the Clean Air Act Amendments 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 the EPA's Integrated Risk Information System.[25] In addition, the 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.[26] These are 1,3-butadiene, acetaldehyde, acrolein, benzene, DPM), 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.

6.2.2 Motor Vehicle Emissions Simulator (MOVES)

According to the EPA, MOVES3[27] 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 impacts. MOVES3 also adds updated vehicle sales, population, age distribution, and VMT data. MOVES3 incorporates the impacts of three new federal emissions standard rules not included in MOVES2014. These new standards are all expected to impact MSAT emissions and include Tier 3 emissions and fuel standards starting in 2017 (79 Federal Register 60344), heavy-duty greenhouse gas regulations that phase in during model years 2014-2018 (79 Federal Register 60344), and the second phase of light-duty GHG regulations that phase in during model years 2017-2025 (79 Federal Register 60344).

In November 2020, EPA issued MOVES3 Mobile Source Emissions Model Questions and Answers.[28] EPA states that for on-road emissions, MOVES3 updated heavy-duty diesel and compressed natural gas emission running rates and updated heavy-duty gasoline emission rates. They updated light-duty emission rates for hydrocarbon, CO and NOx and updated light-duty PM rates, incorporating new data on Gasoline Direct Injection vehicles.

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[25] https://www.epa.gov/iris

[26] https://www.epa.gov/national-air-toxics-assessment

[27] The FHWA national-level analysis summarized here for context was based on MOVES3.The analysis conducted for this project was based on an updated version of the model, namely MOVES4.

[28] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1010M06.pdf

Using EPA's MOVES3 model, as shown in **Figure 6-1**, FHWA estimates that even if VMT increases by 31% at a national level from 2020 to 2060 as forecast, a combined reduction of 76% in the total annual emissions for the priority MSAT is projected for the same time period. Diesel PM is the dominant component of MSAT emissions, making up 36% to 56% 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 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.

6.2.3 Mobile Source Air Toxics Research

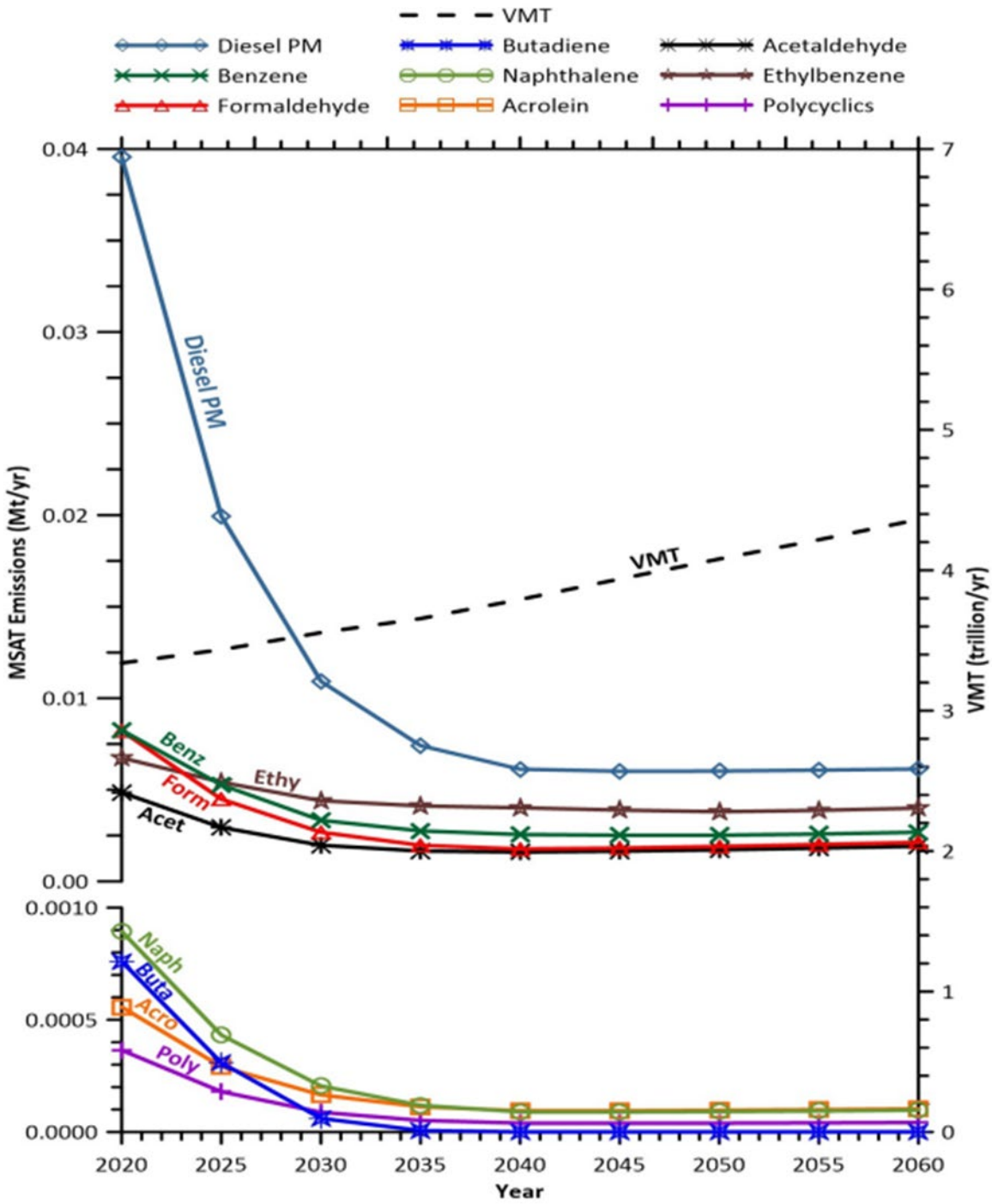
Air toxics analysis is a continuing area of research. While much work has been done to assess the overall health risk of air toxics, many questions remain unanswered. In particular, the tools and techniques for assessing project-specific health outcomes as a result of lifetime MSAT exposure remain limited. 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.

6.2.4 Incomplete or Unavailable Information for Project-Specific Mobile Source Air Toxics Health Impact 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.

Figure 6-1. Federal Highway Administration Projected National Mobile Source Air Toxics Emission Trends for Vehicles Operating on Roadways, 2020–2060



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

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

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 CAA 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 impacts, exposures, and risks posed by air pollutants. They maintain the Integrated Risk Information System, which is "a compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects."[29] Each report contains assessments of non-cancerous and cancerous impacts 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 impacts 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 impacts 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 impacts of MSAT compounds at current environmental concentrations[30] 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.[31] 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 DPM. The EPA states that with respect to diesel engine exhaust, "[t]he

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[29] U.S. Environmental Impact Statement. Integrated Risk Information System. https://www.epa.gov/iris/

[30] Health Effects Institute. 2007. Special Report 16: Mobile-Source Air Toxics: A Critical Review of the Literature on Exposure and Health Effects. November. https://www.healtheffects.org/publication/mobile-source-air-toxics-critical-review-literature-exposure-and-health-effects

[31] Health Effects Institute. 2007. Special Report 16: Mobile-Source Air Toxics: A Critical Review of the Literature on Exposure and Health Effects. November. https://www.healtheffects.org/publication/mobile-source-air-toxics-critical-review-literature-exposure-and-health-effects

absence of adequate data to develop a sufficiently confident dose-response relationship from the epidemiologic studies has prevented the estimation of inhalation carcinogenic risk."[32]

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 CAA 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.[33]

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 while improving access for emergency response, that are better suited for quantitative analysis.

6.2.5 Conclusions

As discussed above, technical shortcomings of emissions and dispersion models and uncertain science with respect to health impacts prevent meaningful or reliable estimates of MSAT emissions and impacts of this project at this time. While it is possible that localized increases in MSAT emissions may occur as a result of this project, emissions will likely be lower than present levels in the design year of this project as a result of EPA's national control programs that are projected in FHWA guidance (2023) to reduce annual MSAT emissions by 76% between 2020 and 2060, even as VMT increases nationally by 31%. Although local conditions may differ from these national projections in terms of fleet mix and turnover, VMT growth rates, and local control measures, the magnitude of the EPA-projected reductions is so great (even after accounting for VMT growth) that MSAT emissions in the study area are likely to be lower in the future in nearly all cases.

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[32] U.S. Environmental Protection Agency. Integrated Risk Information system (IRIS) Chemical Assessment Summary, Diesel engine exhaust; CASRN N.A. https://iris.epa.gov/static/pdfs/0642_summary.pdf

[33] U.S. Court of Appeals for the District of Columbia Circuit, June 2028.

6.3 Mesoscale Analysis

Table 6-1 presents the 2050 forecast VMT, VHT, Daily Trips and average vehicle speeds for the No Build and Build Alternative within the mesoscale study area. Table 6-2 presents the corresponding air quality reductions associated with the Build Alternative compared to the No Build Alternative. A reduction in VMT, VHT, daily trips and vehicles speeds is expected with the Build Alternative when compared to the No Build Alternative due to more efficient traffic flow within the study area. Correspondingly, emissions are also expected to decrease with fewer VMT and higher speeds for the Build Alternative compared to the No Build Alternative.

Table 6-1. 2050 Projected Daily Vehicle Miles Traveled, Vehicle Hours Traveled, Daily Trips, Average Vehicle Speeds (Mesoscale Study Area)

Category	2050 No Build	2050 Build	Change
Daily Vehicle Miles Traveled	3,476,000	3,416,153	-59,847
Daily Vehicle Hours Traveled	94,715	86,788	-7,927
Daily Trips	421,866	421,686	0
Average Speed (miles per hour)	3	39	+2

Table 6-2. Projected Daily Pollutant Emissions (Tons Per Day) (Mesoscale Study Area)

Category	2019 Existing	2050 No Build Alternative	2050 Build Alternative	Change (No Build to Build)
Vehicle Miles Traveled (millions of miles per year)	2.653	3.476	3.416	**-0.06**
Carbon Monoxide	6.37	3.24	2.99	**-0.25**
Volatile Organic Compounds	0.11	0.07	0.07	**-0.01**
Nitrogen Oxide	0.71	0.11	0.10	**-0.01**
Sulfur Dioxide	0.02	0.004	0.004	**-0.0020**
PM10[1]	0.10	0.18	0.14	**-0.04**
PM2.5[2]	0.03	0.03	0.02	**-0.01**

[1] PM10 and PM2.5 include primary exhaust as well as brake wear and tire wear emissions.
[2] Totals may not exactly match due to rounding.

6.4 Greenhouse Gas Emissions

Table 6-3 presents the GHG mesoscale emissions estimates for the 2019 baseline, as well as the 2050 Build and No Build Alternative broken out by emission source type for each year. Table 6-4 presents the CO_2e cumulative change from all emissions sources over the 2019–2050 period for the Build

Alternative compared to the No Build Alternative.[34] This is a conservative estimate as the projected opening year is tentative but scheduled for after the 2019 baseline year (possibly in the 2030s); however, the cumulative emissions are assumed to occur from the 2019 existing year, which is overestimated and will be much lower assuming an opening date much later than 2019. **Table 6-5** shows the change in emissions compared to the 2019 baseline for the 2050 No Build and Build Alternatives, reported in metric tons of CO_2e.

Comparing the 2019 base year and the 2050 No Build Alternative, annual VMT is forecast to increase by about 31% across the mesoscale study area. This VMT change represents the increase in travel activity resulting from anticipated population and job growth. Direct CO2 emissions are forecast to decrease by 21.7% for the 2050 No Build scenarios compared to the baseline, as the increase in VMT is outweighed by improvements in vehicle efficiency, consistent with Commonwealth policies.

Compared to the 2050 No Build Alternative, the Build Alternative is expected to decrease VMT on the mesoscale study area by about -1.7% and direct annual GHG emissions by -4.7%. Similarly, cumulative emissions from the Build Alternative are expected to decrease -298,576 metric tons of CO2e or -3.30% compared to the No Build Alternative for the period from 2019 to the Opening Year.

Table 6-3. Greenhouse Gas Emissions by Alternative (metric tons per year Carbon Dioxide Equivalent)

Category	2019 Existing	2050 No Build Alternative	2050 Build Alternative	Change (No Build to Build)
Vehicle Miles Traveled (millions of miles per year)	968.4	1,268.7	1,246.9	**-21.8**
Methane	12.23	12.49	10.81	**-1.68**
Nitrous Oxide	4.73	7.52	7.17	**-0.35**
Atmospheric Carbon Dioxide	393,277	307,957	293,536	**-14,422**
Carbon Dioxide Equivalent	394,927	310,383	295,817	**-14,566**
Upstream Indirect Emissions	92,608	112,356	108,261	**-4,095**
Construction and Maintenance	1,651	1,651	1,651	**0**
Total Carbon Dioxide Equivalent Emissions	**489,186**	**424,390**	**405,729**	**-18,661**

Source: HMMH February 2025

Note: Totals may not exactly match due to rounding.

[34] Cumulative emissions were estimated by estimating emissions in each year for each alternative. A linear interpolation was performed between 2019 and 2050 for the years in between for each alternative.

Table 6-4. Projected Annual and Cumulative Carbon Dioxide Equivalent Emissions No Build and Build Alternatives for 2019 to 2050 Period (metric tons per year)

Category	2050 No Build Alternative	2050 Build Alternative	Change (No Build to Build)
Vehicle Miles Traveled (millions of miles per year)	1,268.7	1,246.9	**-21.8**
Carbon Dioxide Equivalent	7,101,184	6,868,128	**-233,056**
Upstream Indirect Emissions	2,297,728	2,232,208	**-65,520**
Construction and Maintenance	52,832	52,832	**0**
Total Carbon Dioxide Equivalent Emissions	**9,398,912**	**9,100,336**	**-298,576**

Table 6-5. Change in Carbon Dioxide Equivalent Emissions by Alternative

Source	Existing	2050 No Build Alternative	2050 Build Alternative
Change in Vehicle Miles Traveled from Baseline (million miles)	—	300.3	278.5
Change from Baseline Direct Emissions	—	-84,544	-99,110
Change from No Build to Build Direct Emissions	—	—	-14,566
Change from No Build to Build Total Emissions (direct, upstream and construction and maintenance)		—	-18,661
Cumulative Emissions (direct, upstream, and construction and maintenance)		9,398,912	9,100,336
Cumulative Change Emissions No Build to Build (direct, upstream, and construction and maintenance)		—	-298,576
Percentage Change (cumulative emissions Build minus No Build)			-3.30

Notes: As a conservative estimate, since the opening year is unknown, cumulative emissions were estimated from the 2019 Baseline Year to the 2050 Opening Year. Cumulative emissions are expected to be less than what is presented in the analysis since the opening year is expected to occur well after 2019.

6.4.1 Social Costs of Carbon

For transparency and disclosure, to provide a contextualized monetary measure of greenhouse gases, the SC-GHG was calculated for the CO_2e of direct CO2, CH4, and N2O emissions for existing conditions and the 2050 No Build Alternative and Build Alternative (Table 6-6). These costs were calculated using the IWG 2021 Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide

developed under Executive Order (EO) 13990.[35] The costs in **Table 6-6** were calculated using the direct emissions of CO_2, CH_4, and N_2O in metric tons per year from MOVES4 for each alternative and multiplying by the four discount rates in the Technical Support Document for each pollutant and each year of analysis (i.e., 2019 Baseline and 2050 Design Year). Each pollutant cost for each discount rate is summed to get the T SC-CO_2e for each year and discount rate.

Table 6-6. No Build Alternative and Build Alternative Social Cost of Carbon Dioxide Equivalents from Direct Emissions in U.S. Dollars by Interagency Working Group Average Discount Rates

Source	Discount rates	CO2	CH4	N20	Total
2050 No Build	5%	$9,731,441	$21,233	$97,760	**$9,850,434**
	3%	$26,299,528	$38,719	$248,160	**$26,586,407**
	2.5%	$35,846,195	$47,462	$338,400	**$36,232,057**
	3% 95th Percentile	$80,007,229	$102,418	$661,760	**$80,771,407**
2050 Build	5%	$9,275,738	$18,377	$93,210	**$9,387,325**
	3%	$25,067,974	$33,511	$236,610	**$25,338,095**
	2.5%	$34,167,590	$41,078	$322,650	**$34,531,318**
	3% 95th Percentile	$76,260,653	$88,642	$630,960	**$76,980,255**

Notes:
1. All costs represent direct emissions for CO2, CH4, and N2O, which were derived from the MOVES runs for each alternative.
2. Social costs derived from the White House Technical Support Document social costs and interpolated from range years.

The SC-GHGs were calculated using the IWG average discount rates: 5%, 3%, 2.5% and the 95th percentile damage estimate using the 3% discount rate interpolated between 2020 and 2050 to get the years between reflective of the Opening and Design Years. As noted, the 2020 discount rates were used to estimate the 2019 Baseline costs. The IWG 2021 Social costs discount rates for each pollutant and calculations are provided in **Attachment 5**.

The 5%, 3%, and 2.5% discount rates reflect the average damages from the multiple simulations at each of the three discount rates. The 95th percentile of damages estimated by applying the 3% discount rate reflect higher-than-expected economic impacts from climate change and the associated future economic impacts; this is a low probability and high damage scenario that represents an upper bound of damages within the 3% discount rate model. The calculations of social costs for the four discount rates (5%, 3%, 2.5%, and 95th percentile of the 3%) were completed for direct GHG emissions for 2019, and the Build and No Build for 2050. The term "discount rate" refers to the reduction or discount in value per year as a future cost or benefit is adjusted to be comparable with a current cost or benefit from a proposed project. For this analysis, all three discount rates were used to estimate a

[35] Offices of Management and Budget, "Technical Support Document Social Cost of Carbon Methane Nitrous Oxide", 02/2021.

range of global social costs from the increase in GHG emissions from the Build Alternatives compared to the Baseline and the No Builds.

As shown in **Table 6-6**, the total social cost of GHG equivalents from the 2050 Design Year No Build Alternative and Build Alternative, total SC-GHG equivalents from direct emissions are estimated to range from 9,850,434 to $80,771,407 for the No Build Alternative, and $9,387,325 to $76,980,255 for the Build Alternative, respectively. This range in costs represents the potential social costs associated with adding GHGs to the atmosphere in a given year. It includes the value of all climate change impacts, including but not limited to changes in net agricultural productivity, human health impacts, property damage from increased flood risk natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services.

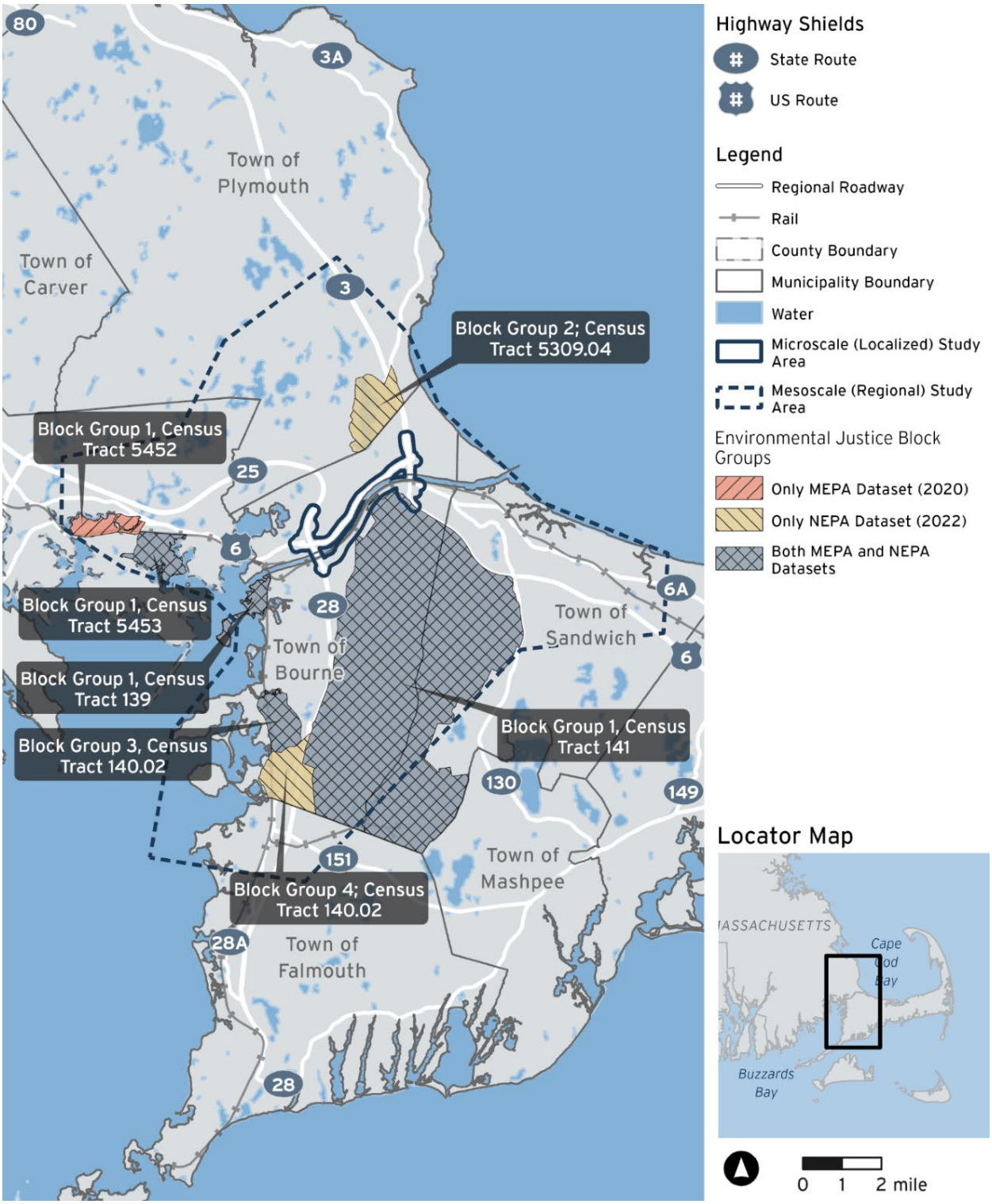
It should be noted that the foregoing social costs are estimates only and are subject to change depending on a variety of factors. They are provided for disclosure and context, but such estimated costs may not actually result.

6.4.2 Environmental Justice

Appendix 4.9, EJScreen Community Report, identifies one EJ population (Block Group 1, Census Tract 141) within 1 mile of the Project Limits based on MEPA data. This EJ population meets the EJ criteria for minority and low income, constitutes the entirety of Joint Base Cape Cod, and is within the towns of Bourne, Sandwich, and Mashpee. Using the NEPA data, **Appendix 4.9, EJScreen Community Report**, identifies the same EJ population (Block Group 1, Census Tract 141) characterized as low income within the towns of Bourne, Sandwich and Mashpee, and one other EJ population (Block Group 2, Census Tract 5309.04) characterized by minority within the town of Plymouth within 1 mile of the Project Limits. Four additional EJ populations are located within 5-miles of the Project Limits based on either the MEPA or NEPA data. These EJ populations meet the criteria for minority or low income and are located in Bourne or Wareham.

Refer to **Figure 6-2**, which depicts these EJ populations relative to the freeway, arterial, and collector roadways located within the Air Quality Study Areas. Construction of the Build Alternative is expected to generate 230,368 construction-period truck trips. The origin of these trips will depend on various factors that are currently unknown, such as the locations of suppliers for construction materials, waste disposal sites, staging areas, and the contractor's office or equipment yards. However, it is anticipated that these trips will primarily utilize U.S. or state routes, including State Routes 3, 130, and 28, and U.S. Routes 6 and 25. State Route 130 passes through an EJ population within five miles of the site, as identified using MEPA data. Similarly, State Route 28 and U.S. Route 6 traverse EJ populations located within five miles of the site, as identified using NEPA data. The other state and U.S. routes travel adjacent to, but do not extend through, identified EJ populations. According to a review of the EPA's EJ Screen, identified EJ populations do not have air quality indicators that are elevated at or above the 80th percentile compared to the statewide average. Refer to **Appendix 4.9, EJScreen Community Report**, for additional information.

Figure 6-2. Environmental Justice Populations Relative to the Air Quality Study Area



Source: Massachusetts Department of Transportation, 2025

6.4.3 New Vessel Traffic

MassDOT estimated annual criteria pollutant emissions from marine transport vessels from fossil fuel fired engines for one year of operation. It is expected these operations would continue each year over a six-year construction period. These emissions were estimated for tugs and launches using EPA emission factors and expected annual trips per year for each vessel.

Table 6-7 presents the estimated annual criteria pollutant emissions from marine transport vessels from fossil fuel fired engines for one year of operation. It is expected these operations would continue each year over a six-year construction period. These emissions were estimated for tugs and launches using EPA emission factors and expected annual trips per year for each vessel.

Table 6-7. Projected Annual Pollutant Emissions for New Vessel Marine Trips (tons per year)

Activity	Trips Per Year	CO	VOC	NOX	SO2	PM10	PM2.5
Tugs	4,380	2.24	0.30	3.16	0.01	0.07	0.07
Launches	2,920	1.07	0.41	2.52	0.41	0.17	0.16
	Total	**3.30**	**0.71**	**5,68**	**0.42**	**0.25**	**0.24**

Source: Massachusetts Department of Transportation, 2025

Note: Assumes total of 7,300 trips of tugs and launches per year to support the Sagamore Bridge and Bourne Bridge construction operations.

The origin of the vessel trips will depend on various factors that are currently unknown, such as the locations of suppliers for construction materials, waste disposal sites, and the location of the marina or docking facilities. However, regardless of their origin, the vessels will need to enter Cape Cod Canal from either the north or south and will pass by many non-EJ populations and one EJ population located adjacent to the southern entrance to the Canal. Furthermore, the emission plume from the vessel stacks will be dispersed and diluted due to meteorological conditions (i.e., wind speed and wind direction) and constant moving nature of the activities which will help mitigate concentrated ground level concentrations and exposure as compared to a stationary source. Therefore, the vessel traffic is not anticipated to result in a disproportionate adverse effect on EJ populations.

6.4.4 Construction

During construction, there is potential for short-term increases in particulate matter emissions (airborne dust) due to site preparation and roadway reconstruction activities, including land clearing, demolition, excavation, grading, compaction, removing or improving existing roadways, and paving roadway surfaces. In addition to airborne dust, the operation of diesel-fueled off-road equipment and heavy-duty trucks have the potential to adversely affect air quality due to direct emissions of CO, oxides of nitrogen, and VOCs. According to the EPA, research has shown that sensitive receptors—including older adults (over age 65), children (under age 18), people with heart or lung diseases, minority populations, and low socioeconomic status populations—are more vulnerable to adverse impacts of exposure to air pollution relative to the general population.[10] Land uses considered sensitive

receptors include residences, schools, daycare centers, parks and playgrounds, and medical facilities. MassDOT's Standard Specifications for Road and Bridge Construction includes construction-related specifications and contract special provisions for dust control, use of cleaner diesel fuel, idling reduction requirements, and installation of emission control devices on contractor vehicles. MassDOT's contractors will comply with all air quality contract specifications to minimize impacts of fugitive dust and construction equipment and vehicle exhaust including ozone precursors VOCs and NOx). **Section 7** outlines specific measures that will be implemented to reduce air quality impacts during construction.

Demolition of the Sagamore and Bourne Bridges would involve lead paint disturbance, which can generate airborne lead dust and fumes. The contractor will be required to comply with MassDOT specifications for proper removal of bridge components coated with lead-based paint. These specifications will require the contractor(s) to develop a Lead Abatement Plan—including containment measures, lead paint removal methods, worker protection measures, waste disposal procedures, and post-abatement protocols—for review and approval by MassDOT. Any demolition activities with the potential to disturb identified or suspected lead-based paint would be performed in accordance with the Occupational Safety and Health Administration Lead in Construction Standard.[36]

7 Mitigation Measures

7.1 Construction Equipment and Vehicle Exhaust

The following Best Management Practices (BMP) and mitigation measures will be employed to control the impacts of construction equipment and vehicle exhaust emissions, including criteria pollutants and ozone precursors. Such measures will include but will not be limited to the following:

- Use of low-emitting diesel-fueled equipment or retrofitting of heavy-duty diesel-fueled construction equipment with diesel oxidation catalysts or diesel particulate filters to meet either the Environmental Protection Agency (EPA) particulate matter emission standards or emission control technology verified by the U.S. Environmental Protection Agency (U.S. EPA) or the California Air Resources Board. This will mitigate sulfur oxides and particulates.
- Installation of on-site anti-idling signage at various loading and drop-off/pick-up/waiting areas to prohibit trucks from engine idling more than five minutes in compliance with Massachusetts General Law (MGL) Chapter 90, Section 16A and MassDEP idling reduction regulation (310 CMR 7.11(1)(b)). This will mitigate criteria pollutant and ozone precursors.
- Ensuring construction equipment is maintained in proper working order to minimize exhaust emissions, including odors. This will mitigate criteria pollutants and ozone precursors.

Use of alternative-fueled or electric equipment where feasible. This will mitigate criteria pollutants and ozone precursors.

[36] https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.62

7.2 Fugitive Dust

The following BMPs and mitigation measures will be employed to control the impacts of fugitive dust emissions and mitigate particulate matter during construction. Such measures will include but will not be limited to the following:

- Seeding, paving, covering, wetting, or otherwise treating disturbed soil surfaces.
- Covering of active stockpiles with plastic tarps or other suitable containment measures.
- Covering of dust-producing materials (e.g., dirt or demolition debris) before transport on public roadways.
- Route and schedule construction traffic through areas that would cause the least disturbance to nearby sensitive receptors.
- Locating aggregate storage piles away from sensitive receptors and environmental resources.
- Modifying work schedules when weather conditions such as dry soil or high wind speeds could lead to adverse impacts.

