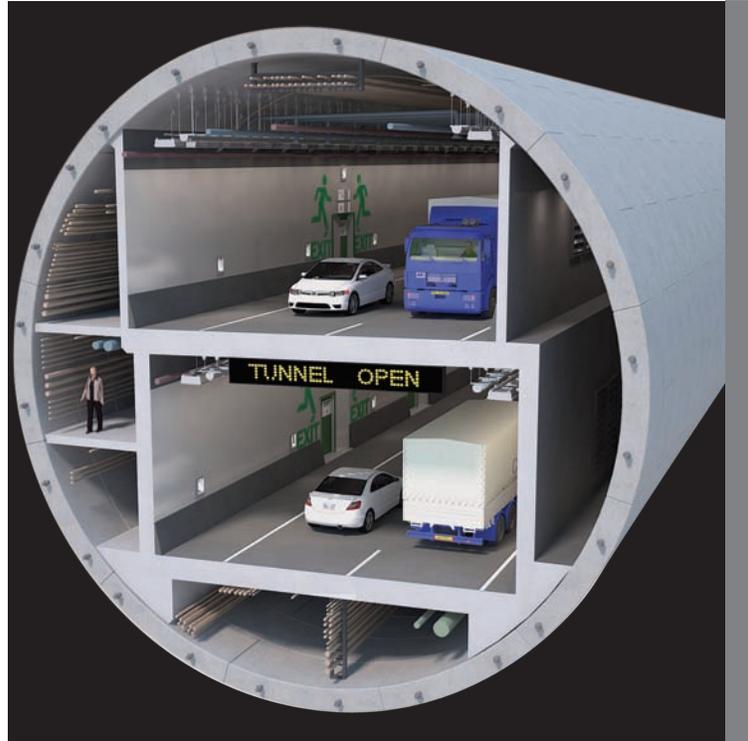


ALASKAN WAY VIADUCT REPLACEMENT PROJECT

2010 Supplemental Draft Environmental Impact Statement

APPENDIX R Energy Discipline Report



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OCTOBER 2010

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Alaskan Way Viaduct Replacement Project

Supplemental Draft EIS

Energy Discipline Report

The Alaskan Way Viaduct Replacement Project is a joint effort between the Federal Highway Administration (FHWA), the Washington State Department of Transportation (WSDOT), and the City of Seattle. To conduct this project, WSDOT contracted with:

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ACRONYMS AND ABBREVIATIONS

BTU	British thermal units
CAFE	Corporate Average Fuel Economy
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalents
eGRID	Emissions & Generation Resource Integrated Database
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FHWA	Federal Highway Administration
GWP	global warming potential
MMBTU	million British thermal units
MOVES	Motor Vehicle Emission Simulator
MWh	megawatt-hour
NEPA	National Environmental Policy Act
Program	Alaskan Way Viaduct and Seawall Replacement Program
project	Alaskan Way Viaduct Replacement Project
SEPA	State Environmental Policy Act
SODO	South of Downtown
SR	State Route
TBM	tunnel boring machine
VMT	vehicle miles of travel
WSDOT	Washington State Department of Transportation

Chapter 1 INTRODUCTION AND SUMMARY

1.1 Introduction

This discipline report evaluates the Bored Tunnel Alternative, the new alternative under consideration for replacing the Alaskan Way Viaduct. This report and the Alaskan Way Viaduct Replacement Project Supplemental Draft Environmental Impact Statement (EIS) that it supports are intended to provide new information and updated analyses to those presented in the March 2004 Alaskan Way Viaduct and Seawall Replacement Project Draft EIS and the July 2006 Alaskan Way Viaduct and Seawall Replacement Project Supplemental Draft EIS. The discipline reports present the detailed technical analyses of existing conditions and predicted effects of the Bored Tunnel Alternative. The results of these analyses are presented in the main volume of the Supplemental Draft EIS.

The Federal Highway Administration (FHWA) is the lead federal agency for this project, primarily responsible for compliance with the National Environmental Policy Act (NEPA) and other federal regulations, as well as distributing federal funding. As part of the NEPA process, FHWA is also responsible for selecting the preferred alternative. FHWA will base their decision on the information evaluated during the environmental review process, including information contained within the Supplemental Draft EIS and the subsequent Final EIS. FHWA can then issue their NEPA decision, called the Record of Decision (ROD).