7.3 Lead Abatement Activities

The following BMPs will be employed to prevent public exposure to lead-based paint hazards during construction and demolition. Such measures will include but will not be limited to the following:

- Developing a Lead Abatement Plan.
- Establishing containment enclosure areas around work zones.
- Wet-misting or vacuuming to control lead dust and paint chips during removal.
- Avoiding abatement activities during precipitation events or periods of high sustained wind speeds.

8 Glossary of Terms

Table 8-1. Glossary of Terms

Term	Definition
Ambient Air Quality Data	Massachusetts Department of Environmental Protection collection of representative samples of ambient air for several pollutants at monitoring stations located across the Commonwealth of Massachusetts. These results are summarized annually in an Air Quality Report.
Attainment	Areas designated by the U.S. Environmental Protection Agency that meet the National Ambient Air Quality Standards.
Average daily traffic (ADT)	The average number of vehicles that travel through a specific area over a period of time.
Carbon Dioxide Equivalent (CO2e)	CO2e is a metric used to compare the global warming potential (GWP) of greenhouse gases (GHG) to carbon dioxide (CO2). It is a way to measure how much a gas contributes to global warming.
Climate Change	Climate Change refers to long-term shifts in temperature and weather patterns.
Criteria Pollutants	The U.S. Environmental Protection Agency sets National Ambient Air Quality Standards for six commonly found air pollutants known as criteria air pollutants.
Environmental Justice	Environmental Justice means the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment.
U.S. Environmental Protection Agency MOVES Model	The U.S. Environmental Protection Agency MOVES model is a state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics.
Federal Highway Administration, "Updated Interim Guidance on Mobile Source Air Toxic (MSAT) Analysis in National Environmental Policy Act (NEPA) Documents"	This guidance document provides a tiered approach for analyzing mobile source air toxics in National Environmental Policy Act documents.
Level of Service (LOS)	A qualitative measure that describes how well a roadway operates based on factors like speed, maneuverability, and delay.

Term	Definition
Maintenance	Areas that were formally designated by the U.S. Environmental Protection Agency as attainment that are now currently meeting the National Ambient Air Quality Standards.
Mesoscale Analysis	Estimate of mobile source emissions generated by a project within the study network for the No Build and Build Alternatives.
Mobile Source Air Toxics (MSAT)	The U.S. Environmental Protection Agency 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. These nine compounds are referred to as MSATs and are considered priority mobile source air toxics.
National Ambient Air Quality Standards (NAAQS)	Standards developed by the U.S. Environmental Protection Agency for criteria pollutants which can be harmful to the public health and environment. They are standards designed to protect public health and welfare.
Nonattainment	Areas designated by the U.S. Environmental Protection Agency that do not meet the National Ambient Air Quality Standards
Regional Transportation Plans	Usually developed by metropolitan planning organizations for a five-year period that identifies the transportation needs of the region
Social Costs of Carbon	Economic damages caused by emitting one additional ton of carbon dioxide into the atmosphere.
Transportation Conformity	Transportation conformity is the process that is used in a nonattainment or maintenance area to review the current transportation plan and program in a region to ensure they conform to the state's air quality plan or State Implementation Plan (SIP)
Vehicle Miles Traveled	Measurement of how many miles vehicles travel within a specific area based on a set period of time.

9 References

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Attachment 1. Traffic Level of Service (LOS)

Table 1-1: Synchro and SIDRA Results Summary - 2019 Existing Fall

Intersection	2019 Existing Fall Weekday AM					2019 Existing Fall Weekday PM				
	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
6:: Scenic Highway (Route 6) / Main Street (Route 6) / Nightingale Road / Andy Olivia Drive	**B**	**14.7**				**B**	**17.9**			
Main Street (Route 6) EB (left/thru)	A	6.2	0.70	162	207	A	7.1	0.74	132	157
Main Street (Route 6) EB (thru/right)	A	6.2	0.70	162	207	A	7.1	0.74	132	157
Scenic Hwy (Route 6) WB (left/thru)	B	19.9	0.84	420	535	C	24.6	0.91	495	#677
Scenic Hwy (Route 6) WB (thru/right)	B	19.9	0.84	420	535	C	24.6	0.91	495	#677
Andy Olivia Dr NB (left/thru/right)	D	39.5	0.02	0	0	D	39.5	0.03	0	0
Nightingale Pond Rd SB (left/thru)	D	40.8	0.28	18	46	D	40.1	0.15	10	28
Nightingale Pond Rd SB (right)	D	39.5	0.05	0	14	D	39.5	0.03	0	0
8:: Trowbridge Rd./Veterans Way	**A**	**0.7**				**A**	**2.9**			
Trowbridge Rd EB (left/thru/right)	A	8.0	0.01	-	0	A	7.9	0.02	-	1
Trowbridge Rd WB (left/thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Driveway NB (left/thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Veterans Way SB (left/thru/right)	B	13.4	0.09	-	7	C	18.4	0.32	-	34
9:: Bourne Rotary	**F**	**521.0**				**F**	**419.8**			
General MacArthur Boulevard NB (left/thru)	F	360.4	1.75	-	4706	F	597.7	2.28	-	6836
General MacArthur Boulevard NB (right)	C	16.3	0.62	-	101	C	22.9	0.72	-	132
Sandwich Road WB (left/thru)	F	236.0	1.44	-	1849	C	23.0	0.66	-	98
Sandwich Road WB (right)	B	10.0	0.13	-	10	F	311.9	1.63	-	2831
Route 28 (Bourne Bridge) SB (left/thru)	F	941.9	3.05	-	11668	F	594.7	2.28	-	8618
Route 28 (Bourne Bridge) SB (right)	A	6.5	0.09	-	8	A	6.1	0.15	-	14
Trowbridge Road EB (left/thru/right)	F	136.4	1.18	-	810	F	206.2	1.36	-	1371
10:: Sandwich Road / Bourne Rotary Connector	**F**	**103.7**				**F**	**352.0**			
Sandwich Rd SB (left/right)	F	648.6	2.29	-	717	F	1996.4	5.25	-	Err
Bourne Rotary Connector EB (left/thru)	A	9.4	0.01	-	0	A	0.0	0.00	-	0
Sandwich Rd WB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
11:: Sandwich Road / Upper Cape Cod Technical School Driveway	**D**	**42.5**				**F**	**181.3**			
Cape Cod Technical School Driveway NB (left/right)	F	630.1	2.08	-	335	F	2709.6	6.44	-	Err
Sandwich Rd EB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Sandwich Rd WB (left)	B	12.3	0.22	-	21	B	13.5	0.13	-	11
Sandwich Rd WB (thru)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
15:: Sandwich Road (Route 6 Bypass) / Mid-Cape Connector	**B**	**11.4**				**B**	**12.4**			
Sandwich Rd EB (thru)	C	21.3	0.69	133	234	C	21.0	0.71	159	266
Sandwich Rd EB (right)	A	0.9	0.44	0	0	A	1.7	0.60	0	0
Sandwich Rd WB (left)	A	8.6	0.29	22	46	A	8.8	0.40	30	56
Sandwich Rd WB (thru)	A	9.0	0.48	106	180	B	14.0	0.78	234	360
Mid-Cape Connector NB (left)	C	24.2	0.72	118	#241	C	26.6	0.71	115	#265
Mid-Cape Connector NB (right)	B	10.9	0.16	0	29	B	14.4	0.41	33	118
16:: Mid-Cape Connector / Factory Outlet Way	**B**	**11.1**				**B**	**15.2**			
Factory Outlet Way (Market Basket Driveway) WB (left)	C	26.9	0.10	5	17	C	30.0	0.25	30	52
Factory Outlet Way (Market Basket Driveway) WB (left)	C	26.9	0.10	5	17	C	30.0	0.25	30	52
Factory Outlet Way (Market Basket Driveway) WB (right)	B	14.0	0.15	20	46	B	16.8	0.37	79	111
Mid-Cape Connector NB (thru)	B	17.1	0.68	170	303	C	21.8	0.65	207	#381
Mid-Cape Connector NB (right)	A	7.1	0.05	0	12	A	7.1	0.07	0	18
Mid-Cape Connector SB (left)	C	25.7	0.46	47	111	C	35.0	0.64	93	149
Mid-Cape Connector SB (thru)	A	3.4	0.31	47	79	A	5.4	0.36	84	113
Mid-Cape Connector SB (thru)	A	3.4	0.31	47	79	A	5.4	0.36	84	113
20:: Scenic Highway (Route 6) / Church Lane / Route 6 SB On-Ramp	**C**	**22.1**				**C**	**20.7**			
Scenic Hwy (Route 6) EB (left)	D	54.9	0.44	10	36	D	45.0	0.53	39	80
Scenic Hwy (Route 6) EB (thru)	C	26.6	0.97dr	304	#591	C	24.0	0.87dr	320	437
Scenic Hwy (Route 6) EB (thru/right)	C	26.6	0.97dr	304	#591	C	24.0	0.87dr	320	437
Scenic Hwy (Route 6) WB (left)	E	56.2	0.85	195	316	D	46.5	0.77	149	247
Scenic Hwy (Route 6) WB (thru)	A	8.9	0.85	126	305	B	11.3	0.55	209	313
Scenic Hwy (Route 6) WB (thru)	A	8.9	0.85	126	305	B	11.3	0.55	209	313
Scenic Hwy (Route 6) WB (thru/right)	A	8.9	0.51	126	305	B	11.3	0.55	209	313
Church Lane SB (left/thru/right)	D	52.4	0.66	76	151	D	43.7	0.56	56	99

Table 1-1: Synchro and SIDRA Results Summary - 2019 Existing Fall

Intersection	2019 Existing Fall Weekday AM					2019 Existing Fall Weekday PM				
	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
21:: Scenic Highway (Route 6) & Route 3 SB Off-Ramp	**C**	**29.5**				**D**	**38.6**			
Scenic Hwy (Route 6) EB (thru)	B	10.7	0.44	176	247	B	13.6	0.57	236	319
Scenic Hwy (Route 6) WB (thru)	C	23.2	0.90	606	555	B	19.1	0.81	428	515
Scenic Hwy (Route 6) WB (thru)	C	23.2	0.90	606	555	B	19.1	0.81	428	515
Route 3 Off-Ramp SB (left/right)	F	82.3	0.98	~315	#529	F	124.2	1.14	~433	#693
22:: Meetinghouse Lane / State Road / Canal Street	**D**	**51.1**				**E**	**63.9**			
Meetinghouse Ln EB (left)	C	27.5	0.69	199	#624	C	34.1	0.88	265	#807
Meetinghouse Ln EB (thru)	B	19.2	0.23	74	202	C	21.7	0.50	121	#479
Meetinghouse Ln EB (right)	B	19.1	0.21	0	75	B	16.8	0.17	0	63
Meetinghouse Ln WB (left)	D	37.8	0.11	8	34	D	37.5	0.11	5	22
Meetinghouse Ln WB (thru/right)	F	141.0	1.13	249	#435	F	261.8	1.43	~222	#328
Canal St NB (left)	D	40.7	0.72	147	167	C	31.1	0.61	94	145
Canal St NB (thru/right)	D	40.9	0.53	156	187	C	34.8	0.37	82	138
State Rd SB (left)	D	44.5	0.18	18	38	D	36.4	0.16	18	36
State Rd SB (thru/right)	D	49.6	0.36	35	109	D	40.6	0.27	23	69
23:: State Road / Route 3 NB On-Ramp	**A**	**4.4**				**A**	**3.4**			
State Rd NB (left)	A	9.0	0.33	-	37	A	8.7	0.29	-	31
State Rd NB (thru)	A	0.0	0.13	-	0	A	0.0	0.23	-	0
State Rd SB (thru)	A	0.0	0.13	-	0	A	0.0	0.13	-	0
State Rd SB (right)	A	0.0	0.01	-	0	A	0.0	0.01	-	0
24:: Cranberry Highway / Adams Street	**A**	**4.4**				**A**	**3.6**			
Cranberry Highway EB (thru)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Cranberry Highway EB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Cranberry Highway WB (left/thru)	A	7.6	0.00	-	0	A	8.9	0.01	-	0
Cranberry Highway WB (thru)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Adams Street NB [left/thru/right]	B	10.6	0.07	-	6	C	15.0	0.06	-	7
Adams Street SB [left/thru/right]	B	11.0	0.30	-	32	B	13.2	0.43	-	55
25:: Sandwich Road / Adams Street	**A**	**0.3**				**A**	**0.6**			
Sandwich Rd EB (thru/right)	A	0.0	0.37	-	0	A	0.0	0.50	-	0
Sandwich Rd WB (left/thru)	A	0.7	0.03	-	2	A	1.0	0.03	-	2
39:: Belmont Circle	**F**	**274.1**				**F**	**315.9**			
Buzzards Bay Bypass (Route 6) EB (left/thru/right)	B	13.1	0.32	-	24	C	16.8	0.60	-	66
Main Street (Route 6) WB (left/thru)	A	9.3	0.35	-	29	C	21.9	0.72	-	109
Main Street (Route 6) WB (right)	F	472.0	2.01	-	6334	F	420.1	1.89	-	5143
Old Bridge Road NB (left/thru/right)	B	10.1	0.02	-	1	A	9.1	0.01	-	1
Route 28/25 Ramps SB (left/thru/right)	F	241.7	1.49	-	151	F	490.3	2.05	-	6322
Main Street NEB (left/thru/right)	F	226.5	1.43	-	2032	F	268.6	1.54	-	2963
Head of the Bay Road SEB (left/thru/right)	F	74.5	1.03	-	425	C	18.0	0.57	-	57
40:: Sandwich Road / Veterans Way	**A**	**0.7**				**A**	**0.6**			
Sandwich Road EB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Sandwich Road WB (left/thru)	A	0.0	8.50	-	0	A	0.0	7.90	-	0
Veterans Way (left/right)	C	0.1	15.00	-	8	B	0.0	11.80	-	3

~ : Volume exceeds capacity
$: Delay exceeds 300s
: 95th percentile volume exceeds capacity, queue may be longer
Err : Error

Table 2-1: Synchro and SIDRA Results Summary - 2050 No-Build Fall

Intersection	2050 No-Build Fall Weekday AM					2050 No-Build Fall Weekday PM				
	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
6:: Scenic Highway (Route 6) / Main Street (Route 6) / Nightingale Road / Andy Olivia Drive	**E**	**75.8**				**F**	**98.9**			
Main Street (Route 6) EB (left/thru)	D	48.6	1.06	~441	#771	F	142.7	1.28	~907	#1048
Main Street (Route 6) EB (thru/right)	D	48.6	1.06	~441	#771	F	142.7	1.28	~907	#1048
Scenic Hwy (Route 6) WB (left/thru)	F	102.2	1.17	~831	#977	D	53.1	1.04	~686	#827
Scenic Hwy (Route 6) WB (thru/right)	F	102.2	1.17	~831	#977	D	53.1	1.04	~686	#827
Andy Olivia Dr NB (left/thru/right)	D	40.4	0.22	15	43	D	40.2	0.17	11	36
Nightingale Pond Rd SB (left/thru)	D	41.4	0.38	24	57	D	40.2	0.17	11	34
Nightingale Pond Rd SB (right)	D	39.5	0.05	0	20	D	39.7	0.03	0	0
8:: Trowbridge Rd./Veterans Way	**A**	**4.5**				**A**	**2.4**			
Trowbridge Rd EB (left/thru/right)	A	8.3	0.09	-	8	A	8.8	0.01	-	1
Trowbridge Rd WB (left/thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Driveway NB (left/thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Veterans Way SB (left/thru/right)	E	45.2	0.52	-	62	F	77.4	0.54	-	62
9:: Bourne Rotary	**F**	**521.9**				**F**	**466.1**			
General MacArthur Boulevard NB (left/thru)	F	611.6	2.32	-	8341	F	590.6	2.27	-	7381
General MacArthur Boulevard NB (right)	F	75.4	1.06	-	1135	B	10.1	0.35	-	38
Sandwich Road WB (left/thru)	F	295.5	1.58	-	2412	F	220.9	1.41	-	1770
Sandwich Road WB (right)	D	34.1	0.77	-	157	F	385.8	1.79	-	3169
Route 28 (Bourne Bridge) SB (left/thru)	F	876.0	2.91	-	11079	F	447.6	1.95	-	5707
Route 28 (Bourne Bridge) SB (right)	A	6.7	0.11	-	9	A	6.8	0.15	-	13
Trowbridge Road EB (left/thru/right)	F	329.2	1.65	-	2336	F	649.9	2.39	-	5703
10:: Sandwich Road / Bourne Rotary Connector	**F**	**566.4**				**A**	**3.2**			
Sandwich Rd SB (left/right)	F	$3972.2	9.45	-	Err	F	257.6	0.91	-	87
Bourne Rotary Connector EB (left/thru)	A	11.4	0.01	-	1	C	19.7	0.02	-	2
Sandwich Rd WB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
11:: Sandwich Road / Upper Cape Cod Technical School Driveway	**F**	**226.2**				**F**	**239.1**			
Cape Cod Technical School Driveway NB (left/right)	F	$4611.2	10.15	-	Err	F	4314.4	9.66	-	Err
Sandwich Rd EB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Sandwich Rd WB (left)	C	19.0	0.35	-	38	B	10.0	0.07	-	6
Sandwich Rd WB (thru)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
15:: Sandwich Road (Route 6 Bypass) / Mid-Cape Connector	**C**	**23.8**				**F**	**123.9**			
Sandwich Rd EB (thru)	C	26.8	0.81	209	340	B	13.0	0.32	90	151
Sandwich Rd EB (right)	A	2.4	0.68	0	0	A	0.6	0.35	0	0
Sandwich Rd WB (left)	B	11.1	0.32	20	39	A	6.6	0.12	14	29
Sandwich Rd WB (thru)	B	12.4	0.65	185	281	E	77.0	1.11	~774	#1016
Mid-Cape Connector NB (left)	F	82.5	1.07	~276	#553	F	360.4	1.71	~582	#793
Mid-Cape Connector NB (right)	B	16.0	0.49	58	158	B	19.5	0.07	0	28
16:: Mid-Cape Connector / Factory Outlet Way	**B**	**19.0**				**C**	**21.7**			
Factory Outlet Way (Market Basket Driveway) WB (left)	C	30.5	0.08	4	14	C	21.1	0.20	23	27
Factory Outlet Way (Market Basket Driveway) WB (left)	C	30.5	0.08	4	14	C	21.1	0.20	23	27
Factory Outlet Way (Market Basket Driveway) WB (right)	B	19.5	0.17	22	48	B	13.5	0.35	164	333
Mid-Cape Connector NB (thru)	D	35.5	0.96	~458	#755	C	28.9	0.58	106	163
Mid-Cape Connector NB (right)	A	5.2	0.05	0	12	B	10.1	0.07	34	69
Mid-Cape Connector SB (left)	C	34.8	0.57	45	93	D	52.7	0.60	170	#314
Mid-Cape Connector SB (thru)	A	3.6	0.43	78	123	A	8.5	0.34	36	47
Mid-Cape Connector SB (thru)	A	3.6	0.43	78	123	A	8.5	0.34	36	47
20:: Scenic Highway (Route 6) / Church Lane / Route 6 SB On-Ramp	**E**	**58.5**				**E**	**69.0**			
Scenic Hwy (Route 6) EB (left)	E	57.5	0.46	11	38	D	41.3	0.47	31	80
Scenic Hwy (Route 6) EB (thru)	F	111.4	1.15dr	~716	#1080	F	119.1	1.21	~747	#1098
Scenic Hwy (Route 6) EB (thru/right)	F	111.4	1.15dr	~716	#1080	F	119.1	1.21	~747	#1098
Scenic Hwy (Route 6) WB (left)	E	58.3	0.88	232	368	D	37.9	0.54	64	136
Scenic Hwy (Route 6) WB (thru)	B	10.5	0.63	189	442	B	12.0	0.61	222	341
Scenic Hwy (Route 6) WB (thru)	B	10.5	0.63	189	442	B	12.0	0.61	222	341
Scenic Hwy (Route 6) WB (thru/right)	B	10.5	0.63	189	442	B	12.0	0.61	222	341
Church Lane SB (left/thru/right)	E	55.4	0.68	85	171	D	39.7	0.52	47	111

Table 2-1: Synchro and SIDRA Results Summary - 2050 No-Build Fall

Intersection	2050 No-Build Fall Weekday AM					2050 No-Build Fall Weekday PM				
	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
21:: Scenic Highway (Route 6) & Route 3 SB Off-Ramp	**F**	**112.3**				**F**	**95.8**			
Scenic Hwy (Route 6) EB (thru)	B	11.7	0.47	179	251	D	36.8	0.56	730	#1118
Scenic Hwy (Route 6) WB (thru)	B	19.9	0.84	471	572	B	13.4	0.85	311	375
Scenic Hwy (Route 6) WB (thru)	B	19.9	0.84	471	572	B	13.4	0.85	311	375
Route 3 Off-Ramp SB (left/right)	F	385.8	1.75	~830	#1165	F	342.9	1.38	~812	#1054
22:: Meetinghouse Lane / State Road / Canal Street	**F**	**142.3**				**F**	**169.1**			
Meetinghouse Ln EB (left)	F	474.8	1.94	~468	#680	F	328.7	1.67	~992	#1714
Meetinghouse Ln EB (thru)	D	38.7	0.20	51	98	C	21.4	0.49	122	#462
Meetinghouse Ln EB (right)	D	38.8	0.20	0	76	B	17.6	0.23	0	76
Meetinghouse Ln WB (left)	D	39.4	0.13	20	46	D	37.5	0.07	3	18
Meetinghouse Ln WB (thru/right)	F	191.6	1.26	~302	#495	D	43.8	0.33	42	86
Canal St NB (left)	C	21.8	0.64	79	185	C	28.5	0.58	80	126
Canal St NB (thru/right)	B	19.9	0.29	102	234	C	33.3	0.42	100	161
State Rd SB (left)	B	19.0	0.11	17	54	C	33.6	0.16	18	40
State Rd SB (thru/right)	C	34.1	0.73	246	#687	D	42.6	0.61	86	165
23:: State Road / Route 3 NB On-Ramp	**A**	**4.6**				**A**	**2.6**			
State Rd NB (left)	B	12.3	0.50	-	72	A	9.4	0.37	-	44
State Rd NB (thru)	A	0.0	0.12	-	0	A	0.0	0.57	-	0
State Rd SB (thru)	A	0.0	0.34	-	0	A	0.0	0.16	-	0
State Rd SB (right)	A	0.0	0.02	-	0	A	0.0	0.01	-	0
24:: Cranberry Highway / Adams Street	**A**	**3.8**				**A**	**1.9**			
Cranberry Highway EB (thru)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Cranberry Highway EB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Cranberry Highway WB (left/thru)	A	8.0	0.01	-	0	A	7.9	0.01	-	1
Cranberry Highway WB (thru)	A	0.0	0.00	-	0	A	0.1	0.00	-	0
Adams Street NB [left/thru/right]	B	10.4	0.04	-	3	C	17.0	0.13	-	12
Adams Street SB [left/thru/right]	B	11.0	0.30	-	32	B	13.2	0.17	-	16
25:: Sandwich Road / Adams Street	**A**	**0.4**				**A**	**0.8**			
Sandwich Rd EB (thru/right)	A	0.0	0.56	-	0	A	0.0	0.19	-	0
Sandwich Rd WB (left/thru)	A	0.8	0.03	-	2	A	1.0	0.02	-	1
39:: Belmont Circle	**F**	**467.1**				**F**	**273.2**			
Buzzards Bay Bypass (Route 6) EB (left/thru/right)	D	30.0	0.75	-	122	A	8.5	0.28	-	21
Main Street (Route 6) WB (left/thru)	D	30.4	0.83	-	270	C	18.3	0.66	-	117
Main Street (Route 6) WB (right)	F	653.4	2.41	-	8337	A	7.7	0.19	-	13
Old Bridge Road NB (left/thru/right)	B	10.1	0.02	-	1	A	7.8	0.01	-	1
Route 28/25 Ramps SB (left/thru/right)	F	632.9	2.36	-	7911	F	537.4	2.15	-	7068
Main Street NEB (left/thru/right)	F	476.5	2.00	-	4488	F	148.0	1.27	-	2710
Head of the Bay Road SEB (left/thru/right)	F	153.2	1.25	-	1163	B	12.6	0.44	-	47
40:: Sandwich Road / Veterans Way	**A**	**2.1**				**A**	**0.7**			
Sandwich Road EB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Sandwich Road WB (left/thru)	A	0.0	8.20	-	3	A	0.0	8.80	-	3
Veterans Way (left/right)	B	0.2	12.30	-	20	C	0.1	18.20	-	10

~ : Volume exceeds capacity
$: Delay exceeds 300s
: 95th percentile volume exceeds capacity, queue may be longer
Err : Error

Table 3-1: Synchro and SIDRA Results Summary - 2050 Build Fall

Intersection	2050 Build Fall Weekday AM					2050 Build Fall Weekday PM				
	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
6:: Scenic Highway (Route 6) / Main Street (Route 6) / Nightingale Road / Andy Olivia Drive	**E**	**65.8**				**B**	**12.5**			
Main Street (Route 6) EB (left)	B	13.4	0.25	4	34	A	6.8	0.22	10	63
Main Street (Route 6) EB (thru/right)	E	55.7	1.03	156	#923	A	9.7	0.49	66	#441
Scenic Hwy (Route 6) WB (left)	B	13.2	0.03	1	9	A	8.3	0.01	1	8
Scenic Hwy (Route 6) WB (thru/right)	F	86.3	1.12	~167	#925	B	12.9	0.58	126	#482
Andy Olivia Dr NB (left/thru/right)	C	24	0.16	5	39	C	30.7	0.24	6	37
Nightingale Pond Rd SB (left/thru)	C	25.1	0.32	7	#76	C	30.8	0.26	6	52
8:: Trowbridge Road / Veterans Way	**A**	**3.1**				**A**	**0.8**			
Trowbridge Rd EB (left/thru)	A	8.3	0.09	-	8	A	8.9	0.01	-	1
Trowbridge Rd EB (thru)	A	0.3	0.00	-	0	A	0.1	0.00	-	0
Trowbridge Rd WB (thru)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Trowbridge Rd WB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Veterans Way SB (left/thru/right)	C	17.8	0.26	-	25	C	23.4	0.22	-	18
9:: Trowbridge Road / Route 25 SB Off-Ramp	**C**	**22.8**				**C**	**31.9**			
Trowbridge Rd EB (thru)	C	20.9	0.22	31	101	C	31.2	0.78	314	#603
Trowbridge Rd EB (thru/right)	C	20.9	0.22	31	101	C	31.2	0.78	314	#603
Trowbridge Rd WB (left)	C	30.3	0.55	149	#282	E	65.5	0.65	137	#276
Trowbridge Rd WB (thru)	A	9.0	0.11	14	132	B	11.7	0.22	41	161
Trowbridge Rd WB (thru)	A	9.0	0.11	14	132	B	11.7	0.22	41	161
Route 25 SB Off-Ramp (left)	D	46.2	0.42	34	73	D	49.9	0.67	125	#288
Route 25 SB Off-Ramp (thru/right)	D	42.9	0.04	0	0	D	40.8	0.25	26	103
9:: Sandwich Road / Trowbridge Road / Route 28 NB Off-Ramp	**C**	**29.2**				**C**	**25.7**			
Trowbridge Rd EB (left)	D	40.6	0.50	48	65	E	56.1	0.76	188	#293
Trowbridge Rd EB (left)	D	40.6	0.50	48	65	E	56.1	0.76	188	#293
Trowbridge Rd EB (thru)	A	4.9	0.03	2	18	A	2.9	0.26	39	95
Trowbridge Rd EB (thru)	A	4.9	0.03	2	18	A	2.9	0.26	39	95
Sandwich Road WB (thru)	B	17.7	0.30	77	210	B	19.5	0.39	121	290
Sandwich Road WB (thru)	B	17.7	0.30	77	210	B	19.5	0.39	121	290
Sandwich Road WB (right)	B	17.2	0.22	0	77	C	23.0	0.52	1	144
Route 28 NB Off-Ramp (left/thru)	D	37.2	0.09	12	38	D	49.2	0.29	26	60
Route 28 NB Off-Ramp (right)	D	41.0	0.49	0	#206	D	48.1	0.15	0	#91
10:: Sandwich Road / Bourne Rotary Connector	**A**	**5.0**				**A**	**1.0**			
Sandwich Road EB (left/right)	F	75.1	0.77	-	125	F	152.1	0.42	-	46
Sandwich Road (Bourne Rotary Connector) NB (left/thru)	B	10.4	0.01	-	0	C	19.7	0.02	-	2
Sandwich Road (Bourne Rotary Connector) NB (thru)	A	0.1	0.00	-	0	A	0.4	0.00	-	0
Sandwich Rd WB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
11:: Sandwich Road / Upper Cape Cod Technical School Driveway	**C**	**26.1**				**F**	**239.1**			
Cape Cod Technical School Driveway NB (left/right)	F	411.5	1.62	-	278	F	$4314.4	9.66	-	560
Sandwich Rd EB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Sandwich Rd WB (left)	B	11.1	0.19	-	18	B	10.0	0.07	-	5
Sandwich Rd WB (thru)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
15:: Sandwich Road (Route 6 Bypass) / Mid-Cape Connector	**C**	**33.7**				**C**	**24**			
Sandwich Rd EB (thru)	D	46.4	0.78	242	316	C	24.3	0.38	129	227
Sandwich Rd EB (right)	A	6.6	0.44	82	320	A	10.3	0.50	93	393
Sandwich Rd WB (left)	E	57.2	0.3	47	93	B	15.4	0.18	30	69
Sandwich Rd WB (thru)	D	54.8	0.52	254	320	C	24.8	0.83	411	#653
Sandwich Rd WB (thru)	D	54.8	0.52	254	320	C	24.8	0.83	411	#653
Mid-Cape Connector NB (left)	C	23.0	0.31	75	247	C	41.0	0.68	220	#434
Mid-Cape Connector NB (right)	C	23.0	0.31	75	247	C	41.0	0.68	220	#434
16:: Mid-Cape Connector / Cranberry Highway Extension	**B**	**19.5**				**C**	**30.7**			
Cranberry Highway Extension WB (left)	D	48.2	0.60	114	153	D	51.2	0.81	410	m#557
Cranberry Highway Extension WB (left/right)	D	48.2	0.60	114	153	B	15.4	0.55	131	m156
Cranberry Highway Extension WB (right)	C	31.0	0.15	38	42	B	15.4	0.55	131	m156
Mid-Cape Connector NB (thru)	B	16.7	0.43	146	#525	C	30.1	0.34	108	#341
Mid-Cape Connector NB (right)	A	7.4	0.37	57	173	A	6.8	0.40	39	136
Mid-Cape Connector SB (left)	E	55.9	0.53	50	102	F	119.6	0.51	93	#217
Mid-Cape Connector SB (thru)	A	7.4	0.23	76	229	B	18.8	0.37	132	264
Mid-Cape Connector SB (thru)	A	7.4	0.23	76	229	B	18.8	0.37	132	264
16:: Cranberry Highway / Route 6 E NB Off-Ramp	**C**	**26.5**				**D**	**50.5**			
Cranberry Highway EB (left)	A	0.0	0.00	0	0	A	0.0	0.00	0	0
Cranberry Highway EB (thru)	B	10.9	0.32	134	160	C	21.5	0.15	40	m56
Cranberry Highway WB (thru/right)	A	9.7	0.27	78	204	E	71.8	1.01	488	#940
Route 6 E NB Off-Ramp (left/thru)	D	47.4	0.73	160	225	D	41.1	0.90	354	#559
Route 6 E NB Off-Ramp (right)	D	48.2	0.75	179	245	B	17.7	0.27	79	121
Sandwich Road Connector SB (left/right)	A	0.0	0.00	0	0	A	0.0	0.00	0	0

Table 3-1: Synchro and SIDRA Results Summary - 2050 Build Fall

Intersection	2050 Build Fall Weekday AM					2050 Build Fall Weekday PM				
	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
20:: Scenic Highway (Route 6) / Church Lane / Route 6 SB On-Ramp	**B**	**19.4**				**B**	**17.1**			
Scenic Hwy (Route 6) EB (left)	E	57.9	0.36	17	44	E	57.5	0.55	46	89
Scenic Hwy (Route 6) EB (thru)	C	27.1	0.30	86	188	C	21.2	0.59	200	#567
Scenic Hwy (Route 6) EB (thru/right)	C	27.1	0.30	86	188	C	21.2	0.59	200	#567
Scenic Hwy (Route 6) WB (left)	C	30.1	0.46	123	197	D	37.5	0.36	48	67
Scenic Hwy (Route 6) WB (left)	C	30.1	0.46	123	197	D	37.5	0.36	48	67
Scenic Hwy (Route 6) WB (thru)	B	13.4	0.78	261	#964	A	9.5	0.63	208	#663
Scenic Hwy (Route 6) WB (thru)	B	13.4	0.78	261	#964	A	9.5	0.63	208	#663
Scenic Hwy (Route 6) WB (thru/right)	B	13.4	0.78	261	#964	A	9.5	0.63	208	#663
Church Lane SB (left/thru/right)	E	58.4	0.70	111	172	E	57.0	0.63	82	137
21:: Scenic Highway (Route 6) & Route 3 SB Off-Ramp	**A**	**8.1**				**B**	**14.7**			
Scenic Hwy (Route 6) EB (thru)	A	3.3	0.18	8	83	B	14.3	0.53	94	247
Scenic Hwy (Route 6) EB (thru)	A	3.3	0.18	8	83	B	14.3	0.53	94	247
Scenic Hwy (Route 6) WB (thru)	B	10.5	0.5	57	m530	B	13.7	0.46	121	m375
Scenic Hwy (Route 6) WB (thru)	B	10.5	0.5	57	m530	B	13.7	0.46	121	m375
Scenic Hwy (Route 6) WB (thru)	B	10.5	0.5	57	m530	B	13.7	0.46	121	m375
Route 3 Off-Ramp SB (left)	E	57.0	0.53	53	99	E	56.3	0.74	166	236
Route 3 Off-Ramp SB (right)	A	1.2	0.52	0	0	A	0.5	0.33	0	0
22:: Meetinghouse Lane / State Road / Scenic Highway	**B**	**13.4**				**C**	**15.1**			
Scenic Highway EB (left)	A	6.8	0.28	-	32	C	17.6	0.74	-	266
Scenic Highway EB (left/right)	A	6.8	0.28	-	32	C	17.6	0.74	-	266
Meetinghouse Lane NB (left/thru)	C	20.3	0.80	-	381	C	19.2	0.65	-	116
State Rd SB (thru)	B	10.6	0.50	-	85	A	7.3	0.40	-	54
State Rd SB (right)	B	11.6	0.54	-	104	A	4.4	0.14	-	14
22:: Meetinghouse Lane / Canal Street	**A**	**7.9**				**A**	**9.8**			
Meetinghouse Lane WB (left/right)	A	9.9	0.46	-	75	A	4.6	0.10	-	10
Canal St NB (thru/right)	A	7.3	0.41	-	64	A	9.0	0.40	-	54
Meetinghouse Lane SB (thru/right)	A	6.9	0.43	-	74	B	10.7	0.65	-	180
23:: State Road / Route 3 NB Ramps	**F**	**176.8**				**C**	**24.1**			
Route 3 NB Off-Ramp (left)	C	21.3	0.08	6	31	C	28.4	0.73	117	#372
Route 3 NB Off-Ramp (right)	B	13.3	0.37	33	85	B	12.6	0.45	52	126
State Rd NB (left)	C	22.3	0.63	69	#204	C	27.8	0.67	80	#204
State Rd NB (left)	C	22.3	0.63	69	#204	C	27.8	0.67	80	#204
State Rd NB (thru)	A	6.9	0.18	21	108	B	17.7	0.73	163	#565
State Rd SB (thru/right)	F	385.8	1.78	~348	#850	D	40.9	0.82	102	#336
24:: Cranberry Highway / Adams Street	**A**	**1.7**				**A**	**1.7**			
Cranberry Highway EB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Cranberry Highway WB (left)	A	8.9	0.01	-	0	A	7.9	0.01	-	0
Cranberry Highway WB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Adams Street NB (left/thru/right)	C	20.4	0.16	-	13	C	23.5	0.18	-	9
Adams Street SB (left/thru/right)	C	15.9	0.12	-	10	B	17.6	0.12	-	7
25:: Sandwich Road / Adams Street	**A**	**0.3**				**A**	**0.8**			
Sandwich Rd EB (thru/right)	A	0.0	0.24	-	0	A	0.0	0.16	-	0
Sandwich Rd WB (left/thru)	A	0.5	0.02	-	13	A	0.9	0.02	-	25
39:: Belmont Circle	**F**	**146.4**				**F**	**273.2**			
Buzzards Bay Bypass (Route 6) EB (left/thru/right)	C	18.5	0.63	-	99	A	8.5	0.28	-	21
Main Street (Route 6) WB (left/thru/right)	D	25.7	0.77	-	181	C	18.3	0.66	-	117
Main Street (Route 6) WB (right)	D	26.0	0.77	-	177	A	7.7	0.19	-	13
Old Bridge Road NB (left/thru/right)	A	8.9	0.01	-	1	A	7.8	0.01	-	1
Route 28/25 Ramps SB (left/thru/right)	F	186.5	1.35	-	2436	F	537.4	2.15	-	7068
Main Street NEB (left/thru/right)	F	282.4	1.57	-	3370	F	148.0	1.27	-	2710
Head of the Bay Road SEB (left/thru/right)	F	126.9	1.18	-	989	B	12.6	0.44	-	47
40:: Sandwich Road / Veterans Way	**A**	**2.1**				**A**	**0.5**			
Sandwich Road EB (thru/right)	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Sandwich Road WB (left/thru)	A	7.8	0.03	-	3	A	7.4	0.02	-	3
Veterans Way NB (left/right)	B	10.8	0.16	-	15	B	11.0	0.03	-	3
41:: Sandwich Road / Sandwich Road Connector	**D**	**37.7**				**B**	**14.4**			
Sandwich Road EB (thru/right)	D	46.2	0.77	230	202	A	3.2	0.21	6	182
Sandwich Road WB (left/thru)	C	34.6	0.60	196	220	A	9.1	0.57	181	491
Sandwich Road WB (thru)	C	34.6	0.60	196	220	A	9.1	0.57	181	491
Sandwich Road Connector NB (left)	B	11.8	0.03	8	34	D	49.9	0.68	104	151
Sandwich Road Connector NB (left/right)	B	11.8	0.03	8	34	D	49.9	0.68	104	151

~ : Volume exceeds capacity
$: Delay exceeds 300s
: 95th percentile volume exceeds capacity, queue may be longer
Err : Error

Attachment 2 – Representative MOVES Runspec

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File Edit Action Post Processing Tools Settings Help

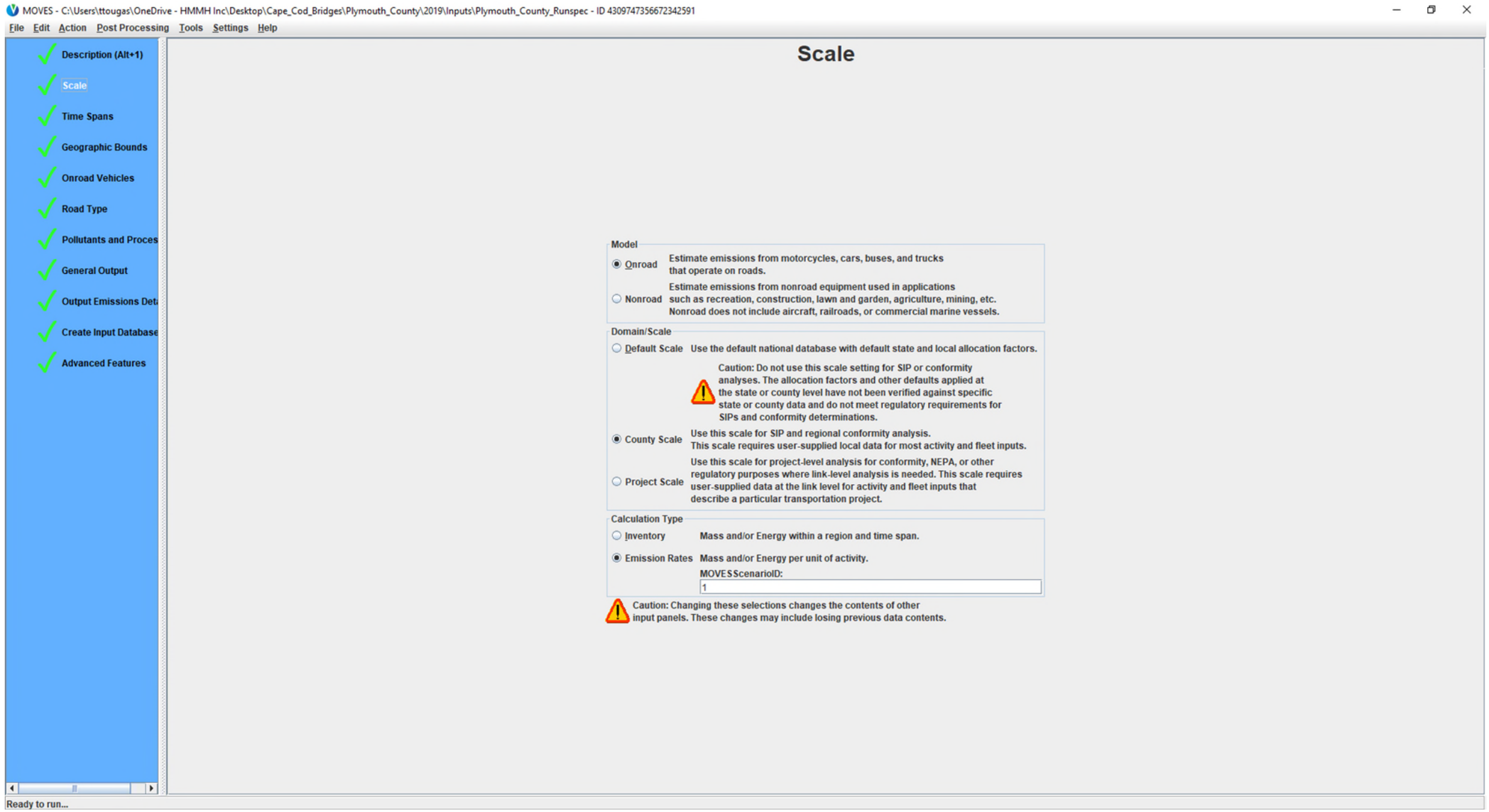
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- Scale
- Time Spans
- Geographic Bounds
- Onroad Vehicles
- Road Type
- Pollutants and Proces
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- Create Input Database
- Advanced Features

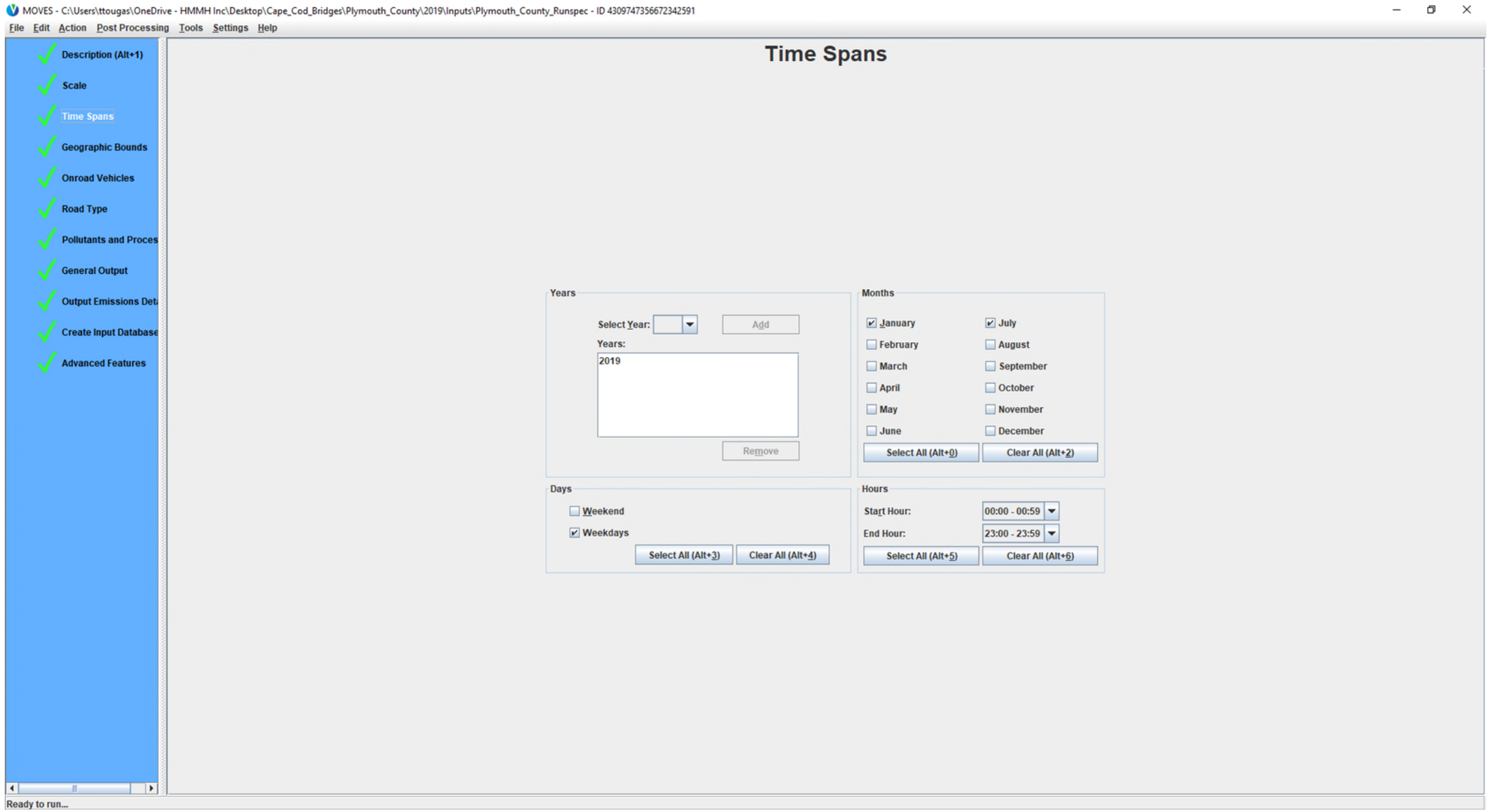
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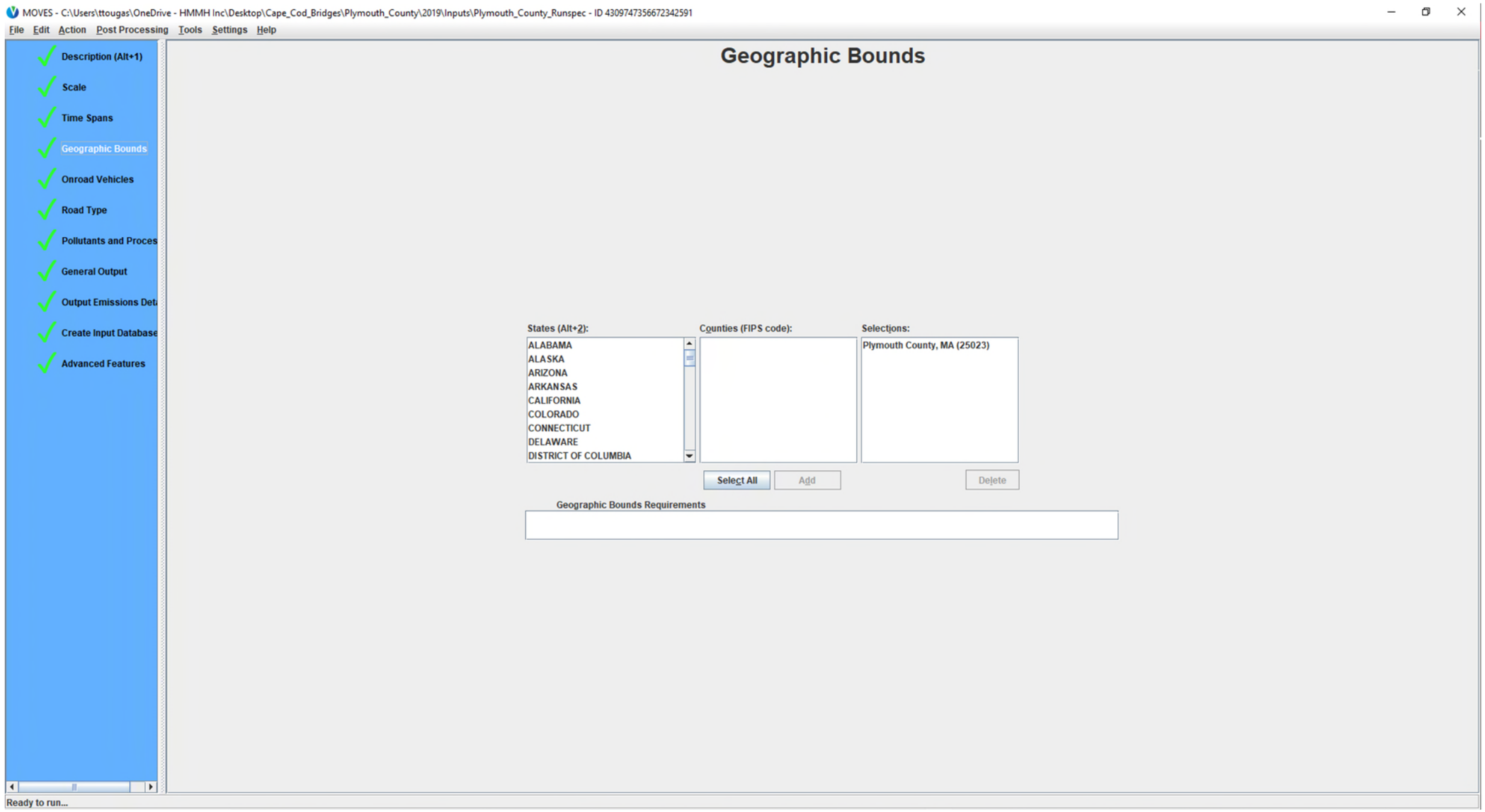
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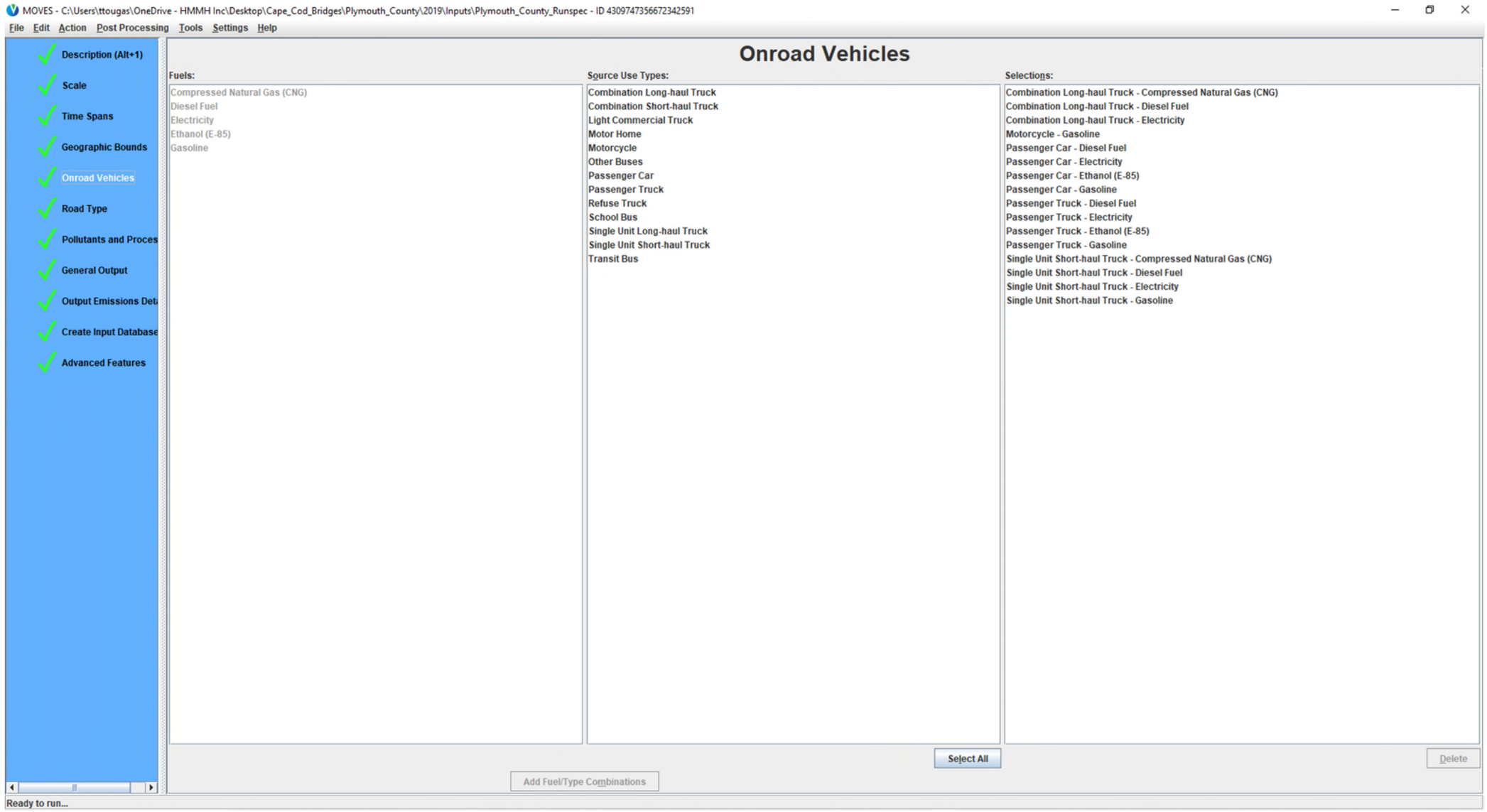
Plymouth County Bourne Bridges 2019 Runspec

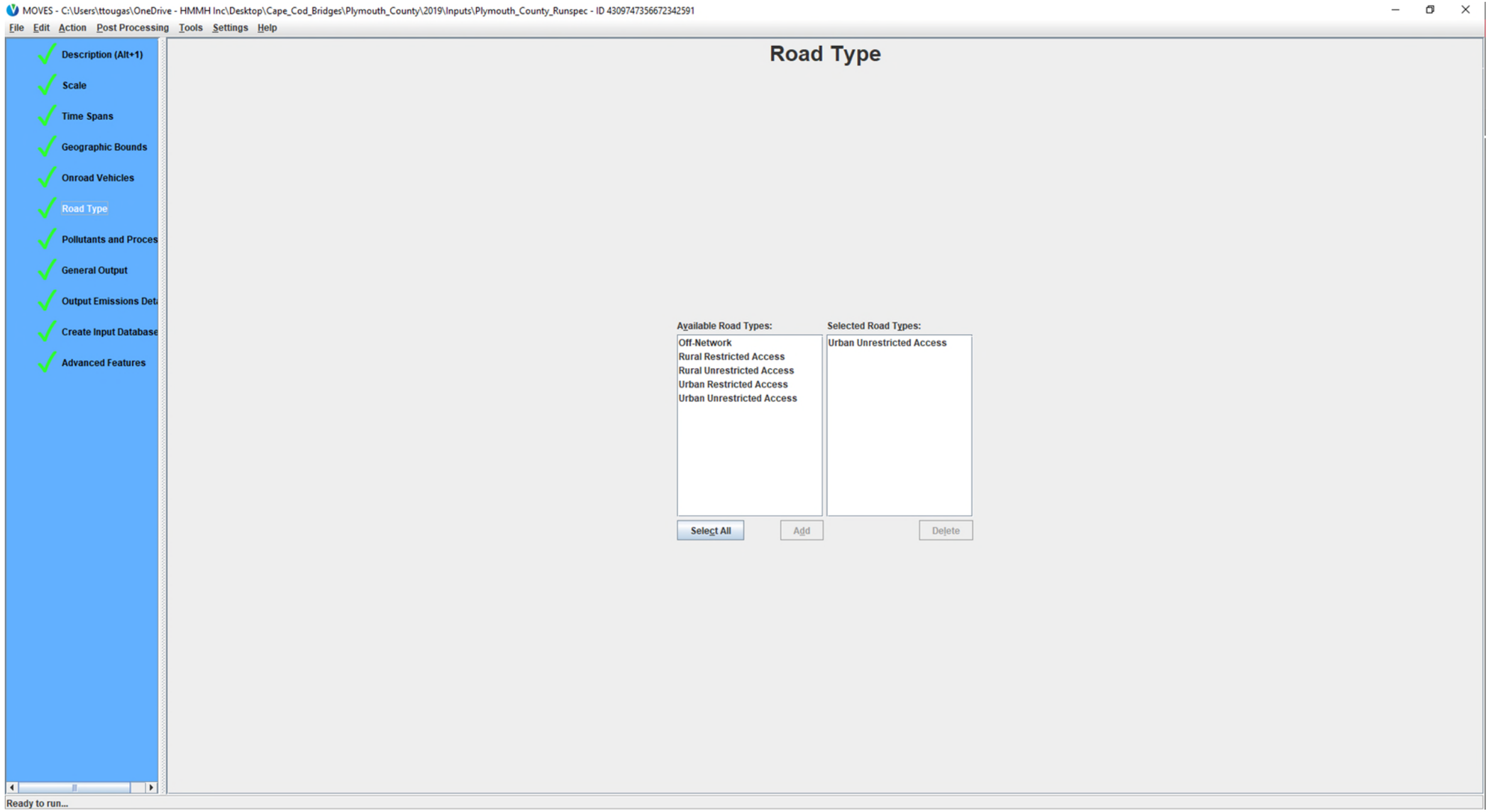
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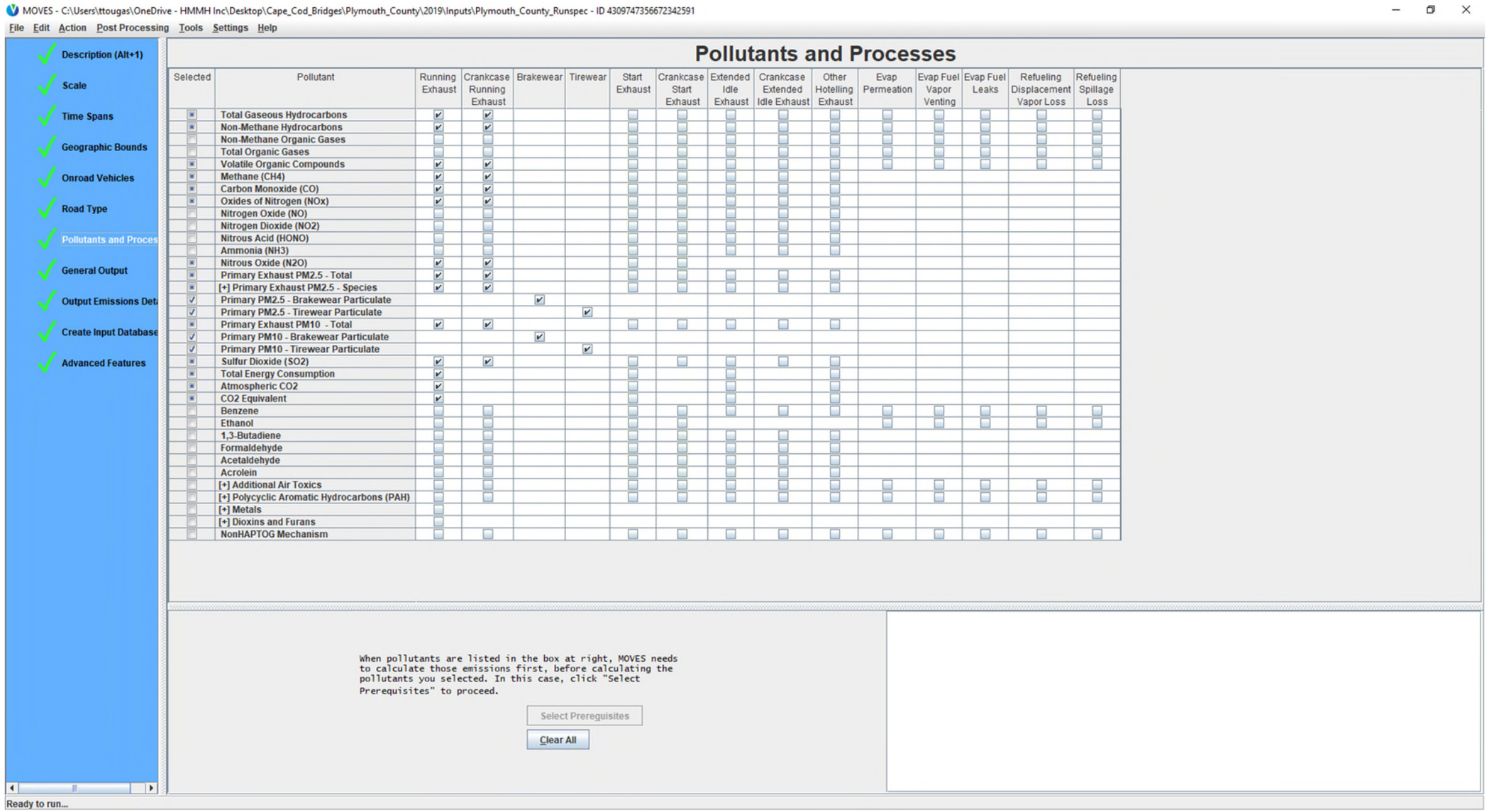

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Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
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Create Input Database
Advanced Features
Scale
Model
Onroad
Estimate emissions from motorcycles, cars, buses, and trucks that operate on roads.
Nonroad
Estimate emissions from nonroad equipment used in applications such as recreation, construction, lawn and garden, agriculture, mining, etc. Nonroad does not include aircraft, railroads, or commercial marine vessels.
Domain/Scale
Default Scale
Use the default national database with default state and local allocation factors.
Caution: Do not use this scale setting for SIP or conformity analyses. The allocation factors and other defaults applied at the state or county level have not been verified against specific state or county data and do not meet regulatory requirements for SIPs and conformity determinations.
County Scale
Use this scale for SIP and regional conformity analysis. This scale requires user-supplied local data for most activity and fleet inputs.
Project Scale
Use this scale for project-level analysis for conformity, NEPA, or other regulatory purposes where link-level analysis is needed. This scale requires user-supplied data at the link level for activity and fleet inputs that describe a particular transportation project.
Calculation Type
Inventory
Mass and/or Energy within a region and time span.
Emission Rates
Mass and/or Energy per unit of activity.
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Ready to run...