The 2004 Draft EIS (WSDOT et al. 2004) evaluated five Build Alternatives and a No Build Alternative. In December 2004, the project proponents identified the cut-and-cover Tunnel Alternative as the preferred alternative and carried the Rebuild Alternative forward for analysis as well. The 2006 Supplemental Draft EIS (WSDOT et al. 2006) analyzed two alternatives—a refined cut-and-cover Tunnel Alternative and a modified rebuild alternative called the Elevated Structure Alternative. After continued public and agency debate, Governor Gregoire called for an advisory vote to be held in the city of Seattle. The March 2007 ballot included an elevated alternative and a surface-tunnel hybrid alternative. The citizens voted down both alternatives.

Following this election, the lead agencies committed to a collaborative process to find a solution to replace the viaduct along Seattle's central waterfront. This Partnership Process is described in Appendix S, the Project History Report. In January 2009, Governor Gregoire, King County Executive Sims, and Seattle Mayor Nickels announced that the agencies had reached a consensus and recommended replacing the aging viaduct with a bored tunnel.

The environmental review process for the Alaskan Way Viaduct Replacement Project (the project) builds on the five Build Alternatives evaluated in the 2004

Draft EIS and the two Build Alternatives evaluated in the 2006 Supplemental Draft EIS. It also incorporates the work done during the Partnership Process. The bored tunnel was not studied as part of the previous environmental review process, and so it becomes the eighth alternative to be evaluated in detail.

The Bored Tunnel Alternative analyzed in this discipline report and in the Supplemental Draft EIS has been evaluated both quantitatively and qualitatively. The Bored Tunnel Alternative includes replacing State Route (SR) 99 with a bored tunnel and associated improvements, such as relocating utilities located on or under the viaduct, removing the viaduct, decommissioning the Battery Street Tunnel, and making improvements to the surface streets in the tunnel's south and north portal areas.

Improvements at the south portal area include full northbound and southbound access to and from SR 99 between S. Royal Brougham Way and S. King Street. Alaskan Way S. would be reconfigured with three lanes in each direction. Two options are being considered for new cross streets that would intersect with Alaskan Way S.:

- New Dearborn Intersection – Alaskan Way S. would have one new intersection and cross street at S. Dearborn Street.
- New Dearborn and Charles Intersections – Alaskan Way S. would have two new intersections and cross streets at S. Charles Street and S. Dearborn Street.

Improvements at the north portal area would include restoring Aurora Avenue and providing full northbound and southbound access to and from SR 99 near Harrison and Republican Streets. Aurora Avenue would be restored to grade level between Denny Way and John Street, and John, Thomas, and Harrison Streets would be connected as cross streets. This rebuilt section of Aurora Avenue would connect to the new SR 99 alignment via the ramps at Harrison Street. Mercer Street would be widened for two-way operation from Fifth Avenue N. to Dexter Avenue N. Broad Street would be filled and closed between Ninth Avenue N. and Taylor Avenue N. Two options are being considered for Sixth Avenue N. and the southbound on-ramp:

- The Curved Sixth Avenue option proposes to build a new roadway that would extend Sixth Avenue N. in a curved formation between Harrison and Mercer Streets. The new roadway would have a signalized intersection at Republican Street.
- The Straight Sixth Avenue option proposes to build a new roadway that would extend Sixth Avenue N. from Harrison Street to Mercer Street in a typical grid formation. The new roadway would have signalized intersections at Republican and Mercer Streets.

For these project elements, the analyses of effects and benefits have been quantified with supporting studies, and the resulting data are found in the discipline reports (Appendices A through R). These analyses focus on assessing the Bored Tunnel Alternative's potential effects for both construction and operation, and consider appropriate mitigation measures that could be employed. The Viaduct Closed (No Build Alternative) is also analyzed.