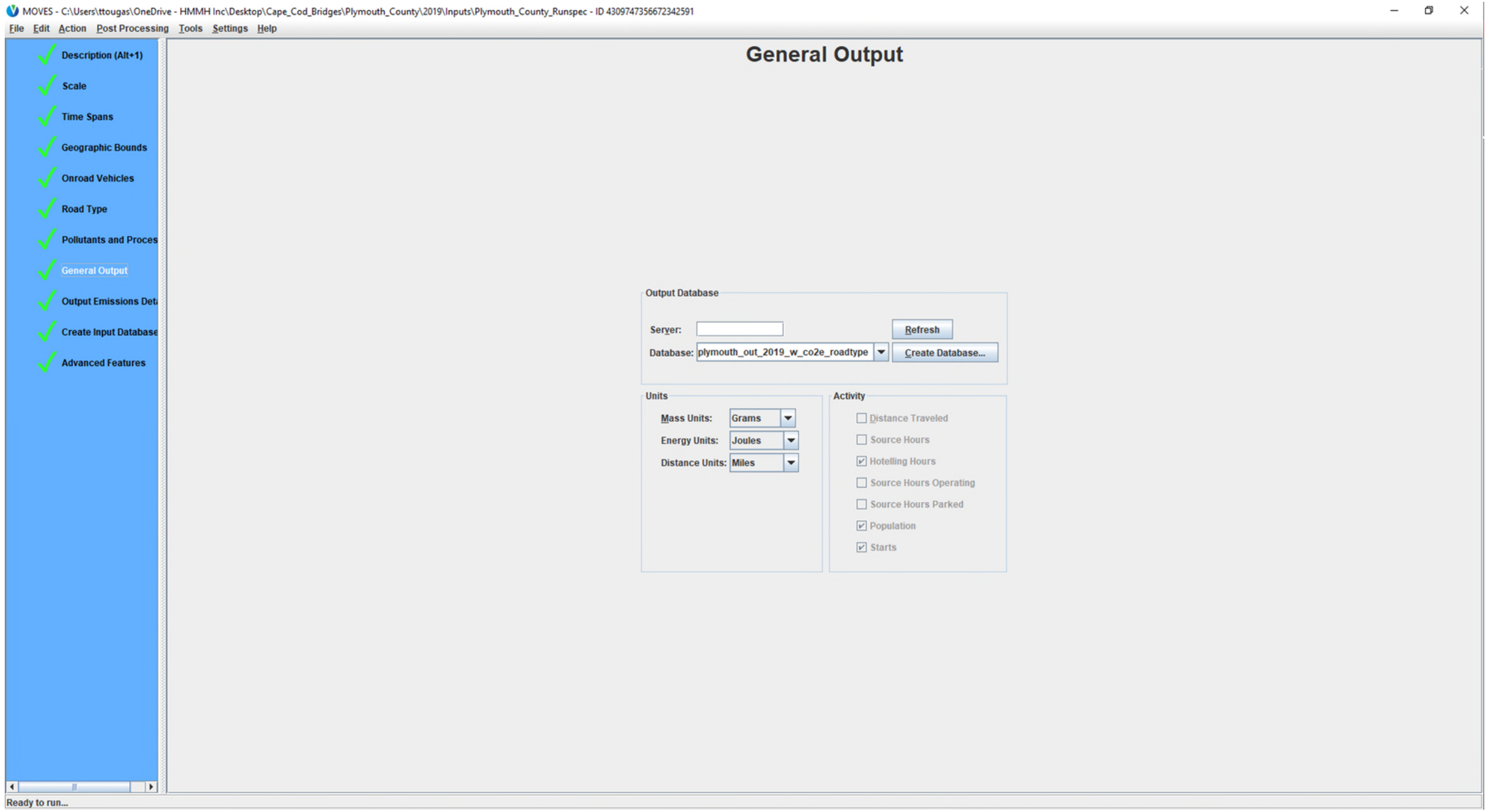

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Time Spans
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Onroad Vehicles
Road Type
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November
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Days
Weekend
Weekdays
Select All (Alt+3)
Clear All (Alt+4)
Hours
Start Hour:
00:00 - 00:59
End Hour:
23:00 - 23:59
Select All (Alt+5)
Clear All (Alt+6)
Ready to run...

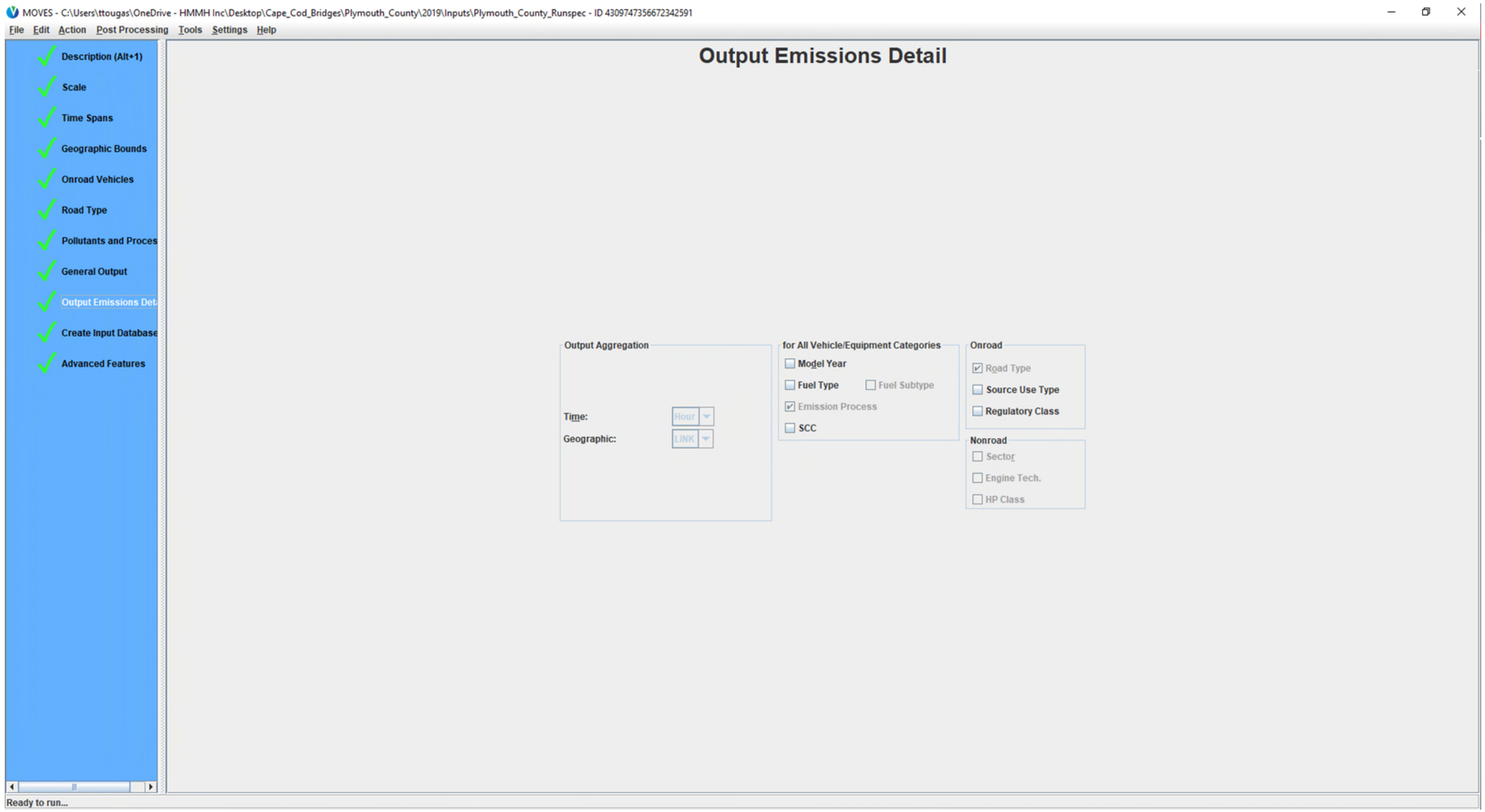

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Plymouth_County\2019\Inputs\Plymouth_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Geographic Bounds
States (Alt+2):
ALABAMA
ALASKA
ARIZONA
ARKANSAS
CALIFORNIA
COLORADO
CONNECTICUT
DELAWARE
DISTRICT OF COLUMBIA
Counties (FIPS code):
Selections:
Plymouth County, MA (25023)
Select All
Add
Delete
Geographic Bounds Requirements
Ready to run...

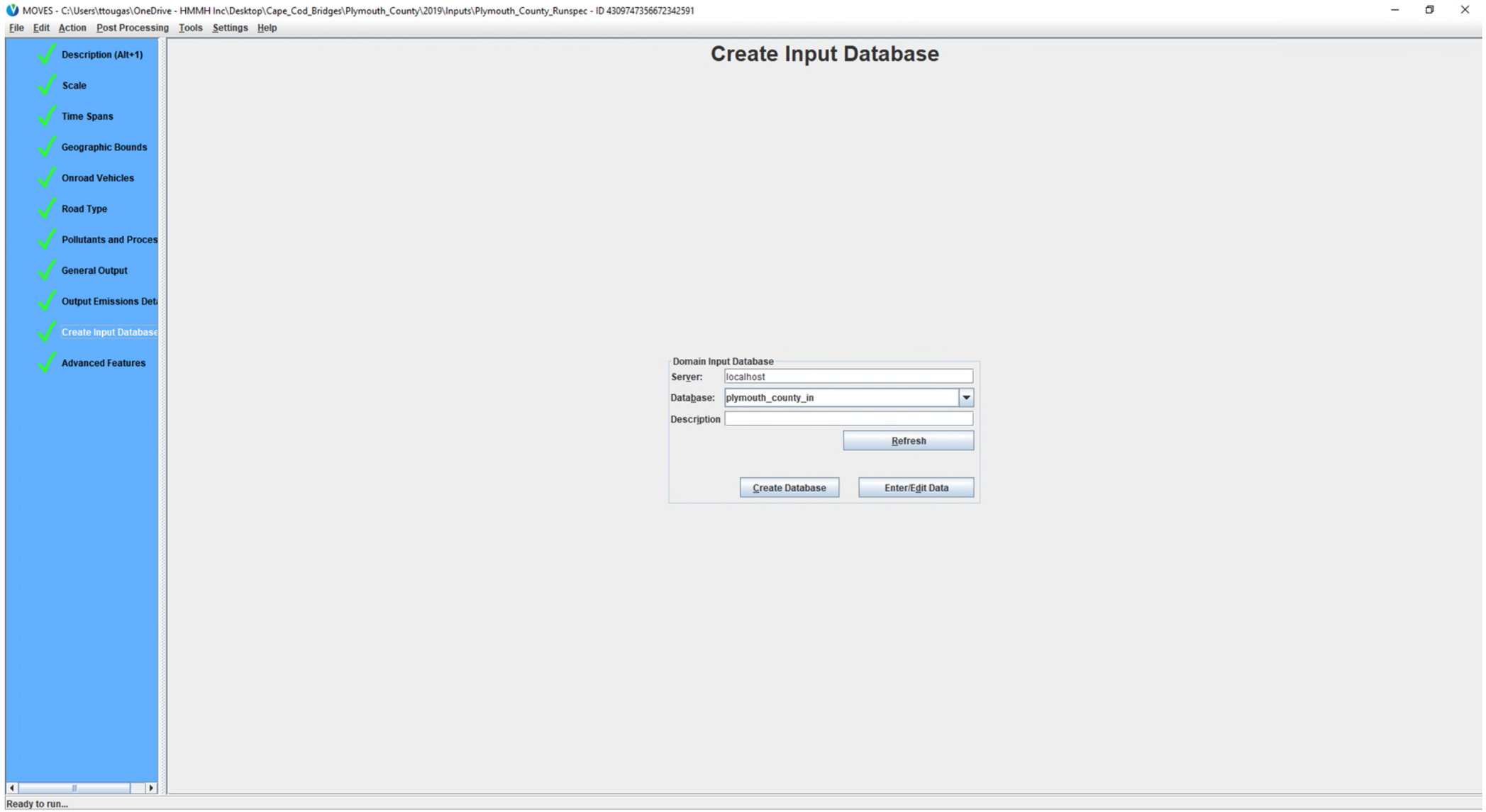

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Plymouth_County\2019\Inputs\Plymouth_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Onroad Vehicles
Fuels:
Compressed Natural Gas (CNG)
Diesel Fuel
Electricity
Ethanol (E-85)
Gasoline
Source Use Types:
Combination Long-haul Truck
Combination Short-haul Truck
Light Commercial Truck
Motor Home
Motorcycle
Other Buses
Passenger Car
Passenger Truck
Refuse Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus
Selections:
Combination Long-haul Truck - Compressed Natural Gas (CNG)
Combination Long-haul Truck - Diesel Fuel
Combination Long-haul Truck - Electricity
Motorcycle - Gasoline
Passenger Car - Diesel Fuel
Passenger Car - Electricity
Passenger Car - Ethanol (E-85)
Passenger Car - Gasoline
Passenger Truck - Diesel Fuel
Passenger Truck - Electricity
Passenger Truck - Ethanol (E-85)
Passenger Truck - Gasoline
Single Unit Short-haul Truck - Compressed Natural Gas (CNG)
Single Unit Short-haul Truck - Diesel Fuel
Single Unit Short-haul Truck - Electricity
Single Unit Short-haul Truck - Gasoline
Select All
Delete
Add Fuel/Type Combinations
Ready to run...

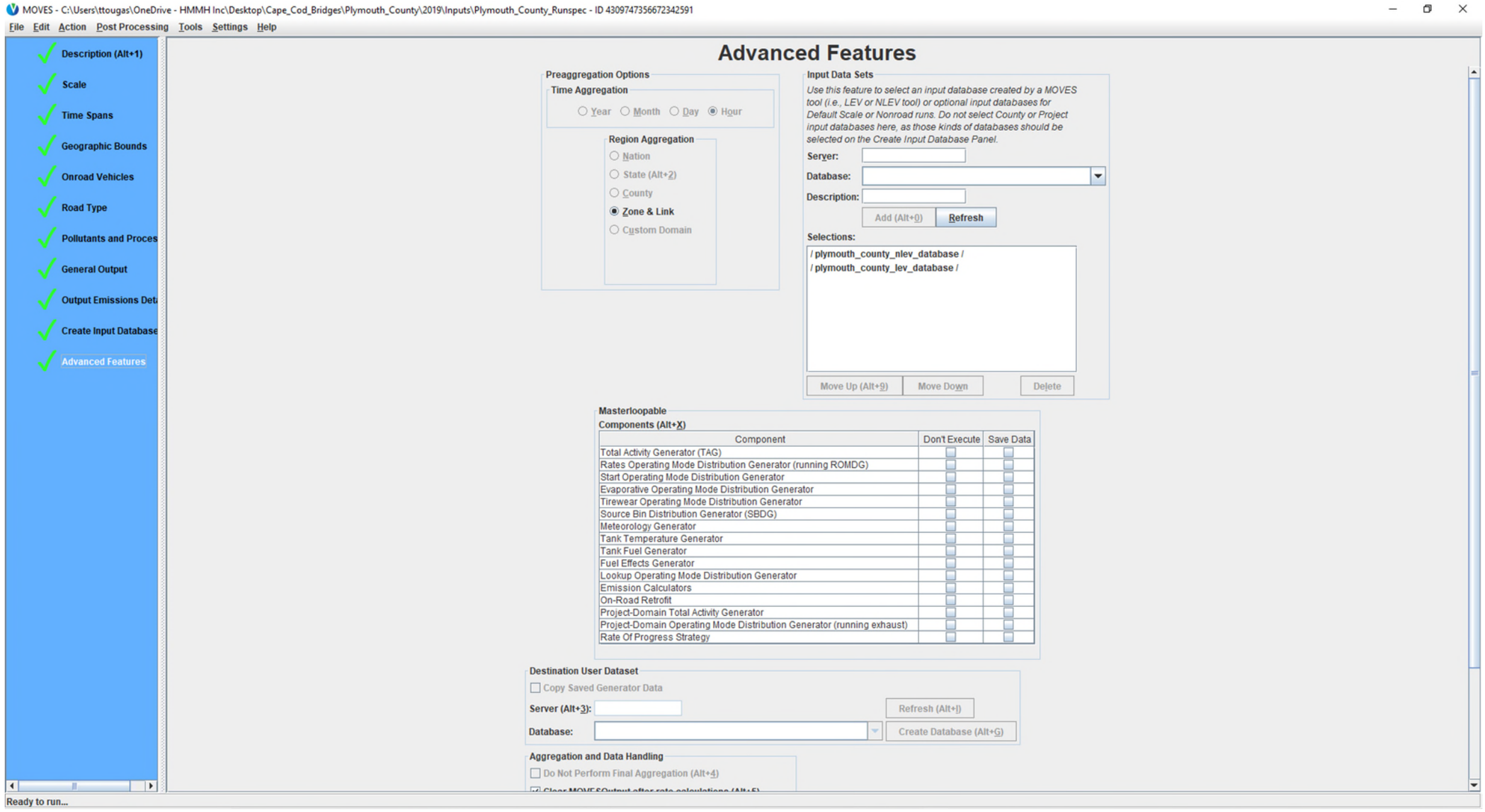

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Plymouth_County\2019\Inputs\Plymouth_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Road Type
Available Road Types:
Off-Network
Rural Restricted Access
Rural Unrestricted Access
Urban Restricted Access
Urban Unrestricted Access
Selected Road Types:
Urban Unrestricted Access
Select All
Add
Delete
Ready to run...

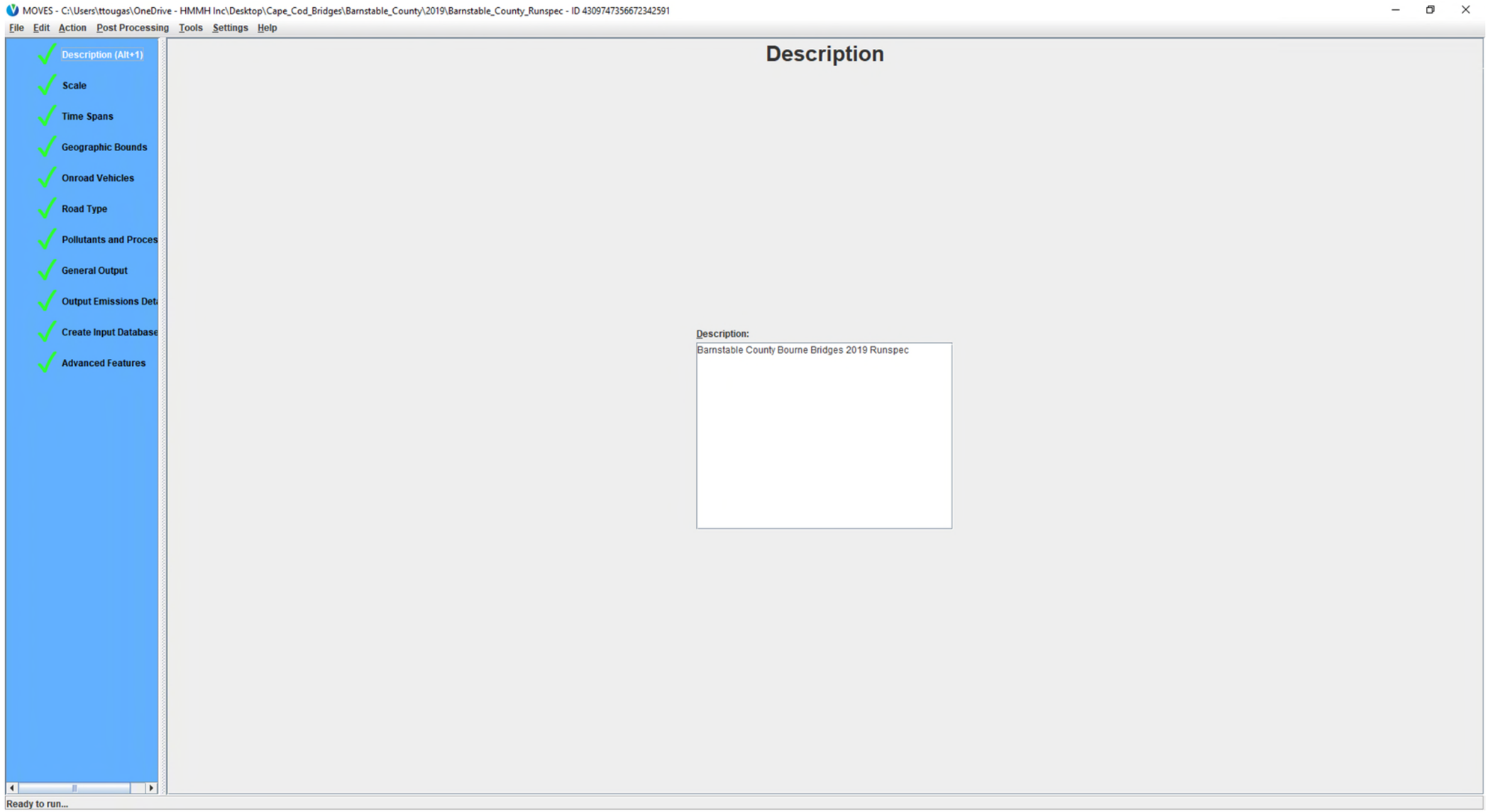

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Plymouth_County\2019\Inputs\Plymouth_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Pollutants and Processes
Selected
Pollutant
Running Exhaust
Crankcase Running Exhaust
Brakewear
Tirewear
Start Exhaust
Crankcase Start Exhaust
Extended Idle Exhaust
Crankcase Extended Idle Exhaust
Other Hotelling Exhaust
Evap Permeation
Evap Fuel Vapor Venting
Evap Fuel Leaks
Refueling Displacement Vapor Loss
Refueling Spillage Loss
Total Gaseous Hydrocarbons
Non-Methane Hydrocarbons
Non-Methane Organic Gases
Total Organic Gases
Volatile Organic Compounds
Methane (CH4)
Carbon Monoxide (CO)
Oxides of Nitrogen (NOx)
Nitrogen Oxide (NO)
Nitrogen Dioxide (NO2)
Nitrous Acid (HONO)
Ammonia (NH3)
Nitrous Oxide (N2O)
Primary Exhaust PM2.5 - Total
[+] Primary Exhaust PM2.5 - Species
Primary PM2.5 - Brakewear Particulate
Primary PM2.5 - Tirewear Particulate
Primary Exhaust PM10 - Total
Primary PM10 - Brakewear Particulate
Primary PM10 - Tirewear Particulate
Sulfur Dioxide (SO2)
Total Energy Consumption
Atmospheric CO2
CO2 Equivalent
Benzene
Ethanol
1,3-Butadiene
Formaldehyde
Acetaldehyde
Acrolein
[+] Additional Air Toxics
[+] Polycyclic Aromatic Hydrocarbons (PAH)
[+] Metals
[+] Dioxins and Furans
NonHAPTOG Mechanism
When pollutants are listed in the box at right, MOVES needs to calculate those emissions first, before calculating the pollutants you selected. In this case, click "Select Prerequisites" to proceed.
Select Prerequisites
Clear All
Ready to run...

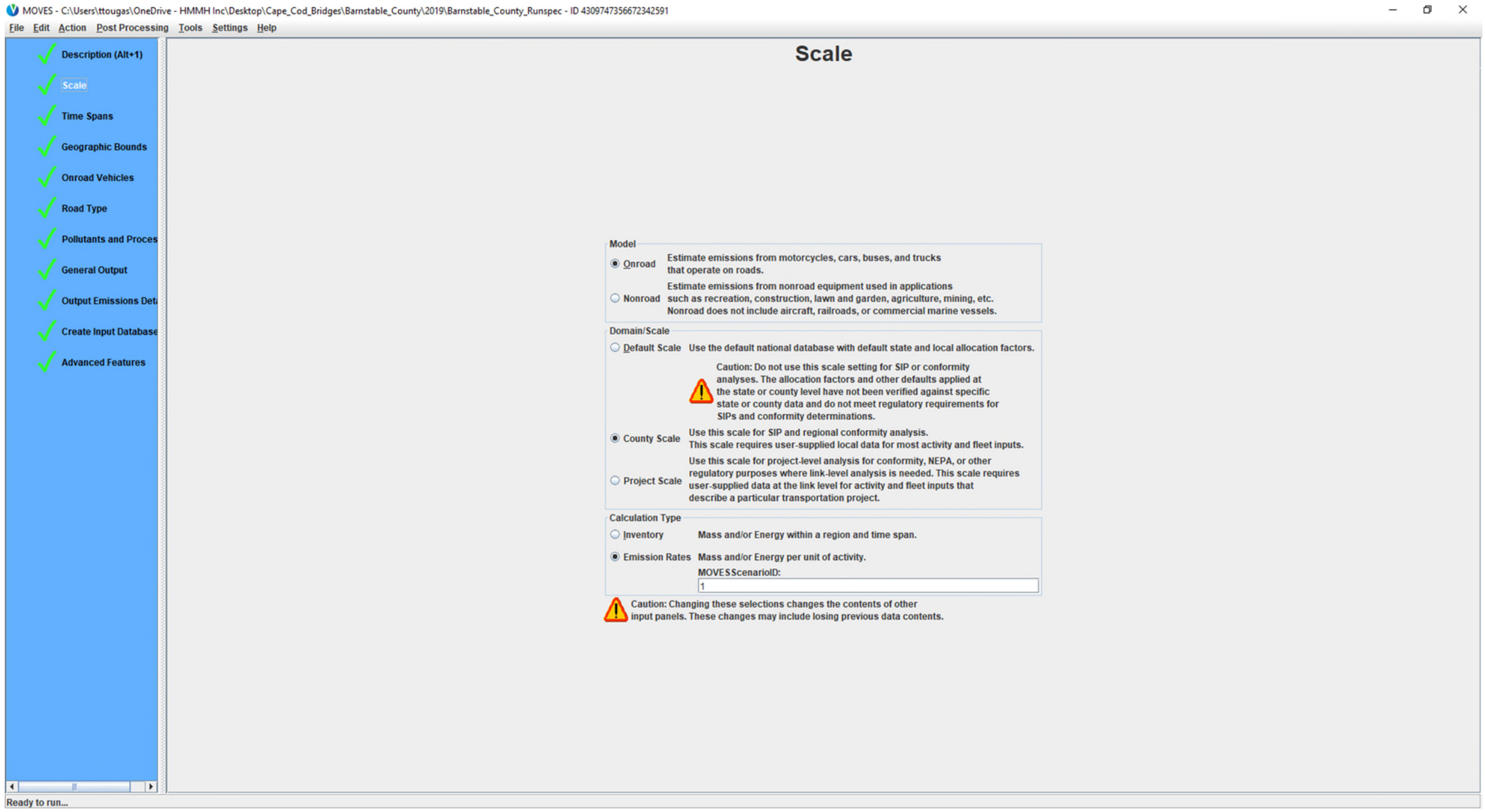

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Plymouth_County\2019\Inputs\Plymouth_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
General Output
Output Database
Server:
Refresh
Database: plymouth_out_2019_w_co2e_roadtype
Create Database...
Units
Mass Units: Grams
Energy Units: Joules
Distance Units: Miles
Activity
Distance Traveled
Source Hours
Hotelling Hours
Source Hours Operating
Source Hours Parked
Population
Starts
Ready to run...

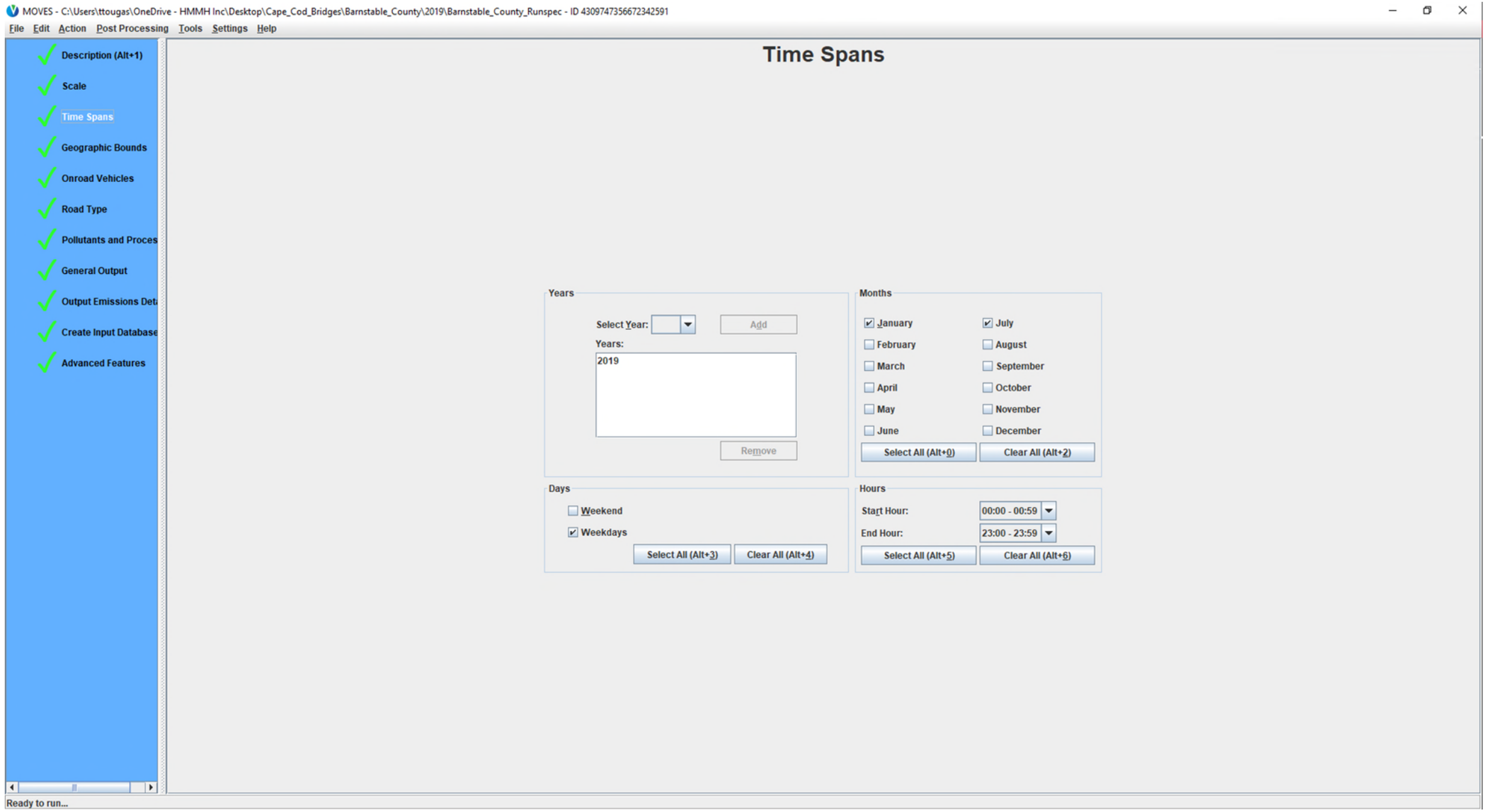

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Plymouth_County\2019\Inputs\Plymouth_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Det
Create Input Database
Advanced Features
Output Emissions Detail
Output Aggregation
Time:
Hour
Geographic:
LINK
for All Vehicle/Equipment Categories
Model Year
Fuel Type
Fuel Subtype
Emission Process
SCC
Onroad
Road Type
Source Use Type
Regulatory Class
Nonroad
Sector
Engine Tech.
HP Class
Ready to run...

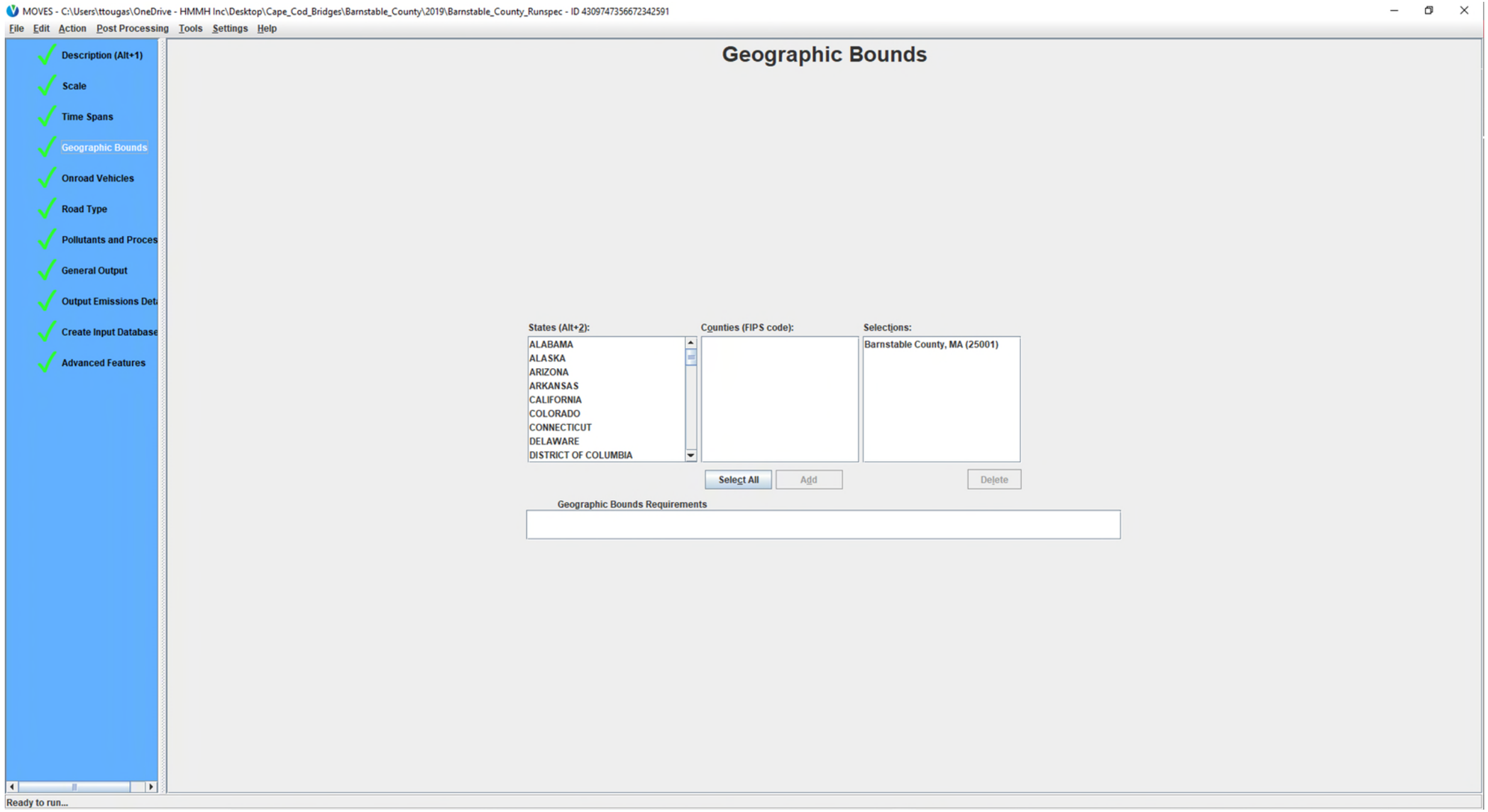

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Plymouth_County\2019\Inputs\Plymouth_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Create Input Database
Domain Input Database
Server: localhost
Database: plymouth_county_in
Description
Refresh
Create Database
Enter/Edit Data
Ready to run...

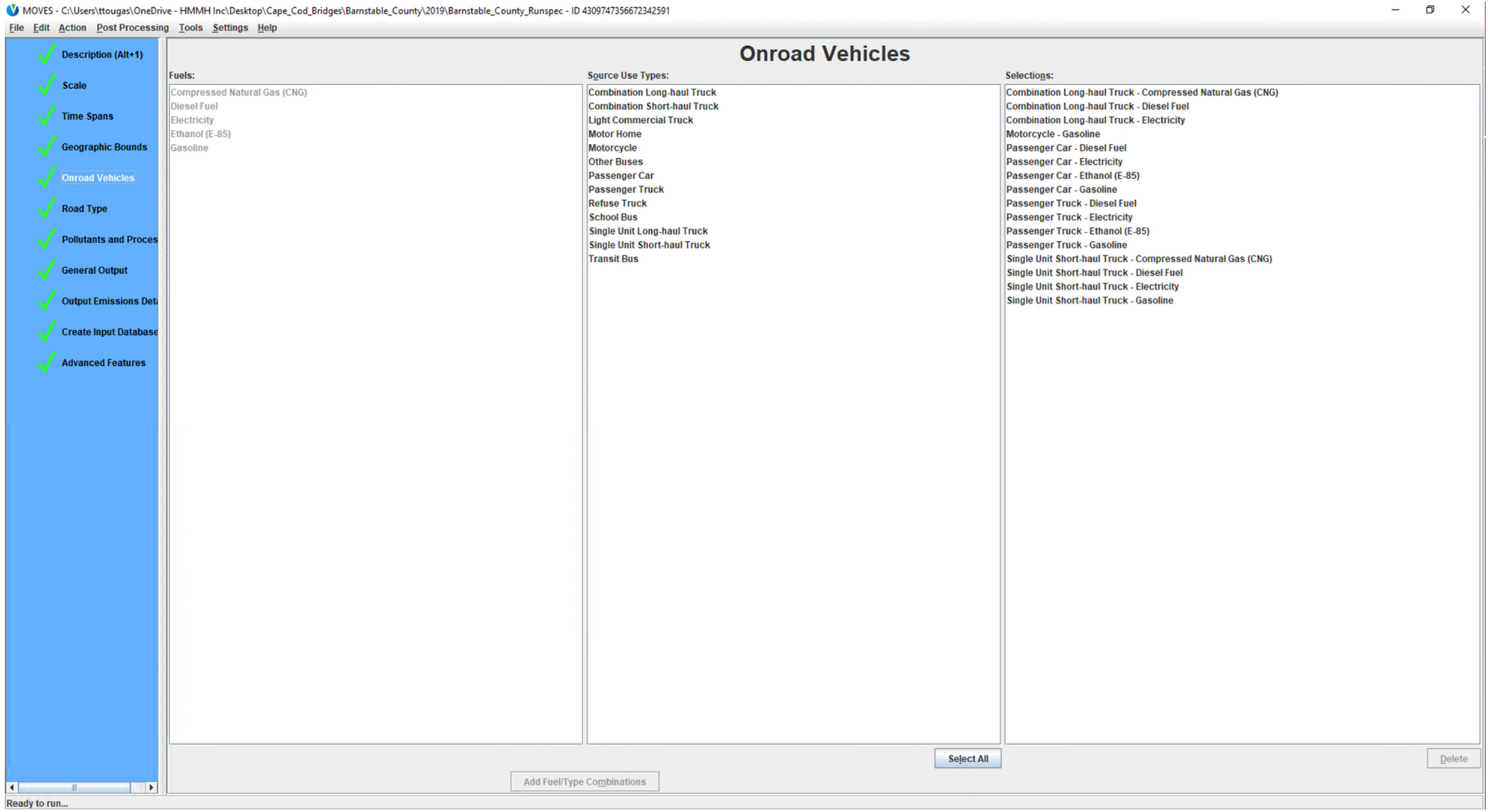

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Plymouth_County\2019\Inputs\Plymouth_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Advanced Features
Preaggregation Options
Time Aggregation
Year Month Day Hour
Region Aggregation
Nation
State (Alt+2)
County
Zone & Link
Custom Domain
Input Data Sets
Use this feature to select an input database created by a MOVES tool (i.e., LEV or NLEV tool) or optional input databases for Default Scale or Nonroad runs. Do not select County or Project input databases here, as those kinds of databases should be selected on the Create Input Database Panel.
Server:
Database:
Description:
Add (Alt+0)
Refresh
Selections:
/ plymouth_county_nlev_database /
/ plymouth_county_lev_database /
Move Up (Alt+9)
Move Down
Delete
Masterloopable
Components (Alt+X)
Component
Don't Execute
Save Data
Total Activity Generator (TAG)
Rates Operating Mode Distribution Generator (running ROMDG)
Start Operating Mode Distribution Generator
Evaporative Operating Mode Distribution Generator
Tirewear Operating Mode Distribution Generator
Source Bin Distribution Generator (SBDG)
Meteorology Generator
Tank Temperature Generator
Tank Fuel Generator
Fuel Effects Generator
Lookup Operating Mode Distribution Generator
Emission Calculators
On-Road Retrofit
Project-Domain Total Activity Generator
Project-Domain Operating Mode Distribution Generator (running exhaust)
Rate Of Progress Strategy
Destination User Dataset
Copy Saved Generator Data
Server (Alt+3):
Refresh (Alt+I)
Database:
Create Database (Alt+G)
Aggregation and Data Handling
Do Not Perform Final Aggregation (Alt+4)
Ready to run...

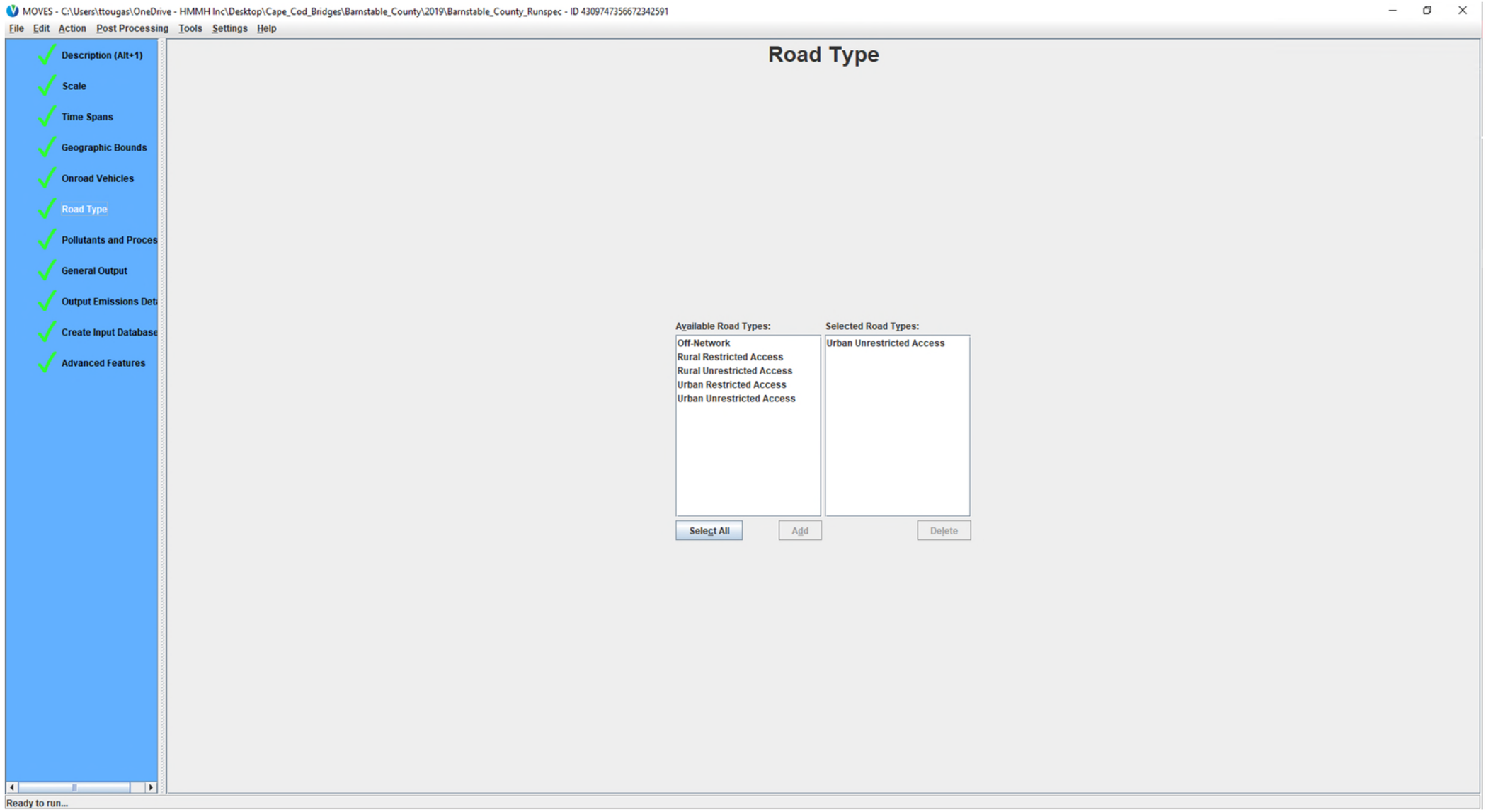

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Description
Description:
Barnstable County Bourne Bridges 2019 Runspec
Ready to run...

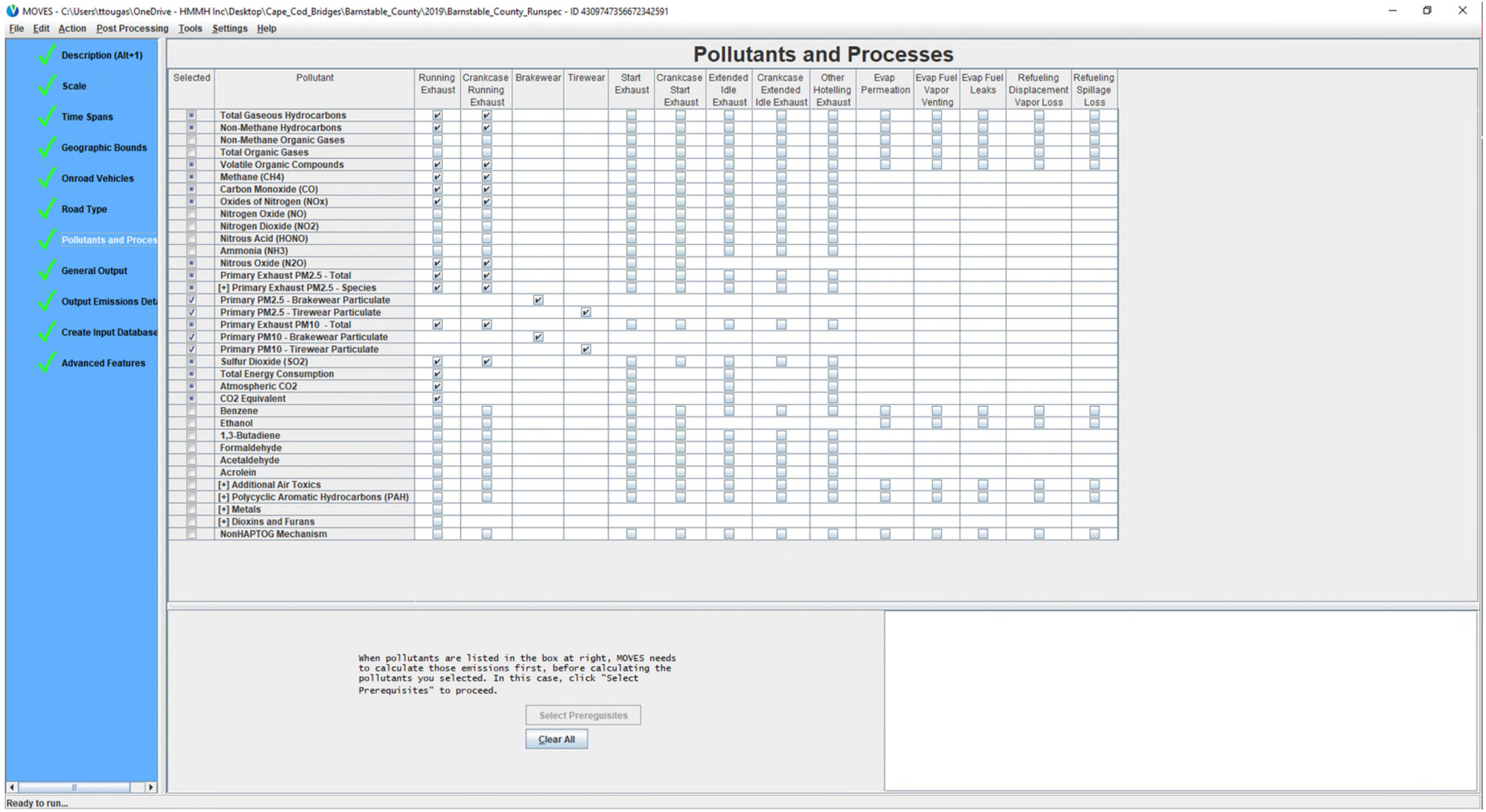

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Scale
Model
Onroad
Estimate emissions from motorcycles, cars, buses, and trucks that operate on roads.
Nonroad
Estimate emissions from nonroad equipment used in applications such as recreation, construction, lawn and garden, agriculture, mining, etc. Nonroad does not include aircraft, railroads, or commercial marine vessels.
Domain/Scale
Default Scale
Use the default national database with default state and local allocation factors.
Caution: Do not use this scale setting for SIP or conformity analyses. The allocation factors and other defaults applied at the state or county level have not been verified against specific state or county data and do not meet regulatory requirements for SIPs and conformity determinations.
County Scale
Use this scale for SIP and regional conformity analysis. This scale requires user-supplied local data for most activity and fleet inputs.
Project Scale
Use this scale for project-level analysis for conformity, NEPA, or other regulatory purposes where link-level analysis is needed. This scale requires user-supplied data at the link level for activity and fleet inputs that describe a particular transportation project.
Calculation Type
Inventory
Mass and/or Energy within a region and time span.
Emission Rates
Mass and/or Energy per unit of activity.
MOVESScenarioID:
1
Caution: Changing these selections changes the contents of other input panels. These changes may include losing previous data contents.
Ready to run...

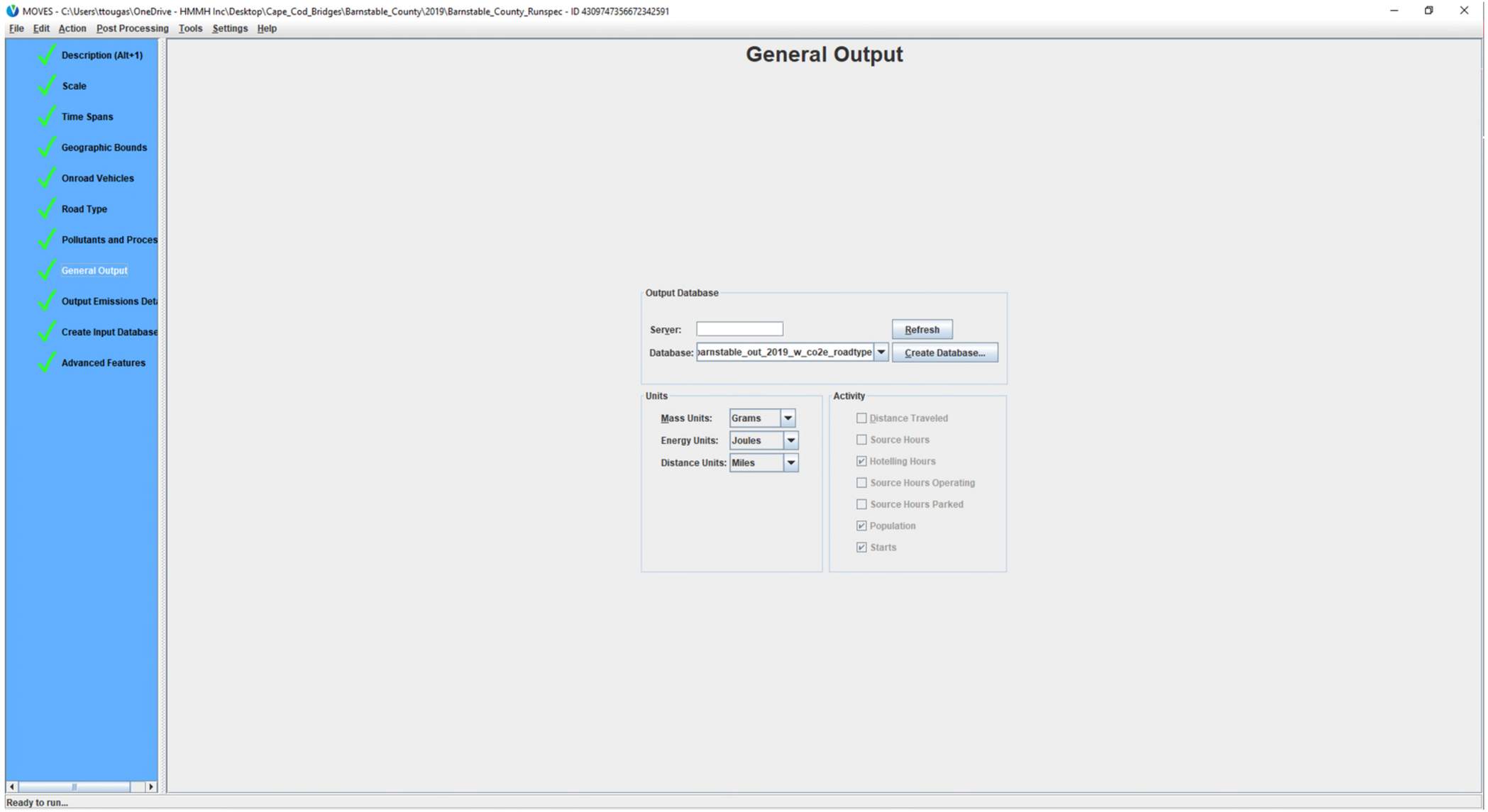

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Time Spans
Years
Select Year:
Add
Years:
2019
Remove
Months
January
February
March
April
May
June
July
August
September
October
November
December
Select All (Alt+0)
Clear All (Alt+2)
Days
Weekend
Weekdays
Select All (Alt+3)
Clear All (Alt+4)
Hours
Start Hour:
00:00 - 00:59
End Hour:
23:00 - 23:59
Select All (Alt+5)
Clear All (Alt+6)
Ready to run...