The Alaskan Way Viaduct Replacement Project is one of several independent projects that improve safety and mobility along SR 99 and the Seattle waterfront from the South of Downtown (SODO) area to Seattle Center. Collectively, these individual projects are often referred to as the Alaskan Way Viaduct and Seawall Replacement Program (the Program). This Supplemental Draft EIS evaluates the cumulative effects of all projects in the Program; however, direct and indirect environmental effects of these independent projects will be considered separately in independent environmental documents. This collection of independent projects is categorized into four groups: roadway elements, non-roadway elements, projects under construction, and completed projects.

Roadway Elements

- Alaskan Way Surface Street Improvements
- Elliott/Western Connector
- Mercer West Project (Mercer Street improvements from Fifth Avenue N. to Elliott Avenue)

Non-Roadway Elements

- First Avenue Streetcar Evaluation
- Transit Enhancements
- Elliott Bay Seawall Project
- Alaskan Way Promenade/Public Space

Projects Under Construction

- S. Holgate Street to S. King Street Viaduct Replacement
- Transportation Improvements to Minimize Traffic Effects During Construction

Completed Projects

- SR 99 Yesler Way Vicinity Foundation Stabilization (Column Safety Repairs)
- S. Massachusetts Street to Railroad Way S. Electrical Line Relocation Project (Electrical Line Relocation Along the Viaduct's South End)

1.2 Summary

An analysis was conducted to determine the energy requirements and greenhouse gas emissions associated with the project. Analyses were conducted for 2005 existing conditions, 2015 Existing Viaduct conditions (assuming that the viaduct would still be functional), conditions resulting from the Bored Tunnel Alternative in 2015 and 2030, and conditions for two scenarios under the Viaduct Closed (No Build Alternative) in 2030. Traffic data for the 2030 design year are not available for the Viaduct Closed (No Build Alternative). Therefore, the Viaduct Closed (No Build Alternative) has been qualitatively analyzed and compared to the Bored Tunnel Alternative.

The energy required to construct the facilities associated with the project and the energy required for the operational phase of the project (i.e., to propel vehicles using the affected roadways and to maintain the facilities after construction is completed) were estimated.

Energy estimates for vehicles using the project's roadways were calculated using the 2009 draft Motor Vehicle Emission Simulator (MOVES2009) model from the U.S. Environmental Protection Agency (EPA). Construction energy estimates were calculated based on the latest construction schedule, taking into account several factors, including the equipment to be used, construction activities, equipment load factors, and fuel utilization rates.

Greenhouse gas emissions, discussed in terms of carbon dioxide equivalents (CO₂e), were also calculated for both the construction and operational phases of the project. The potential direct emission of greenhouse gases under the Bored Tunnel Alternative was estimated using the MOVES2009 model and the results of the energy analyses.

The results of these energy analyses are summarized in Exhibit 1-1. In 2015, the Bored Tunnel Alternative would result in similar average daily operational energy requirements and average daily operational greenhouse gas emissions (expressed as CO₂e) than those under 2015 Existing Viaduct conditions. In 2030, the Bored Tunnel Alternative would result in higher average daily operational energy requirements and average daily operational CO₂e emissions than those under existing conditions in 2005, under conditions in 2015 Existing Viaduct, and under the Bored Tunnel Alternative in 2015. This is mainly due to projected increases in future vehicle traffic and fuel use, which would result in an overall increase in energy consumption and CO₂e emissions compared to existing conditions and 2015 Existing Viaduct conditions. Future values, however, are extremely conservative because they do not take into account the expected future shift in vehicle mix (i.e., fewer light-duty trucks and more fuel-efficient vehicles, including hybrids) or the new Corporate Average Fuel Economy (CAFE)

standards, which will lead to better fleetwide fuel efficiency and result in lower energy consumption and CO₂e emissions than the levels currently predicted.