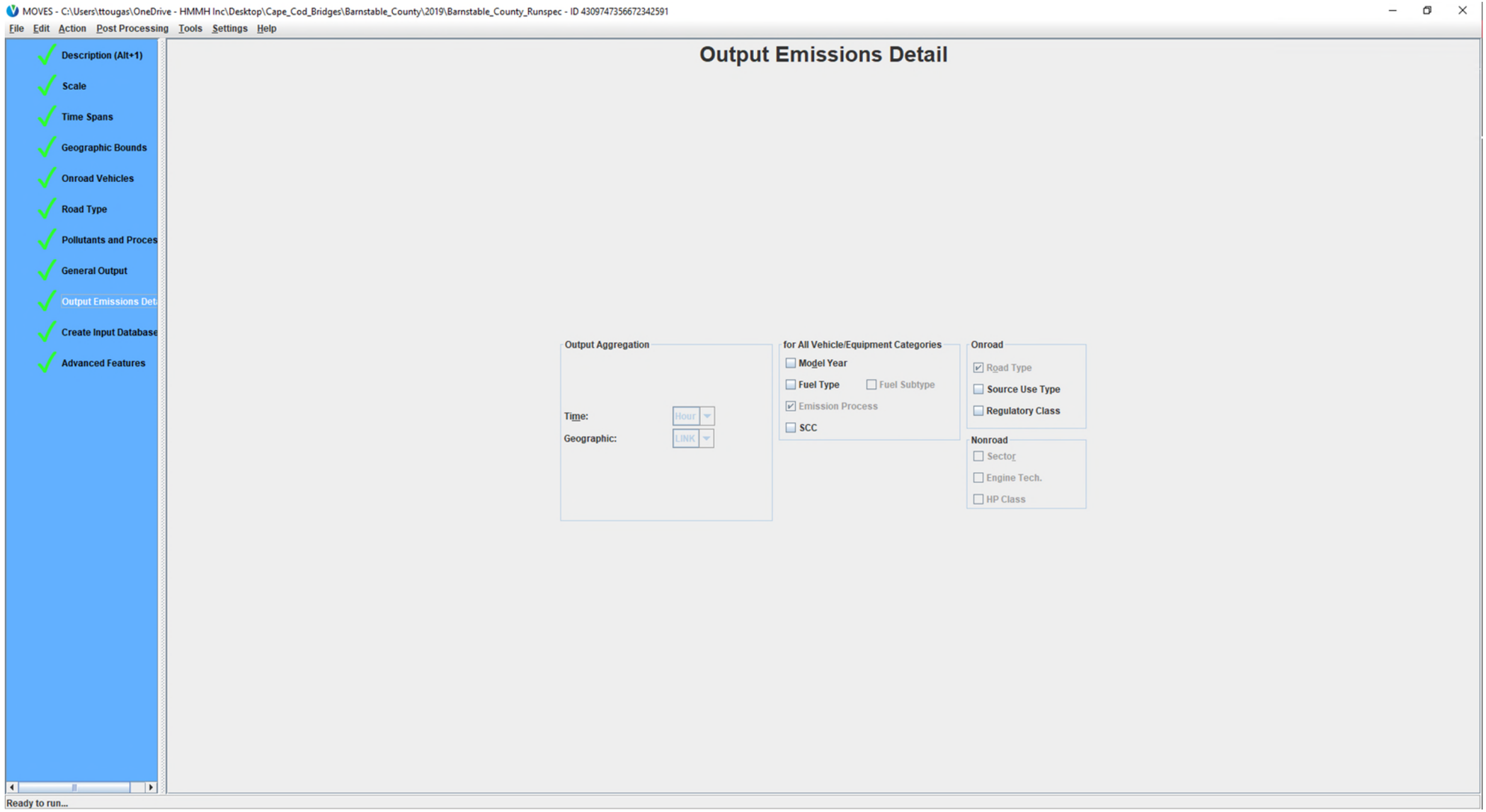

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Geographic Bounds
States (Alt+2):
ALABAMA
ALASKA
ARIZONA
ARKANSAS
CALIFORNIA
COLORADO
CONNECTICUT
DELAWARE
DISTRICT OF COLUMBIA
Counties (FIPS code):
Selections:
Barnstable County, MA (25001)
Select All
Add
Delete
Geographic Bounds Requirements
Ready to run...

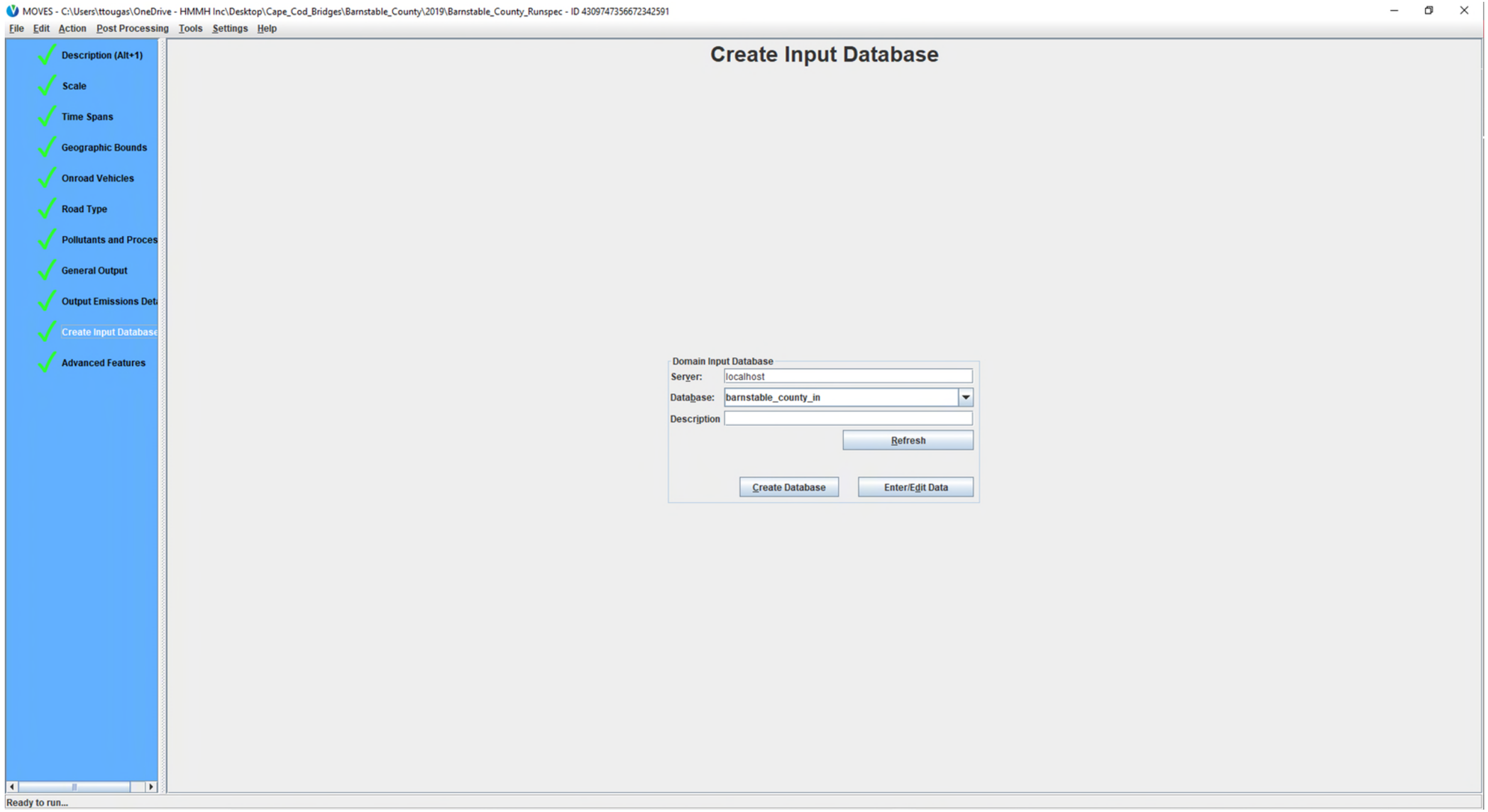

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Onroad Vehicles
Fuels:
Compressed Natural Gas (CNG)
Diesel Fuel
Electricity
Ethanol (E-85)
Gasoline
Source Use Types:
Combination Long-haul Truck
Combination Short-haul Truck
Light Commercial Truck
Motor Home
Motorcycle
Other Buses
Passenger Car
Passenger Truck
Refuse Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus
Selections:
Combination Long-haul Truck - Compressed Natural Gas (CNG)
Combination Long-haul Truck - Diesel Fuel
Combination Long-haul Truck - Electricity
Motorcycle - Gasoline
Passenger Car - Diesel Fuel
Passenger Car - Electricity
Passenger Car - Ethanol (E-85)
Passenger Car - Gasoline
Passenger Truck - Diesel Fuel
Passenger Truck - Electricity
Passenger Truck - Ethanol (E-85)
Passenger Truck - Gasoline
Single Unit Short-haul Truck - Compressed Natural Gas (CNG)
Single Unit Short-haul Truck - Diesel Fuel
Single Unit Short-haul Truck - Electricity
Single Unit Short-haul Truck - Gasoline
Select All
Delete
Add Fuel/Type Combinations
Ready to run...

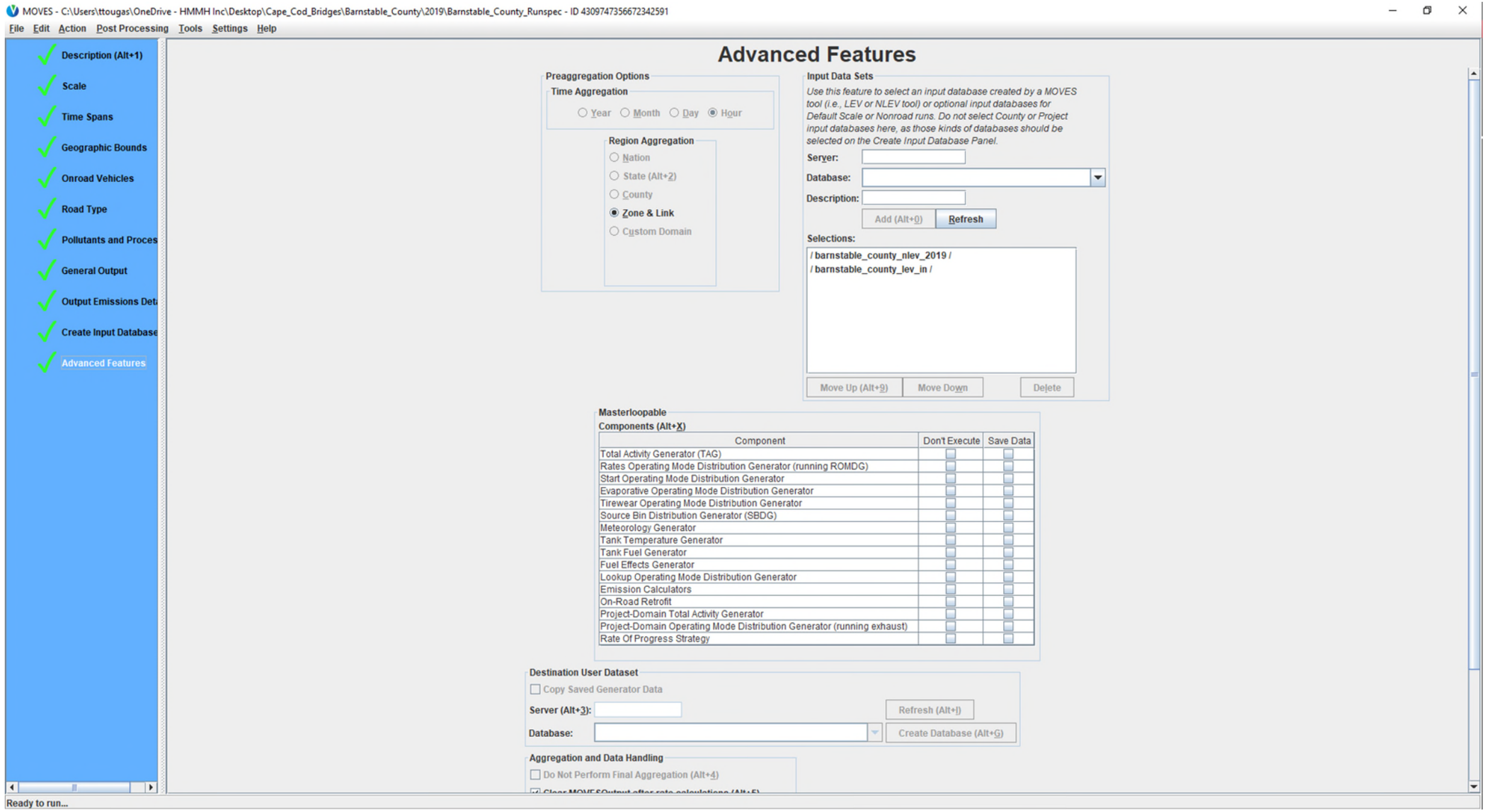

MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Road Type
Available Road Types:
Off-Network
Rural Restricted Access
Rural Unrestricted Access
Urban Restricted Access
Urban Unrestricted Access
Selected Road Types:
Urban Unrestricted Access
Select All
Add
Delete
Ready to run...


MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Pollutants and Processes
Selected
Pollutant
Running Exhaust
Crankcase Running Exhaust
Brakewear
Tirewear
Start Exhaust
Crankcase Start Exhaust
Extended Idle Exhaust
Crankcase Extended Idle Exhaust
Other Hotelling Exhaust
Evap Permeation
Evap Fuel Vapor Venting
Evap Fuel Leaks
Refueling Displacement Vapor Loss
Refueling Spillage Loss
Total Gaseous Hydrocarbons
Non-Methane Hydrocarbons
Non-Methane Organic Gases
Total Organic Gases
Volatile Organic Compounds
Methane (CH4)
Carbon Monoxide (CO)
Oxides of Nitrogen (NOx)
Nitrogen Oxide (NO)
Nitrogen Dioxide (NO2)
Nitrous Acid (HONO)
Ammonia (NH3)
Nitrous Oxide (N2O)
Primary Exhaust PM2.5 - Total
[+] Primary Exhaust PM2.5 - Species
Primary PM2.5 - Brakewear Particulate
Primary PM2.5 - Tirewear Particulate
Primary Exhaust PM10 - Total
Primary PM10 - Brakewear Particulate
Primary PM10 - Tirewear Particulate
Sulfur Dioxide (SO2)
Total Energy Consumption
Atmospheric CO2
CO2 Equivalent
Benzene
Ethanol
1,3-Butadiene
Formaldehyde
Acetaldehyde
Acrolein
[+] Additional Air Toxics
[+] Polycyclic Aromatic Hydrocarbons (PAH)
[+] Metals
[+] Dioxins and Furans
NonHAPTOG Mechanism
When pollutants are listed in the box at right, MOVES needs to calculate those emissions first, before calculating the pollutants you selected. In this case, click "Select Prerequisites" to proceed.
Select Prereguisites
Clear All
Ready to run...


MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
General Output
Output Database
Server:
Refresh
Database: barnstable_out_2019_w_co2e_roadtype
Create Database...
Units
Mass Units: Grams
Energy Units: Joules
Distance Units: Miles
Activity
Distance Traveled
Source Hours
Hotelling Hours
Source Hours Operating
Source Hours Parked
Population
Starts
Ready to run...


MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Output Emissions Detail
Output Aggregation
Time:
Hour
Geographic:
LINK
for All Vehicle/Equipment Categories
Model Year
Fuel Type
Fuel Subtype
Emission Process
SCC
Onroad
Road Type
Source Use Type
Regulatory Class
Nonroad
Sector
Engine Tech.
HP Class
Ready to run...


MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Create Input Database
Domain Input Database
Server: localhost
Database: barnstable_county_in
Description
Refresh
Create Database
Enter/Edit Data
Ready to run...


MOVES - C:\Users\ttougas\OneDrive - HMMH Inc\Desktop\Cape_Cod_Bridges\Barnstable_County\2019\Barnstable_County_Runspec - ID 4309747356672342591
File Edit Action Post Processing Tools Settings Help
Description (Alt+1)
Scale
Time Spans
Geographic Bounds
Onroad Vehicles
Road Type
Pollutants and Proces
General Output
Output Emissions Deta
Create Input Database
Advanced Features
Advanced Features
Preaggregation Options
Time Aggregation
Year Month Day Hour
Region Aggregation
Nation
State (Alt+2)
County
Zone & Link
Custom Domain
Input Data Sets
Use this feature to select an input database created by a MOVES tool (i.e., LEV or NLEV tool) or optional input databases for Default Scale or Nonroad runs. Do not select County or Project input databases here, as those kinds of databases should be selected on the Create Input Database Panel.
Server:
Database:
Description:
Add (Alt+0)
Refresh
Selections:
/ barnstable_county_nlev_2019 /
/ barnstable_county_lev_in /
Move Up (Alt+9)
Move Down
Delete
Masterloopable
Components (Alt+X)
Component
Don't Execute
Save Data
Total Activity Generator (TAG)
Rates Operating Mode Distribution Generator (running ROMDG)
Start Operating Mode Distribution Generator
Evaporative Operating Mode Distribution Generator
Tirewear Operating Mode Distribution Generator
Source Bin Distribution Generator (SBDG)
Meteorology Generator
Tank Temperature Generator
Tank Fuel Generator
Fuel Effects Generator
Lookup Operating Mode Distribution Generator
Emission Calculators
On-Road Retrofit
Project-Domain Total Activity Generator
Project-Domain Operating Mode Distribution Generator (running exhaust)
Rate Of Progress Strategy
Destination User Dataset
Copy Saved Generator Data
Server (Alt+3):
Refresh (Alt+I)
Database:
Create Database (Alt+G)
Aggregation and Data Handling
Do Not Perform Final Aggregation (Alt+4)
Ready to run...

Attachment 3 – Mesoscale Spreadsheets and Criteria Greenhouse Gas (GHG) Pollutants

Cape Cod Bridges Updated Analysis Assumptions

Data Supplied by MADEP: Updated Data Received via Email on 2/18/2025

	2019 Existing	2050 No-Build	2050 Build	Delta Change Daily	Delta VMT Annual	Delta Change Daily (Build-Existing)
Daily VMT	2,653,276	3,476,000	3,416,153	-59,847	-21,844,155	762,877
Daily VHT	56,934	94,715	86,788	-7,927	-2,893,355	29,854
Daily Trips	348,835	421,686	421,686	0	0	72,851
Avg. Speed	47 mph	37 mph	39 mph	2	2	-7

Annual VMT 2050 No Build	Annual VMT 2050 Build
1,268,740,000	1,246,895,845
34,570,975	

Travel Demand Regional Network Summary

		2019 Existing	2050 No-Build	2050 Build
Fall	Daily VMT	2,653,276	3,476,000	3,416,153
	Daily VHT	56,934	94,715	86,788
	Daily Trips	348,835	421,686	421,686
	Avg. Speed	47	37	39

Analysis Scenario	Daily VMT	Avg Speed.	MOVES Emission Factors (GRAMS PER MILE)																	
			Carbon Monoxide (CO)	Volatile Organic Compounds	Oxides of Nitrogen (NOx)	Sulfur Dioxide (SO2)	Primary Exhaust PM10 Total	Primary PM10 - Brakewear Particulate	Primary PM10 - Tirewear Particulate	PM10 TOTAL (Exhaust, Brakewear, Tirewear)	Primary Exhaust PM2.5 Total	Primary PM2.5 - Brakewear Particulate	Primary PM2.5 - Tirewear Particulate	PM2.5 TOTAL (Exhaust, Brakewear, Tirewear)	Atmospheric CO2	Methane (CH4)	Nitrous Oxide (N2O)	CO2 Equivalent	Carbon Monoxide (CO)	Volatile Organic Compounds
2019 Existing	2,653,276	47 mph	2.180	0.038	0.243	0.006	0.006	0.018	0.009	0.033	0.005	0.002	0.001	0.009	368.398	0.011	0.004	369.943	6.37	0.11
2050 No-Build	3,476,000	37 mph	0.846	0.019	0.028	0.001	0.001	0.035	0.011	0.046	0.001	0.004	0.002	0.007	220.197	0.009	0.005	221.932	3.24	0.07
2050 Build	3,416,153	39 mph	0.794	0.017	0.026	0.001	0.001	0.026	0.010	0.036	0.001	0.003	0.001	0.005	213.562	0.008	0.005	215.222	2.99	0.07
																		Daily Delta Build-No Build	-0.25	-0.01
																		Daily Delta Build-Existing	**-3.38**	**-0.05**

Analysis Scenario	Daily VMT	Avg Speed.	MOVES Emission Factors (GRAMS PER MILE)																	
			Carbon Monoxide (CO)	Volatile Organic Compounds	Oxides of Nitrogen (NOx)	Sulfur Dioxide (SO2)	Primary Exhaust PM10 Total	Primary PM10 - Brakewear Particulate	Primary PM10 - Tirewear Particulate	PM10 TOTAL (Exhaust, Brakewear, Tirewear)	Primary Exhaust PM2.5 Total	Primary PM2.5 - Brakewear Particulate	Primary PM2.5 - Tirewear Particulate	PM2.5 TOTAL (Exhaust, Brakewear, Tirewear)	Atmospheric CO2	Methane (CH4)	Nitrous Oxide (N2O)	CO2 Equivalent	Carbon Monoxide (CO)	Volatile Organic Compounds
2019 Existing	2,653,276	47 mph	2.180	0.0385	0.2429	0.0065	0.0055	0.0180	0.0092	0.0327	0.0050	0.0023	0.0014	0.0086	368.398	0.011	0.004	369.943	2,327	41.06
2050 No-Build	3,476,000	37 mph	0.846	0.019	0.028	0.001	0.001	0.035	0.011	0.046	0.001	0.004	0.002	0.007	220.197	0.009	0.005	221.932	1,183	26.07
2050 Build	3,416,153	39 mph	0.794	0.017	0.026	0.001	0.001	0.026	0.010	0.036	0.001	0.003	0.001	0.005	213.562	0.008	0.005	215.222	1,091	23.79
																		Annual Delta Build-No Build	-91	-2

Cape Cod Bridges Updated Analysis Assumptions

Data Supplied by MADEP: Updated Data Received via Email on 2/18/2025

	2019 Existing	2050 No-Build	2050 Build	Delta Change Daily	Delta VMT Annual	Delta Change Daily (Build-Existing)
Daily VMT	2,653,276	3,476,000	3,416,153	-59,847	-21,844,155	762,877
Daily VHT	56,934	94,715	86,788	-7,927	-2,893,355	29,854
Daily Trips	348,835	421,686	421,686	0	0	72,851
Avg. Speed	47 mph	37 mph	39 mph	2	2	-7

Annual VMT 2050 No Build	Annual VMT 2050 Build
1,268,740,000	1,246,895,845
34,570,975	

Travel Demand Regional Network Summary

		2019 Existing	2050 No-Build	2050 Build
Fall	Daily VMT	2,653,276	3,476,000	3,416,153
	Daily VHT	56,934	94,715	86,788
	Daily Trips	348,835	421,686	421,686
	Avg. Speed	47	37	39

MOVES5 Emissions (TONS PER DAY)

Analysis Scenario	Daily VMT	Avg Speed.	Oxides of Nitrogen (NOx)	Sulfur Dioxide (SO2)	PM10 TOTAL (Exhaust, Brakewear, Tirewear)	PM2.5 TOTAL (Exhaust, Brakewear, Tirewear)	Atmospheric CO2	Methane (CH4)	Nitrous Oxide (N2O)	CO2 Equivalent
2019 Existing	2,653,276	47 mph	0.71	0.02	0.10	0.03	1,077	0.03	0.01	1,082
2050 No-Build	3,476,000	37 mph	0.11	0.004	0.18	0.03	844	0.03	0.02	850
2050 Build	3,416,153	39 mph	0.10	0.004	0.14	0.02	804	0.03	0.02	810
			-0.01	-0.0002	-0.04	-0.01	-40	-0.005	-0.001	-40
			-0.61	**-0.01**	**0.04**	**0.00**	**-273.27**	**0.00**	**0.01**	**-271.53**

MOVES5 Emissions (TONS PER YEAR)

Analysis Scenario	Daily VMT	Avg Speed.	Oxides of Nitrogen (NOx)	Sulfur Dioxide (SO2)	PM10 TOTAL (Exhaust, Brakewear, Tirewear)	PM2.5 TOTAL (Exhaust, Brakewear, Tirewear)	Atmospheric CO2	Methane (CH4)	Nitrous Oxide (N2O)	CO2 Equivalent
2019 Existing	2,653,276	47 mph	259.25	6.90	34.96	9.21	393,277	12.23	4.73	394,927
2050 No-Build	3,476,000	37 mph	38.47	1.56	64.78	9.45	307,957	12.49	7.52	310,383
2050 Build	3,416,153	39 mph	36.25	1.49	50.08	7.54	293,536	10.81	7.17	295,817
			-2	-0.07	-14.70	-1.91	-14,422	-1.68	-0.35	-14,566

Attachment 4 – Infrastrucuture Carbon Estimator (ICE) Model Results

Project Inputs

Display result in 508 compliant format:	No

Hide Instructions	No

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 different individual projects (*Project* mode) or a suite of projects in a comprehensive plan (*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.

Clear All User Data

Infrastructure location (state)	MA
The lifetime of your plan or project (years)	30
Use custom electric emission profile (RPS)?	No

Tool Use	Planning

Bridges & Overpasses | Culverts | Lighting | Parking | Roadways | Vehicle Operations | Roadway Rehabilitation

BRT | Light Rail | Heavy Rail | Pathways | Signage | Custom Pavement

	Title:	MassDOT Cape Cod Canal Bridges	Title:		Title:	
Enter comments and comment titles. These will be displayed on the Summary Results worksheet.						

Planning Summary of Inputs - See Individual Tabs for Details

Bridges & Overpasses

	Construct New Bridge/Overpass				Reconstruct Bridge/Overpass				Add Lane to Bridge/Overpass			
Bridge/Overpass Structure	Number of bridges & overpasses	Average number of spans per structure	Average number of lanes per structure	Total number of lane-spans	Number of bridges & overpasses	Average number of spans per structure	Average number of lanes recon-structed per structure	Total number of lane-spans	Number of bridges & overpasses	Average number of spans per structure	Average number of lanes per structure added	Total number of lane-spans
Single-Span	10	1	2	**20**	4	1	3	**12**		1		**0**
Two-Span	6	2	2.5	**30**		2		**0**		2		**0**
Multi-Span (over land)	7	5	2	**70**	1	3	2	**6**				**0**
Multi-Span (over water)	4	5	3	**60**				**0**				**0**

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

Culverts

	Number of culverts	Average culvert length (ft)
Default Culvert	10	273

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

Lighting

Number of roadway miles	34.58

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		142
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	62
High Mast	28800 - 42000	
High Mast	46500-52800	
High Mast	52500-58300	

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

Pathways

Bicycle and Pedestrian Facilities		
Project Type	New Construction	Resurfacing
Off-Street Bicycle or Pedestrian Path - miles	14.56	7.56
On-Street Bicycle Lane - lane miles	18.36	0
On-Street Sidewalk - miles	0	*N/A*

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

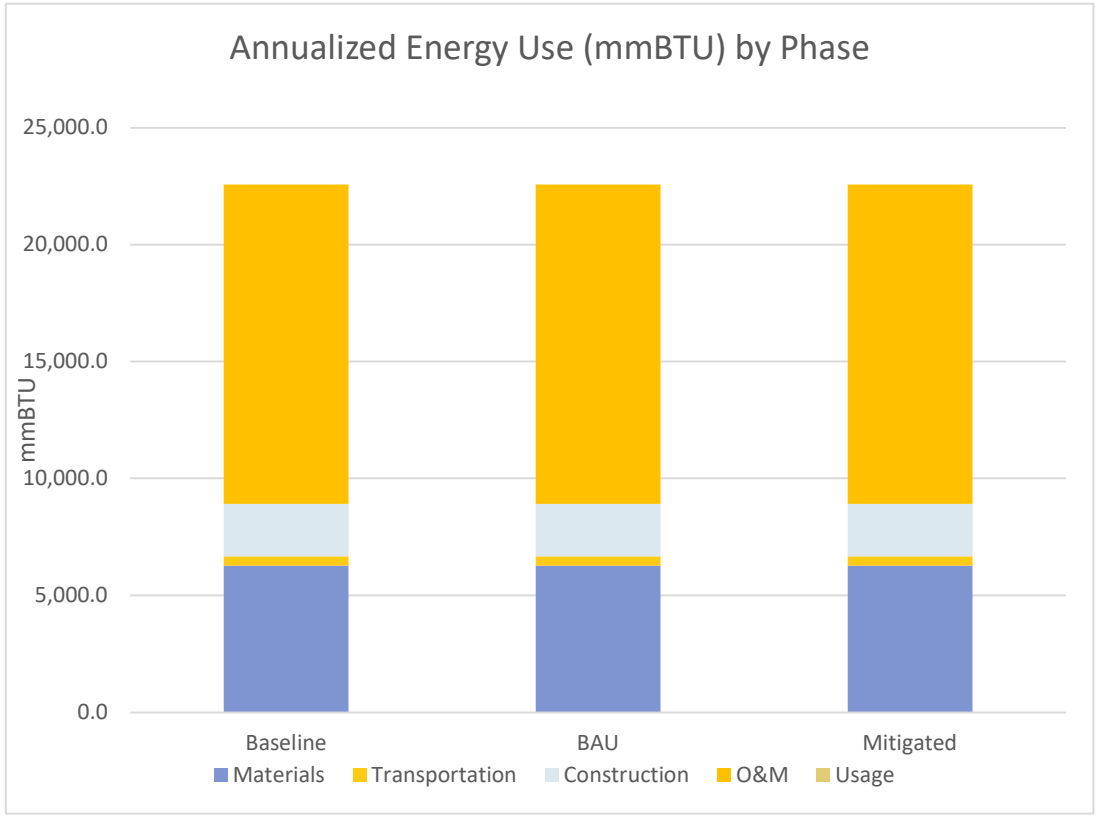
Roadways

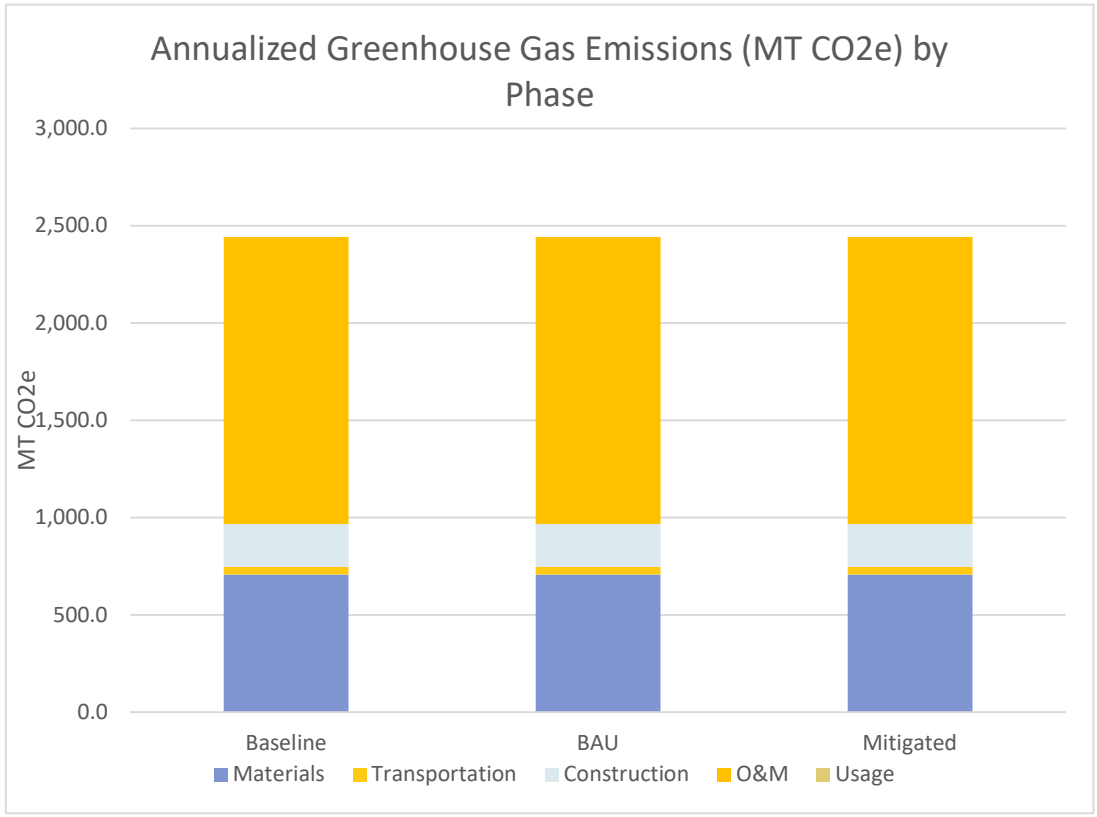
Roadway System	
Total existing centerline miles	15.06
Total newly constructed centerline miles	16.56

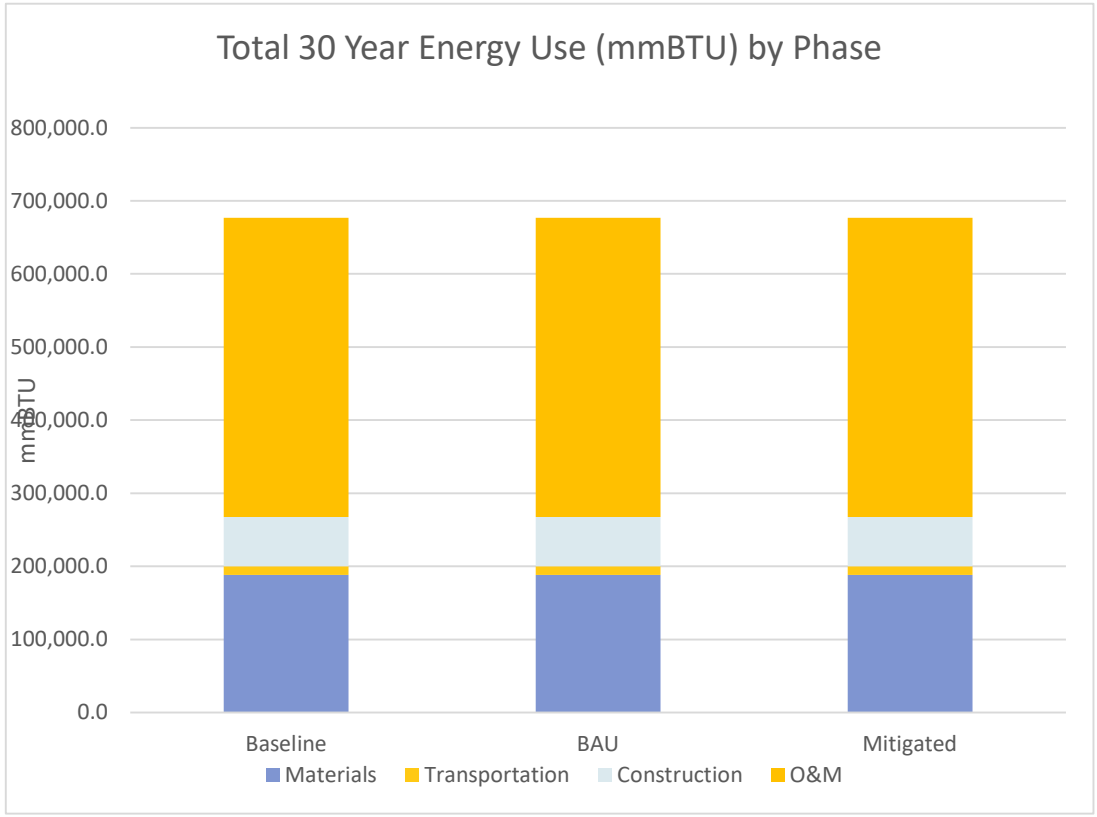
Roadway Projects						
Facility type	Roadway System	Roadway Construction				
	Existing Roadway (lane miles)	New Roadway (lane miles)	Construct Additional Lane (lane miles)	Realignment (lane miles)	Lane Widening (lane miles)	Shoulder Improvement (centerline miles)
Rural Interstates						
Rural Principal Arterials						
Rural Minor Arterials	1.2					
Rural Collectors	4.8					
Urban Interstates / Expressways						
Urban Principal Arterials	5.1	5.3	6	12		
Urban Minor Arterials / Collectors						

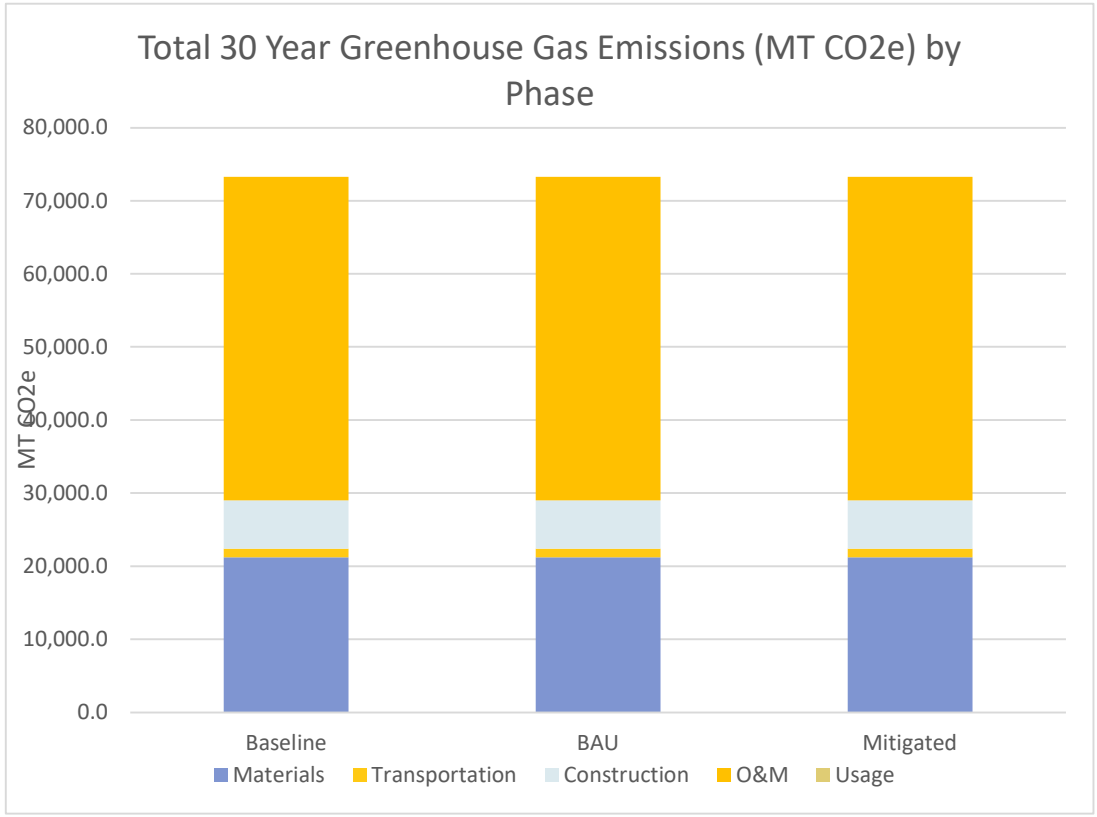
Include roadway rehabilitation activities (reconstruct and resurface)	Yes
% roadway construction on rocky / mountainous terrain	0%

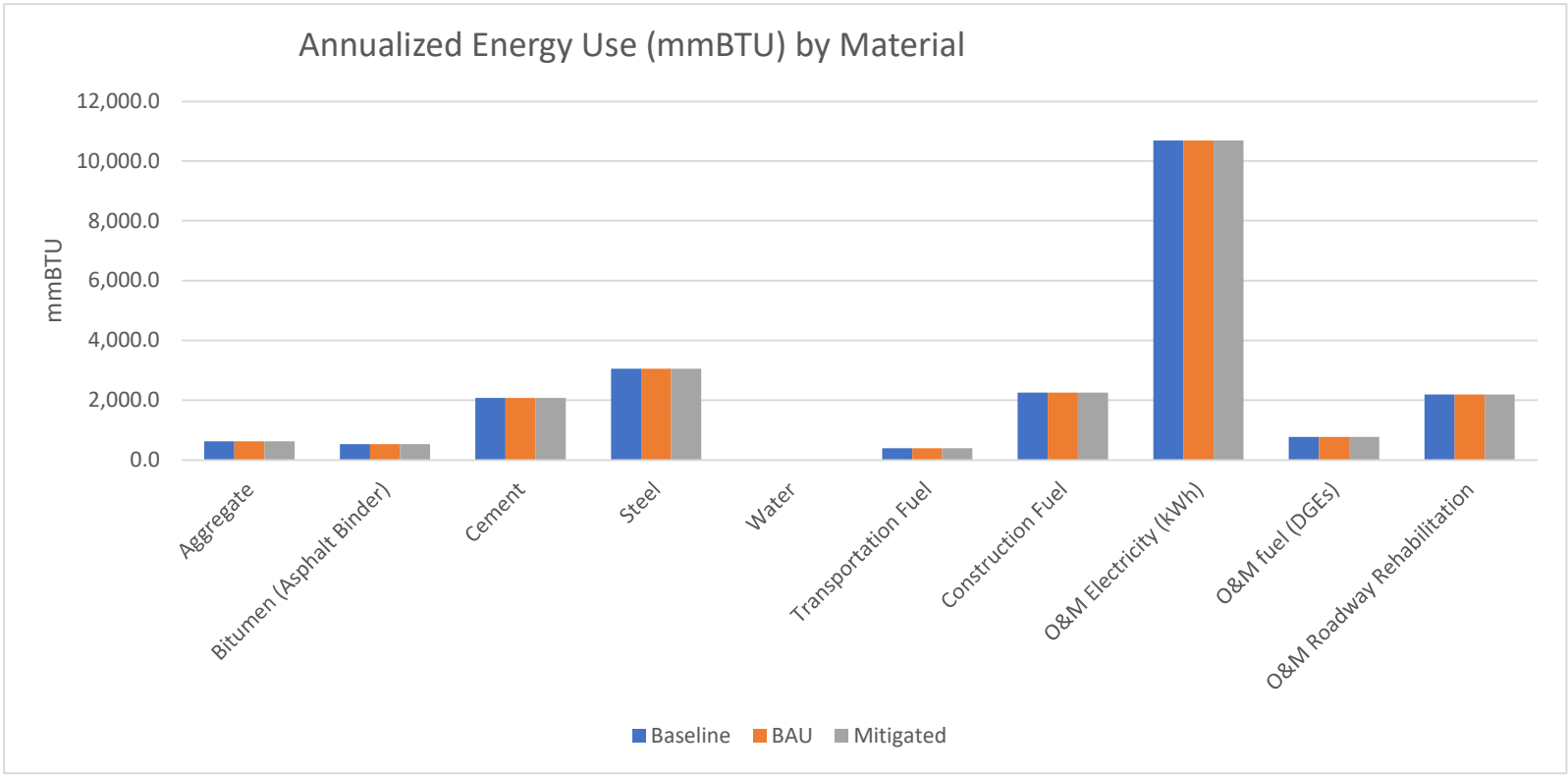
Specification
Baseline Energy Use and GHG Emissions
Mitigated Results
Results - Charts

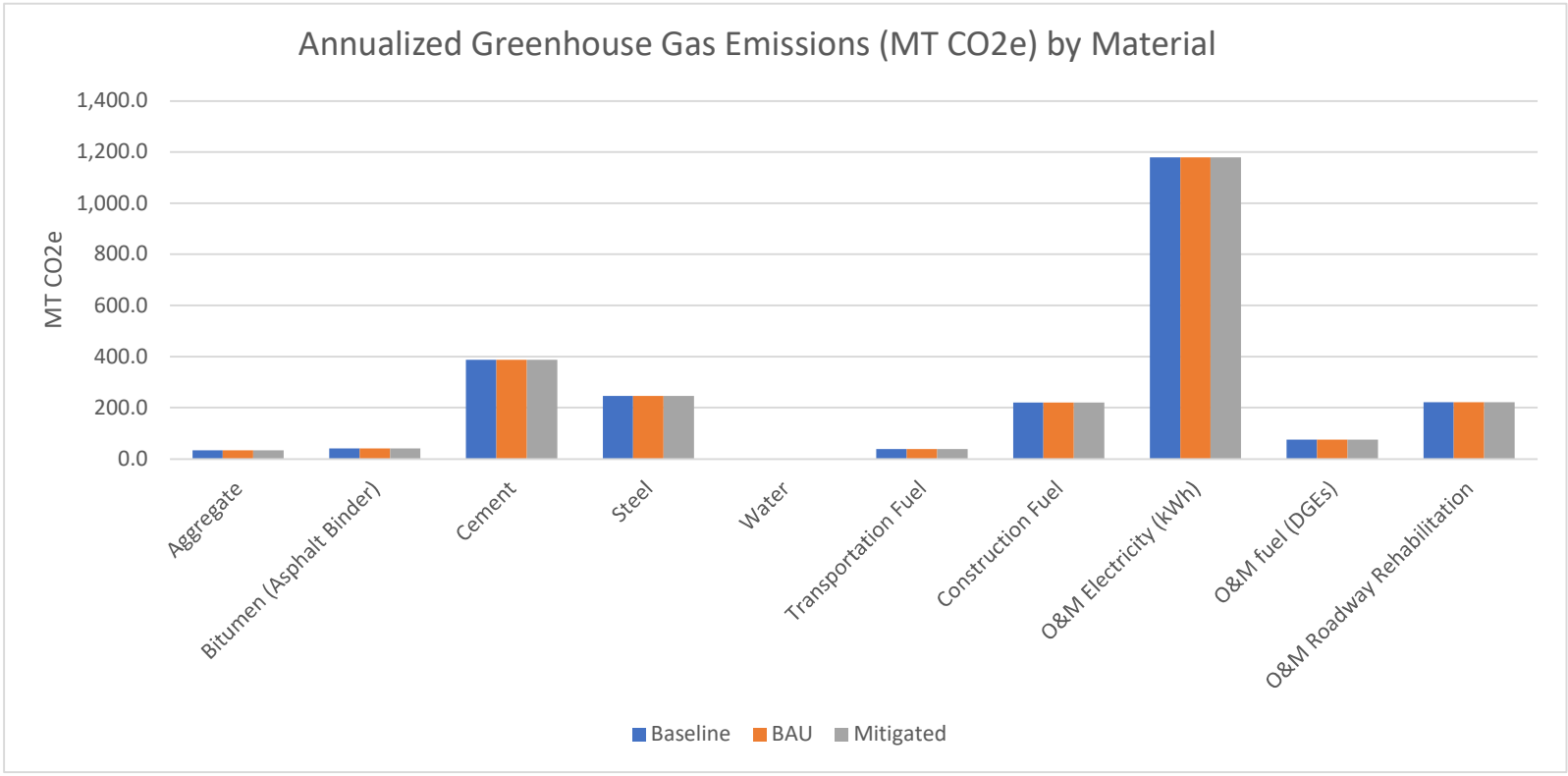

Annualized Energy Use (mmBTU) by Phase
25,000.0
20,000.0
15,000.0
10,000.0
5,000.0
0.0
mmBTU
Baseline
BAU
Mitigated
Materials
Transportation
Construction
O&M
Usage

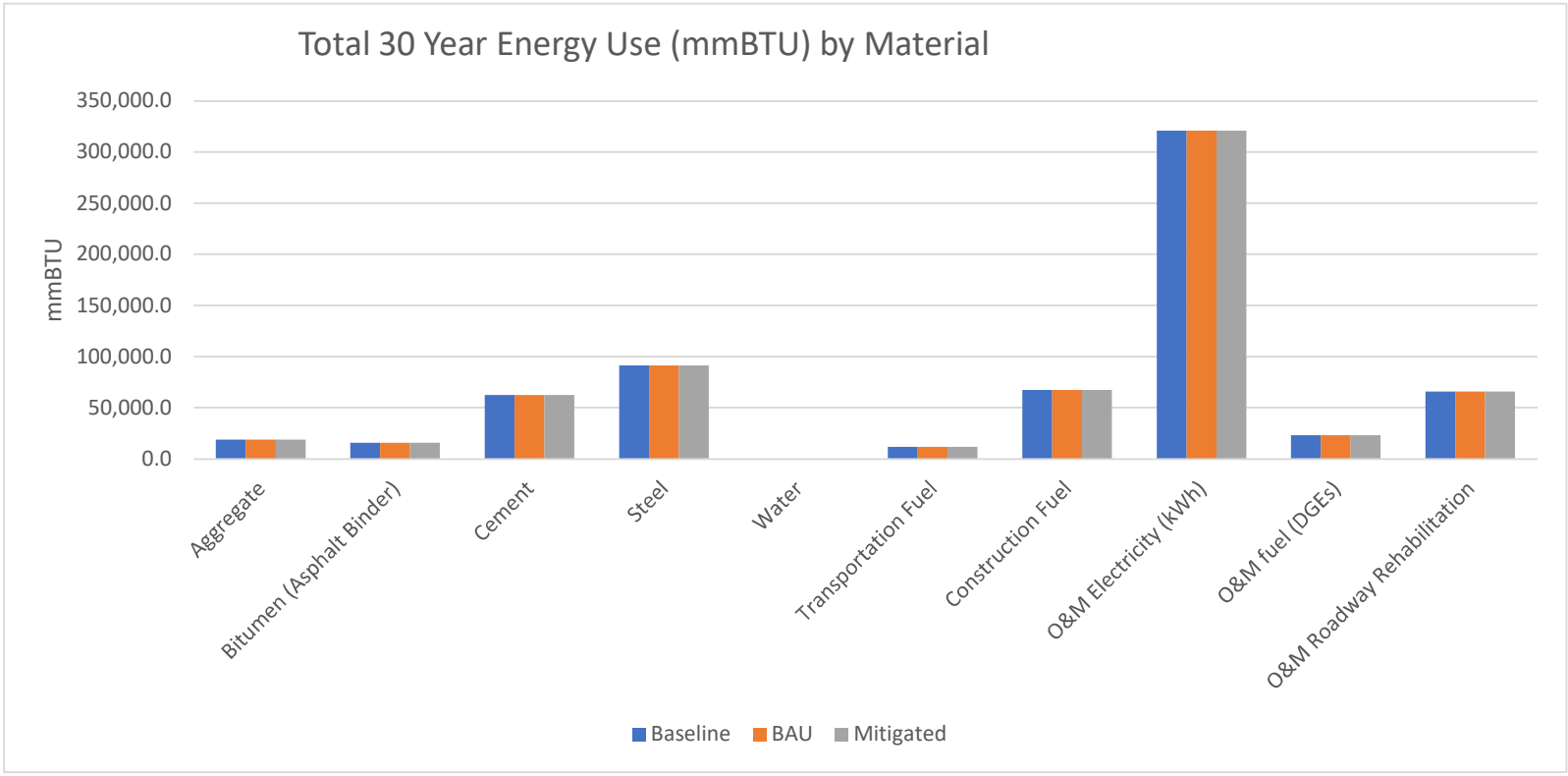

Annualized Greenhouse Gas Emissions (MT CO2e) by Phase
3,000.0
2,500.0
2,000.0
1,500.0
1,000.0
500.0
0.0
MT CO2e
Baseline
BAU
Mitigated
Materials
Transportation
Construction
O&M
Usage

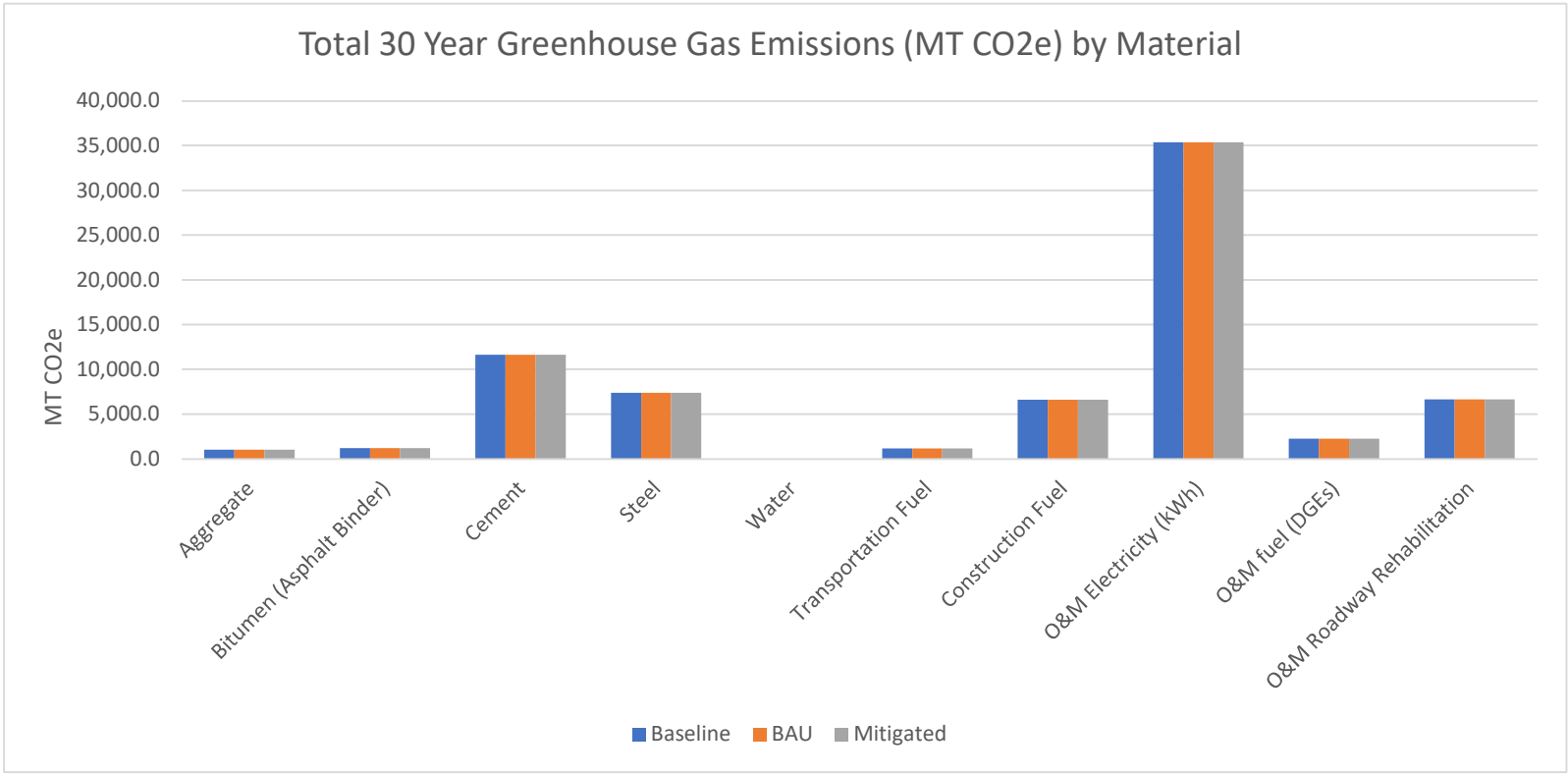

Total 30 Year Energy Use (mmBTU) by Phase
800,000.0
700,000.0
600,000.0
500,000.0
400,000.0
300,000.0
200,000.0
100,000.0
0.0
mmBTU
Baseline
BAU
Mitigated
Materials
Transportation
Construction
O&M

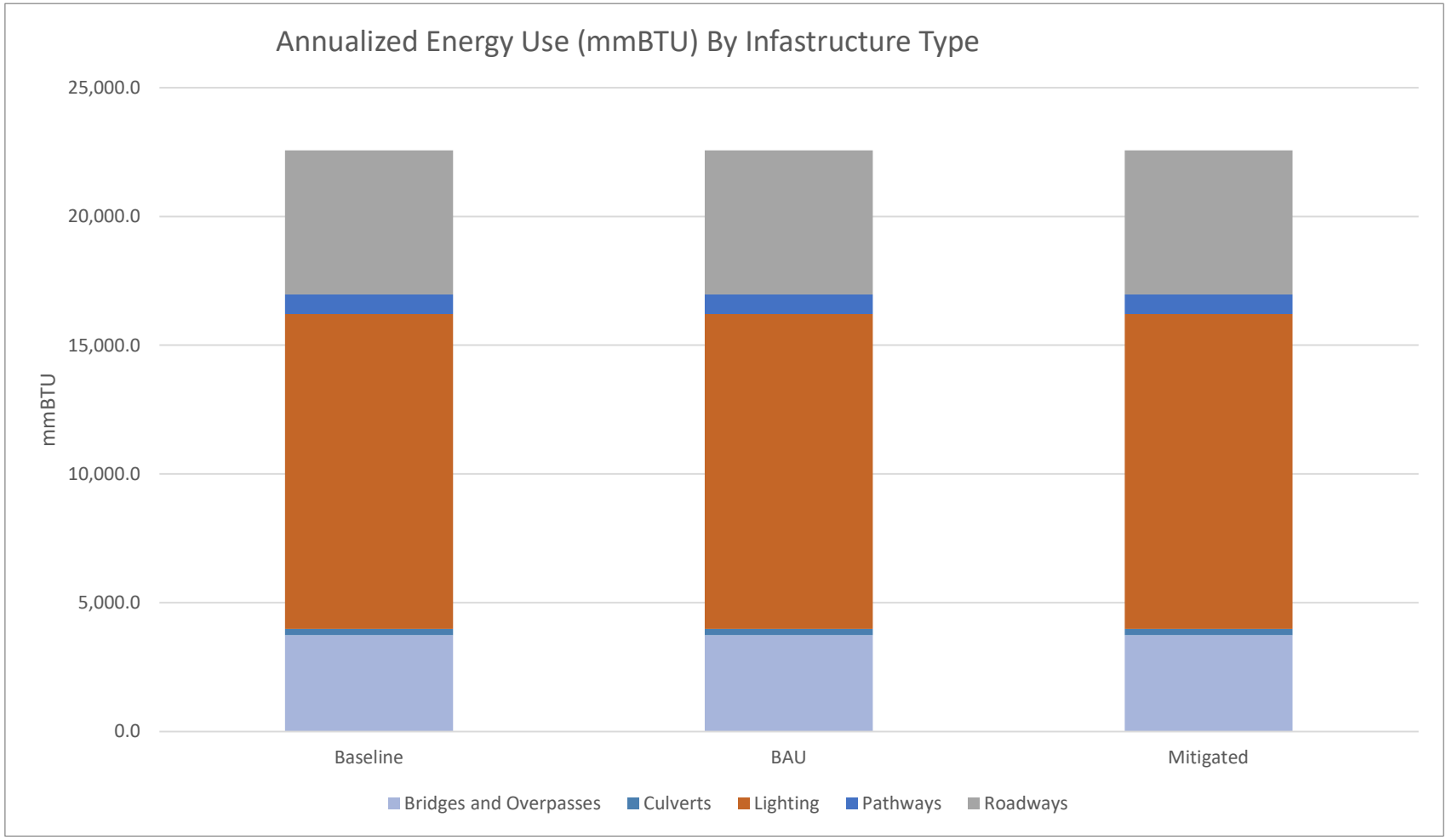

Total 30 Year Greenhouse Gas Emissions (MT CO2e) by Phase
80,000.0
70,000.0
60,000.0
50,000.0
40,000.0
30,000.0
20,000.0
10,000.0
0.0
MT CO2e
Baseline
BAU
Mitigated
Materials
Transportation
Construction
O&M
Usage