Exhibit 1-1. Summary of Results

	2005 Existing Conditions	2015 Existing Viaduct	2015 Bored Tunnel Alternative	2030 Bored Tunnel Alternative
Average daily operational energy required (MMBTU/day, including maintenance)	524,482	624,153	624,345	748,944
Average yearly construction energy (over 66-month construction period [5.5 years]) (MMBTU/year)	Not applicable	Not applicable	48,875	48,875
Average daily CO ₂ e operational emissions (metric tons/day, including maintenance)	39,190	46,558	46,584	55,836
Average annual CO ₂ e construction emissions (metric tons/year)	Not applicable	Not applicable	8,146	8,146

Note:

CO₂e = carbon dioxide equivalents, representing an amount of greenhouse gas

MMBTU = million British thermal units

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Chapter 2 BACKGROUND

2.1 Transportation Energy

Transportation energy is the energy required to move people and goods from place to place. Transportation accounts for a major portion of the energy consumed in Washington State. Transportation energy is broken down into operational energy and construction energy. Operational energy includes both the energy consumed by the vehicles and the energy used to maintain the transportation facility. Construction energy includes the energy used to construct the facility.

Energy is commonly measured in terms of British thermal units (BTU). A BTU is defined as the amount of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit. Fossil fuels (e.g., gasoline, diesel fuel, and jet fuel) are the predominant source of energy for transportation in Washington.

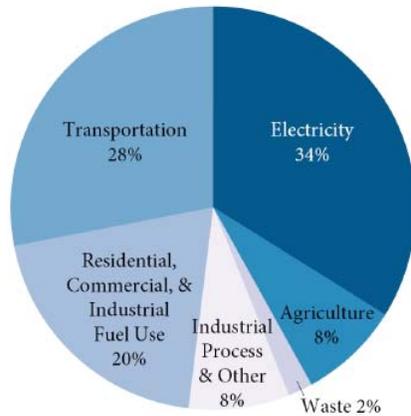
2.2 Greenhouse Gases and Transportation

Vehicles emit a variety of gases during their operation; some of these are greenhouse gases: water vapor, carbon dioxide (CO₂), methane (also known as “marsh gas”), and nitrous oxide (used in dentists’ offices and also referred to as “laughing gas”). Any process that burns fossil fuel releases CO₂ into the air. CO₂ makes up the bulk of the emissions from transportation.

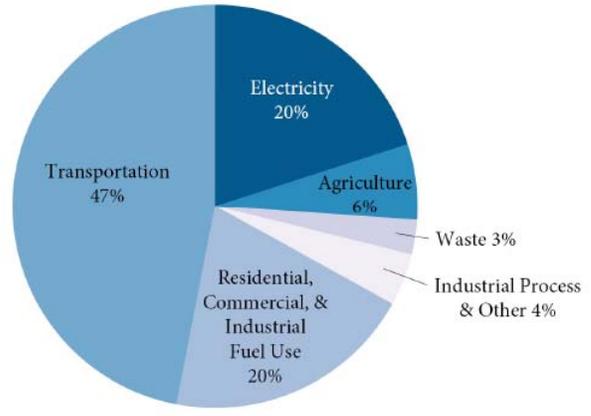
Vehicles are a substantial source of greenhouse gas emissions and contribute to global warming primarily through the burning of gasoline and diesel fuel. National estimates show that the transportation sector (including on-road vehicles, construction activities, airplanes, and boats) accounts for almost 30 percent of total domestic CO₂ emissions. However, in Washington State, transportation accounts for nearly half of the greenhouse gas emissions because the state relies heavily on hydropower for electricity generation, unlike other states that rely on fossil fuels such as coal, petroleum, and natural gas to generate electricity. The next largest contributors to total greenhouse gas emissions in Washington are fossil fuel combustion in the residential, commercial, and industrial sectors at 20 percent and in electricity consumption, also 20 percent. Exhibit 2-1 shows the greenhouse gas emissions by sector, nationally and in Washington State.

Exhibit 2-1. Greenhouse Gas Emissions by Sector in 2005 for the United States and Washington State

U.S. Greenhouse Gas Emissions



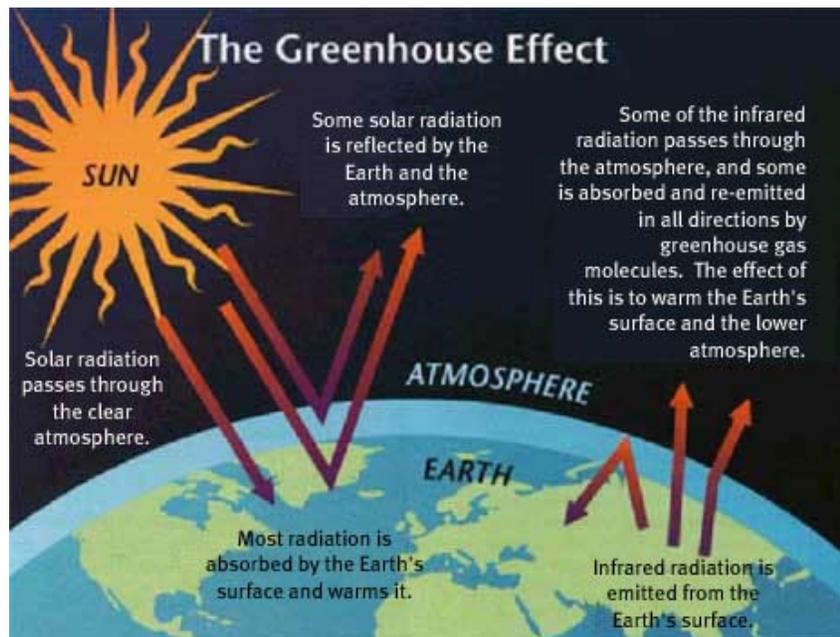
Washington Greenhouse Gas Emissions



Source: WSDOT 2009.

The presence of naturally occurring greenhouse gases in the Earth’s atmosphere keeps the planet’s surface warmer than it otherwise would be and is therefore necessary for life. This is referred to as the greenhouse effect, which is depicted on Exhibit 2-2. As concentrations of greenhouse gases increase, the Earth’s temperature increases. The principal greenhouse gases present in the atmosphere as a result of human activities are described below.

Exhibit 2-2. The Greenhouse Effect



Source: SEI 2007.

Carbon Dioxide (CO₂). CO₂ enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees, and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). CO₂ is also removed from the atmosphere (or “sequestered”) when it is absorbed by plants as part of the biological carbon cycle.

Methane (CH₄). Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

Nitrous Oxide (N₂O). Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

Fluorinated Gases. Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are powerful, synthetic greenhouse gases that are emitted from a variety of industrial processes. These gases are typically emitted in small quantities, but because they are potent greenhouse gases, they are sometimes referred to as high global warming potential (high-GWP) gases.

Greenhouse gases differ in their ability to trap heat. For example, 1 ton of CO₂ emissions has a different effect than 1 ton of methane emissions. To compare emissions of different greenhouse gases, inventory compilers use a weighting factor called the “global warming potential” (GWP). To use the GWP, the heat-trapping ability of 1 metric ton (1,000 kilograms) of CO₂ is taken as the standard, and emissions are expressed in terms of CO₂ equivalents (CO₂e), although they can also be expressed in terms of carbon equivalents.

The gases of concern for this analysis are those associated with the combustion of fossil fuels used in transportation: CO₂, methane, and nitrous oxide. The GWPs of these gases are presented in Exhibit 2-3. A larger number represents a stronger absorption and longer atmospheric residence time.

Exhibit 2-3. Greenhouse Gas Global Warming Potentials

Greenhouse Gas	Formula	Global Warming Potential
Carbon dioxide	CO ₂	1
Methane	CH ₄	25
Nitrous oxide	N ₂ O	298

Source: IPCC 2007.

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Chapter 3 METHODOLOGY

Transportation energy is generally discussed in terms of operational and construction energy consumption. Operational energy consumption involves all energy consumed by vehicle propulsion. This energy is a function of traffic characteristics such as volume, speed, distance traveled, vehicle mix, and the thermal value of the fuel being used. Operational energy consumption also includes the energy required to maintain the transportation facilities. Construction energy consumption involves the nonrecoverable, one-time energy expenditure involved in constructing the physical infrastructure associated with the project. Greenhouse gas emissions are also discussed in terms of operational and construction emissions.