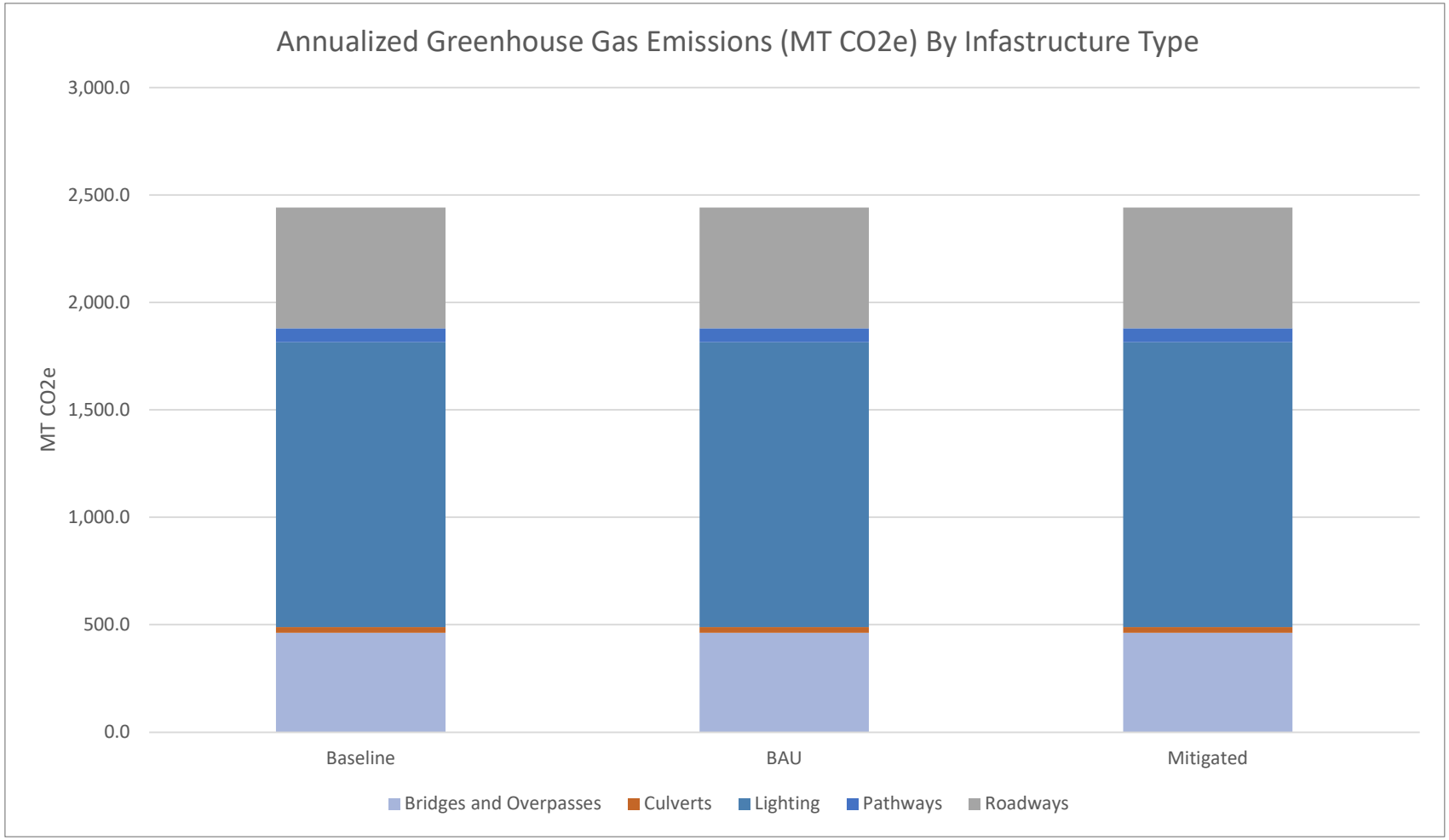

Annualized Energy Use (mmBTU) by Material
12,000.0
10,000.0
8,000.0
6,000.0
4,000.0
2,000.0
0.0
mmBTU
Aggregate
Bitumen (Asphalt Binder)
Cement
Steel
Water
Transportation Fuel
Construction Fuel
O&M Electricity (kWh)
O&M fuel (DGEs)
O&M Roadway Rehabilitation
Baseline
BAU
Mitigated

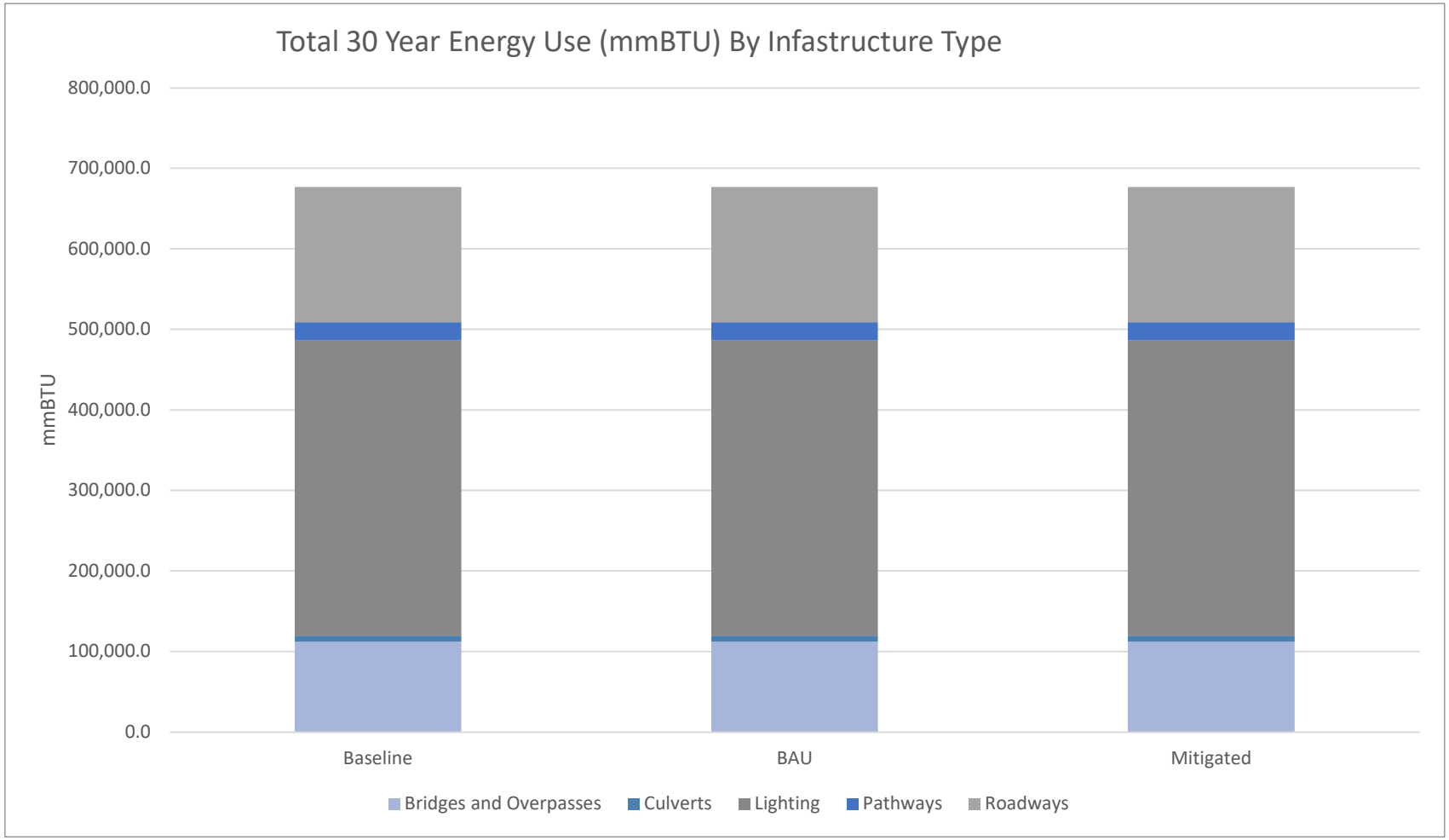

Annualized Greenhouse Gas Emissions (MT CO2e) by Material
MT CO2e
1,400.0
1,200.0
1,000.0
800.0
600.0
400.0
200.0
0.0
Aggregate
Bitumen (Asphalt Binder)
Cement
Steel
Water
Transportation Fuel
Construction Fuel
O&M Electricity (kWh)
O&M fuel (DGEs)
O&M Roadway Rehabilitation
Baseline
BAU
Mitigated

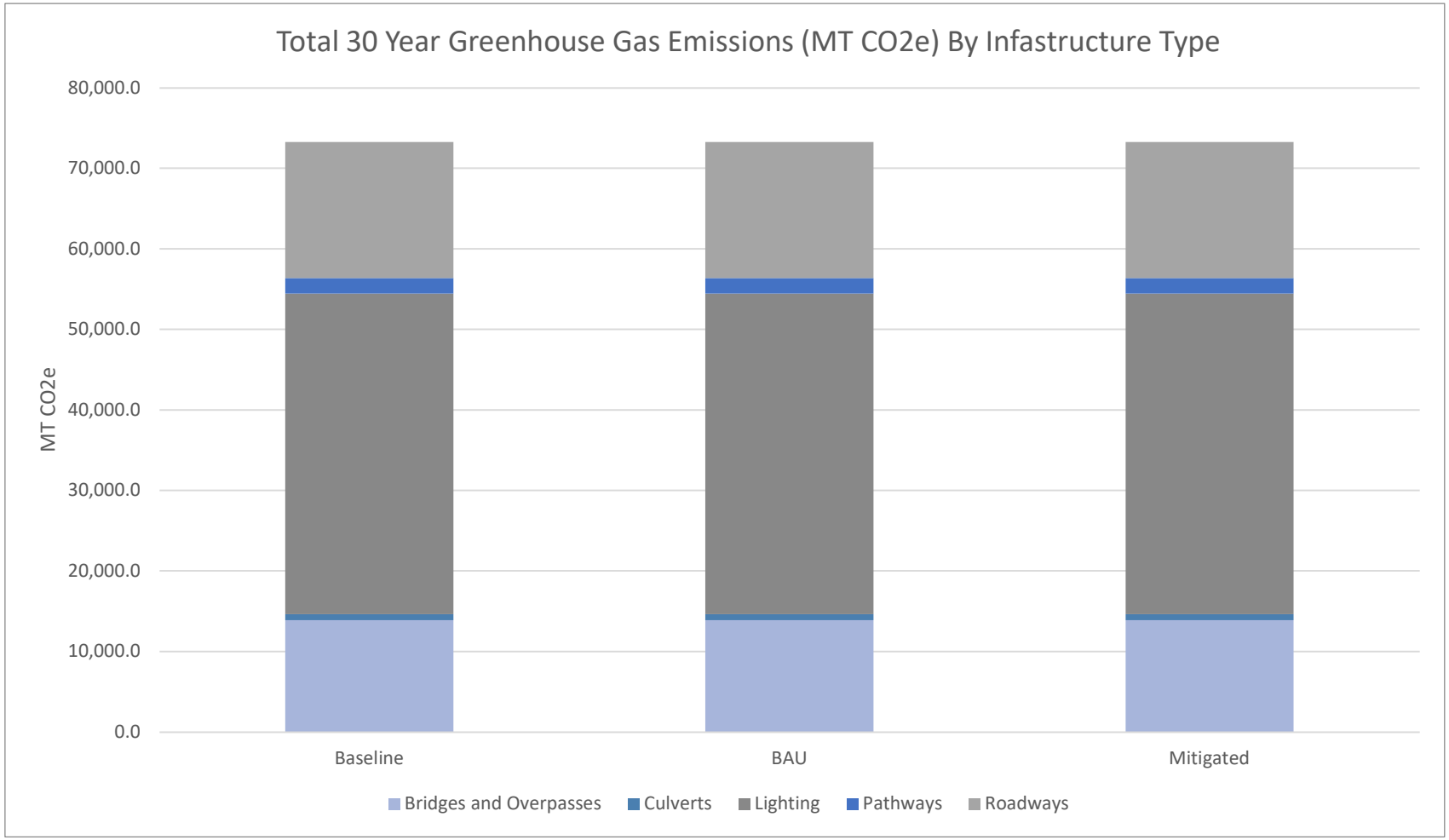

Total 30 Year Energy Use (mmBTU) by Material
mmBTU
350,000.0
300,000.0
250,000.0
200,000.0
150,000.0
100,000.0
50,000.0
0.0
Aggregate
Bitumen (Asphalt Binder)
Cement
Steel
Water
Transportation Fuel
Construction Fuel
O&M Electricity (kWh)
O&M fuel (DGEs)
O&M Roadway Rehabilitation
Baseline
BAU
Mitigated


Total 30 Year Greenhouse Gas Emissions (MT CO2e) by Material
MT CO2e
40,000.0
35,000.0
30,000.0
25,000.0
20,000.0
15,000.0
10,000.0
5,000.0
0.0
Aggregate
Bitumen (Asphalt Binder)
Cement
Steel
Water
Transportation Fuel
Construction Fuel
O&M Electricity (kWh)
O&M fuel (DGEs)
O&M Roadway Rehabilitation
Baseline
BAU
Mitigated


Annualized Energy Use (mmBTU) By Infastructure Type
25,000.0
20,000.0
15,000.0
10,000.0
5,000.0
0.0
mmBTU
Baseline
BAU
Mitigated
Bridges and Overpasses
Culverts
Lighting
Pathways
Roadways


Annualized Greenhouse Gas Emissions (MT CO2e) By Infastructure Type
3,000.0
2,500.0
2,000.0
1,500.0
1,000.0
500.0
0.0
MT CO2e
Baseline
BAU
Mitigated
Bridges and Overpasses
Culverts
Lighting
Pathways
Roadways


Total 30 Year Energy Use (mmBTU) By Infastructure Type
800,000.0
700,000.0
600,000.0
500,000.0
400,000.0
300,000.0
200,000.0
100,000.0
0.0
mmBTU
Baseline
BAU
Mitigated
Bridges and Overpasses
Culverts
Lighting
Pathways
Roadways


Total 30 Year Greenhouse Gas Emissions (MT CO2e) By Infastructure Type
80,000.0
70,000.0
60,000.0
50,000.0
40,000.0
30,000.0
20,000.0
10,000.0
0.0
MT CO2e
Baseline
BAU
Mitigated
Bridges and Overpasses
Culverts
Lighting
Pathways
Roadways

	Annualized Energy Use		
	mmBTU	mmBTU	mmBTU
	Baseline	BAU	Mitigated
Materials	6,274	6,274	6,274
Transportation	394	394	394
Construction	2,249	2,249	2,249
O&M	13,646	13,646	13,646
Total	**22,563**	**22,563**	**22,563**

	Annualized Greenhouse Gas Emissions		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Materials	707	707	707
Transportation	39	39	39
Construction	220	220	220
O&M	1,476	1,476	1,476
Total	**2,442**	**2,442**	**2,442**

	Total Energy Use		
	mmBTU	mmBTU	mmBTU
	Baseline	BAU	Mitigated
Materials	188,232	188,232	188,232
Transportation	11,816	11,816	11,816
Construction	67,474	67,474	67,474
O&M	409,369	409,369	409,369
Total	**676,891**	**676,891**	**676,891**

	Total Greenhouse Gas Emissions		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Materials	21,214	21,214	21,214
Transportation	1,157	1,157	1,157
Construction	6,609	6,609	6,609
O&M	44,285	44,285	44,285
Total	**73,265**	**73,265**	**73,265**

	Annualized Energy Use		
	mmBTU	mmBTU	mmBTU
	Baseline	BAU	Mitigated
Aggregate	624	624	624
Bitumen (Asphalt Binder)	523	523	523
Cement	2,077	2,077	2,077
Steel	3,048	3,048	3,048
Water	2	2	2
Transportation Fuel	394	394	394
Construction Fuel	2,249	2,249	2,249
O&M Electricity (kWh)	10,690	10,690	10,690
O&M fuel (DGEs)	767	767	767
O&M Roadway Rehabilitation	2,189	2,189	2,189
Total	**22,563**	**22,563**	**22,563**

	Annualized Greenhouse Gas Emissions		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Aggregate	34	34	34
Bitumen (Asphalt Binder)	40	40	40
Cement	387	387	387
Steel	246	246	246
Water	0	0	0
Transportation Fuel	39	39	39
Construction Fuel	220	220	220
O&M Electricity (kWh)	1,179	1,179	1,179
O&M fuel (DGEs)	75	75	75
O&M Roadway Rehabilitation	222	222	222
Total	**2,442**	**2,442**	**2,442**

	Total Energy Use		
	mmBTU	mmBTU	mmBTU
	Baseline	BAU	Mitigated
Aggregate	18,710	18,710	18,710
Bitumen (Asphalt Binder)	15,698	15,698	15,698
Cement	62,313	62,313	62,313
Steel	91,443	91,443	91,443
Water	68	68	68
Transportation Fuel	11,816	11,816	11,816
Construction Fuel	67,474	67,474	67,474
O&M Electricity (kWh)	320,687	320,687	320,687
O&M fuel (DGEs)	23,023	23,023	23,023
O&M Roadway Rehabilitation	65,659	65,659	65,659
Total	**676,891**	**676,891**	**676,891**

	Total Greenhouse Gas Emissions		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Aggregate	1,008	1,008	1,008
Bitumen (Asphalt Binder)	1,215	1,215	1,215
Cement	11,614	11,614	11,614
Steel	7,368	7,368	7,368
Water	9	9	9
Transportation Fuel	1,157	1,157	1,157
Construction Fuel	6,609	6,609	6,609
O&M Electricity (kWh)	35,383	35,383	35,383
O&M fuel (DGEs)	2,255	2,255	2,255
O&M Roadway Rehabilitation	6,646	6,646	6,646
Total	**73,265**	**73,265**	**73,265**

	Annualized Energy Use		
	mmBTU	mmBTU	mmBTU
	Baseline	BAU	Mitigated
Bridges and Overpasses	3,741	3,741	3,741
Culverts	248	248	248
Lighting	12,222	12,222	12,222
Pathways	757	757	757
Roadways	5,595	5,595	5,595
Total	**22,563**	**22,563**	**22,563**

	Annualized Greenhouse Gas Emissions		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Bridges and Overpasses	462	462	462
Culverts	26	26	26
Lighting	1,327	1,327	1,327
Pathways	65	65	65
Roadways	563	563	563
Total	**2,442**	**2,442**	**2,442**

	Total Energy Use		
	mmBTU	mmBTU	mmBTU
	Baseline	BAU	Mitigated
Bridges and Overpasses	112,237	112,237	112,237
Culverts	7,436	7,436	7,436
Lighting	366,658	366,658	366,658
Pathways	22,703	22,703	22,703
Roadways	167,857	167,857	167,857
Total	**676,891**	**676,891**	**676,891**

	Total Greenhouse Gas Emissions		
	MT CO2e	MT CO2e	MT CO2e
	Baseline	BAU	Mitigated
Bridges and Overpasses	13,867	13,867	13,867
Culverts	773	773	773
Lighting	39,796	39,796	39,796
Pathways	1,945	1,945	1,945
Roadways	16,883	16,883	16,883
Total	**73,265**	**73,265**	**73,265**

Attachment 5 – Social Costs

Cape Cod Bridges Baseline GHG Social Costs-Construction Activities

CO2

Year	CO_2	5%	3%	2.50%	3% 95th
2019	132,814.00	$1,859,396	$6,773,514	$10,093,864	$20,187,728
2022	0	0	0	0	0
2025	0	$0.0	$0.0	$0.0	$0.0
2026	0	$0.0	$0.0	$0.0	$0.0
2027	0	$0	$0	$0	$0
2028	0	$0	$0	$0	$0
2029	0	$0.0	$0.0	$0.0	$0.0
2030	0	$0.0	$0.0	$0.0	$0.0
2031	0	$0.0	$0.0	$0.0	$0.0
2032	0	$0.0	$0.0	$0.0	$0.0
2033	0	$0.0	$0.0	$0.0	$0.0
2034	0	$0.0	$0.0	$0.0	$0.0
2035	0	$0.0	$0.0	$0.0	$0.0
2036	0	$0.0	$0.0	$0.0	$0.0
2037	0	$0.0	$0.0	$0.0	$0.0

Notes:
1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)
3. 2020 costs were used for 2019 emissions from the TSD

CH4

Year	CH4	5%	3%	2.50%	3% 95th
2019	5.1	$3,417	$7,650	$10,200	$19,890
2022	0	$0	$0	$0	$0
2025	0	$0.0	$0.0	$0.0	$0.0
2026	0	$0.0	$0.0	$0.0	$0.0
2027	0	$0	$0	$0	$0
2028	0	$0	$0	$0	$0
2029	0	$0.0	$0.0	$0.0	$0.0
2030	0	$0.0	$0.0	$0.0	$0.0
2031	0	$0.0	$0.0	$0.0	$0.0
2032	0	$0.0	$0.0	$0.0	$0.0
2033	0	$0.0	$0.0	$0.0	$0.0
2034	0	$0.0	$0.0	$0.0	$0.0
2035	0	$0.0	$0.0	$0.0	$0.0
2036	0	$0.0	$0.0	$0.0	$0.0
2037	0	$0.0	$0.0	$0.0	$0.0

Notes:
1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)
3. 2020 costs were used for 2019 emissions from the TSD

N2O

Year	N2O	5%	3%	2.50%	3% 95th
2019	1.75	$10,150	$31,500	$47,250	$84,000
2022	0	$0	$0	$0	$0
2025	0	$0.0	$0.0	$0.0	$0.0
2026	0	$0.0	$0.0	$0.0	$0.0
2027	0	$0	$0	$0	$0
2028	0	$0	$0	$0	$0
2029	0	$0.0	$0.0	$0.0	$0.0
2030	0	$0.0	$0.0	$0.0	$0.0
2031	0	$0.0	$0.0	$0.0	$0.0
2032	0	$0.0	$0.0	$0.0	$0.0
2033	0	$0.0	$0.0	$0.0	$0.0
2034	0	$0.0	$0.0	$0.0	$0.0
2035	0	$0.0	$0.0	$0.0	$0.0
2036	0	$0.0	$0.0	$0.0	$0.0
2037	0	$0.0	$0.0	$0.0	$0.0

Notes:
1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)
3. 2020 costs were used for 2019 emissions from the TSD

Total Costs

Year	Total			
	5%	3%	2.50%	3% 95th
2019	$1,872,963	$6,812,664	$10,151,314	$20,291,618
2022	$0	$0	$0	$0
2025	0	0	0	0
2026	0	0	0	0
2027	0	0	0	0
2028	0	0	0	0
2029	0	0	0	0
2030	0	0	0	0
2031	0	0	0	0
2032	0	0	0	0
2033	0	0	0	0
2034	0	0	0	0
2035	0	0	0	0
2036	0	0	0	0
2037	0	0	0	0

Notes:
1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)
3. 2020 costs were used for 2019 emissions from the TSD

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Cape Cod Bridges 2050 Build GHG Social Costs-Construction Activities

CO2

Year	CO_2 (metric tons/year) Note 2,3	5%	3%	2.50%	3% 95th Percentile
2018	0	$0.0	$0.0	$0.0	$0.0
2024	0	$0.0	$0.0	$0.0	$0.0
2025	0	$0.0	$0.0	$0.0	$0.0
2026	0	$0.0	$0.0	$0.0	$0.0
2027	0	$0	$0	$0	$0
2028	0	$0	$0	$0	$0
2029	0	$0.0	$0.0	$0.0	$0.0
2030	0	$0.0	$0.0	$0.0	$0.0
2031	0	$0.0	$0.0	$0.0	$0.0
2032	0	$0.0	$0.0	$0.0	$0.0
2033	0	$0.0	$0.0	$0.0	$0.0
2034	0	$0.0	$0.0	$0.0	$0.0
2035	0	$0.0	$0.0	$0.0	$0.0
2036	0	$0.0	$0.0	$0.0	$0.0
2050	94764	$2,994,542	$8,092,846	$11,030,530	$24,619,687

Notes:

1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

CH4

Year	CH4 (metric tons/year) Note 2,3	5%	3%	2.50%	3% 95th Percentile
2023	0	$0.0	$0.0	$0.0	$0.0
2024	0	$0.0	$0.0	$0.0	$0.0
2025	0	$0.0	$0.0	$0.0	$0.0
2026	0	$0.0	$0.0	$0.0	$0.0
2027	0	$0	$0	$0	$0
2028	0	$0	$0	$0	$0
2029	0	$0.0	$0.0	$0.0	$0.0
2030	0	$0.0	$0.0	$0.0	$0.0
2031	0	$0.0	$0.0	$0.0	$0.0
2032	0	$0.0	$0.0	$0.0	$0.0
2033	0	$0.0	$0.0	$0.0	$0.0
2034	0	$0.0	$0.0	$0.0	$0.0
2035	0	$0.0	$0.0	$0.0	$0.0
2036	0	$0.0	$0.0	$0.0	$0.0
2050	3.7	$6,290	$11,470	$14,060	$30,340

Notes:

1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

N2O

Year	N2O (metric tons/year) Note 2,3	5%	3%	2.50%	3% 95th Percentile
2023	3	$17,400.0	$54,000.0	$81,000.0	$144,000.0
2024	0	$0.0	$0.0	$0.0	$0.0
2025	0	$0.0	$0.0	$0.0	$0.0
2026	0	$0.0	$0.0	$0.0	$0.0
2027	0	$0	$0	$0	$0
2028	0	$0	$0	$0	$0
2029	0	$0.0	$0.0	$0.0	$0.0
2030	0	$0.0	$0.0	$0.0	$0.0
2031	0	$0.0	$0.0	$0.0	$0.0
2032	0	$0.0	$0.0	$0.0	$0.0
2033	0	$0.0	$0.0	$0.0	$0.0
2034	0	$0.0	$0.0	$0.0	$0.0
2035	0	$0.0	$0.0	$0.0	$0.0
2036	0	$0.0	$0.0	$0.0	$0.0
2050	2.32	$30,160	$76,560	$104,400	$204,160

Notes:

1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

Total Costs

Year	Total			
	5%	3%	2.50%	3% 95th Percentile
2023	17400	54000	81000	144000
2024	0	0	0	0
2025	0	0	0	0
2026	0	0	0	0
2027	0	0	0	0
2028	0	0	0	0
2029	0	0	0	0
2030	0	0	0	0
2031	0	0	0	0
2032	0	0	0	0
2033	$0	$0	$0	$0
2034	0	0	0	0
2035	0	0	0	0
2036	0	0	0	0
2050	$3,030,992	$8,180,876	$11,148,990	$24,854,187

Notes:

1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

Cape Cod Bridges 2050 No Build GHG Social Costs-Construction Activities

CO2

Year	CO_2 (metric tons/year) Note 2,3	5%	3%	2.50%	3% 95th Percentile
2018	0	$0.0	$0.0	$0.0	$0.0
2024	0	$0.0	$0.0	$0.0	$0.0
2025	0	$0.0	$0.0	$0.0	$0.0
2026	0	$0.0	$0.0	$0.0	$0.0
2027	0	$0	$0	$0	$0
2028	0	$0	$0	$0	$0
2029	0	$0.0	$0.0	$0.0	$0.0
2030	0	$0.0	$0.0	$0.0	$0.0
2031	0	$0.0	$0.0	$0.0	$0.0
2032	0	$0.0	$0.0	$0.0	$0.0
2033	0	$0.0	$0.0	$0.0	$0.0
2034	0	$0.0	$0.0	$0.0	$0.0
2035	0	$0.0	$0.0	$0.0	$0.0
2036	0	$0.0	$0.0	$0.0	$0.0
2050	91014	$2,876,042	$7,772,596	$10,594,030	$23,645,437

Notes:

1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

CH4

Year	CH4 (metric tons/year) Note 2,3	5%	3%	2.50%	3% 95th Percentile
2023	0	$0.0	$0.0	$0.0	$0.0
2024	0	$0.0	$0.0	$0.0	$0.0
2025	0	$0.0	$0.0	$0.0	$0.0
2026	0	$0.0	$0.0	$0.0	$0.0
2027	0	$0	$0	$0	$0
2028	0	$0	$0	$0	$0
2029	0	$0.0	$0.0	$0.0	$0.0
2030	0	$0.0	$0.0	$0.0	$0.0
2031	0	$0.0	$0.0	$0.0	$0.0
2032	0	$0.0	$0.0	$0.0	$0.0
2033	0	$0.0	$0.0	$0.0	$0.0
2034	0	$0.0	$0.0	$0.0	$0.0
2035	0	$0.0	$0.0	$0.0	$0.0
2036	0	$0.0	$0.0	$0.0	$0.0
2050	3.699	$6,288	$11,467	$14,056	$30,332

Notes:

1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

N2O

Year	N2O (metric tons/year) Note 2,3	5%	3%	2.50%	3% 95th Percentile
2023	3	$17,400.0	$54,000.0	$81,000.0	$144,000.0
2024	0	$0.0	$0.0	$0.0	$0.0
2025	0	$0.0	$0.0	$0.0	$0.0
2026	0	$0.0	$0.0	$0.0	$0.0
2027	0	$0	$0	$0	$0
2028	0	$0	$0	$0	$0
2029	0	$0.0	$0.0	$0.0	$0.0
2030	0	$0.0	$0.0	$0.0	$0.0
2031	0	$0.0	$0.0	$0.0	$0.0
2032	0	$0.0	$0.0	$0.0	$0.0
2033	0	$0.0	$0.0	$0.0	$0.0
2034	0	$0.0	$0.0	$0.0	$0.0
2035	0	$0.0	$0.0	$0.0	$0.0
2036	0	$0.0	$0.0	$0.0	$0.0
2050	2.24	$29,120	$73,920	$100,800	$197,120

Notes:

1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

Total Costs

Year	Total			
	5%	3%	2.50%	3% 95th Percentile
2023	17400	54000	81000	144000
2024	0	0	0	0
2025	0	0	0	0
2026	0	0	0	0
2027	0	0	0	0
2028	0	0	0	0
2029	0	0	0	0
2030	0	0	0	0
2031	0	0	0	0
2032	0	0	0	0
2033	$0	$0	$0	$0
2034	0	0	0	0
2035	0	0	0	0
2036	0	0	0	0
2050	$2,911,451	$7,857,983	$10,708,886	$23,872,889

Notes:

1. Direct Emissions derived from MOVES
2. Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)