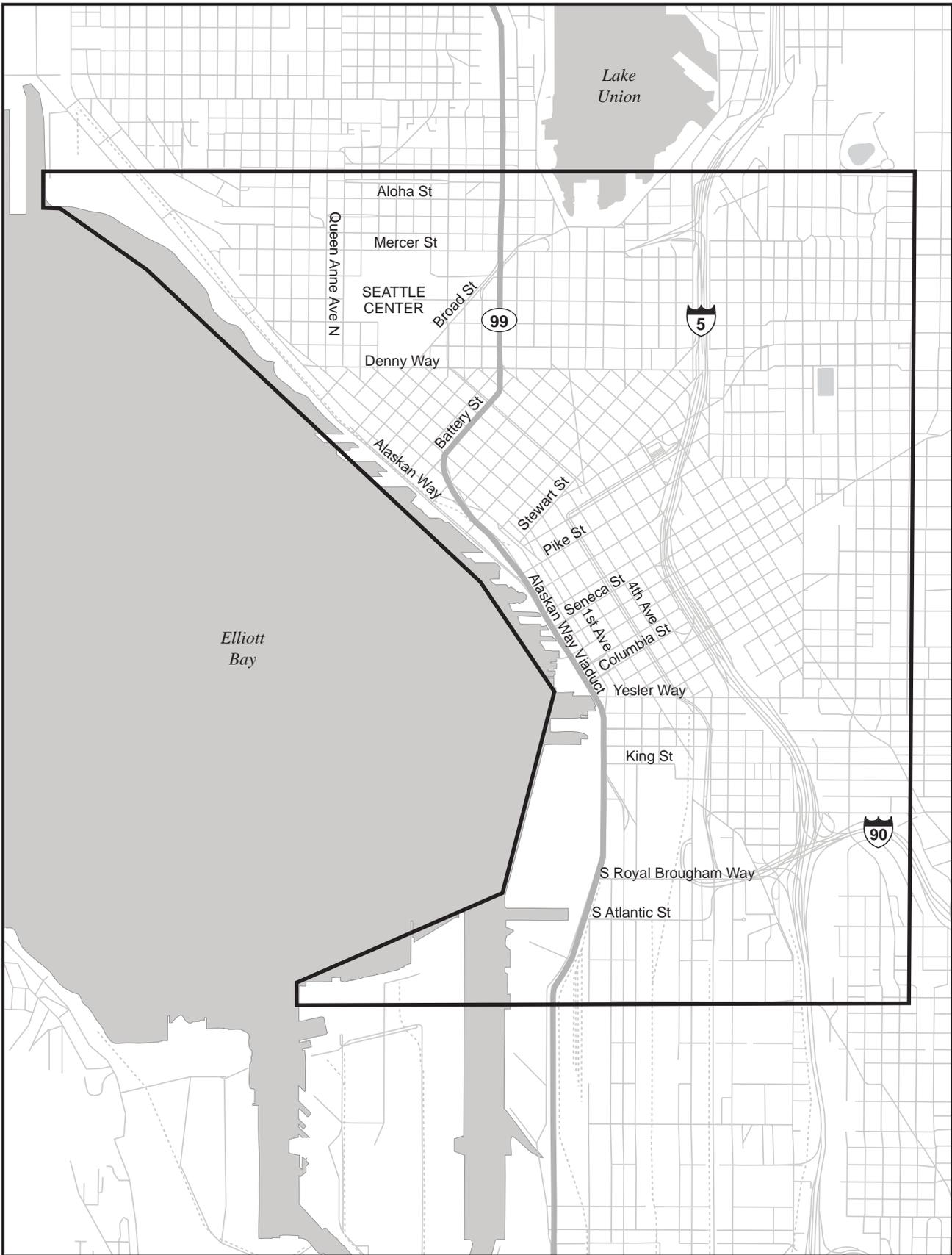
3.1 Study Area

The study area evaluated for energy effects includes areas likely to be affected by changes in energy use and greenhouse gas emissions as a result of the project. The energy and greenhouse gas effects were estimated for roadways within the city center area, as well as on a regional scale. The city center area is bordered by Prospect Street on the north, 15th Avenue on the east, S. Holgate Street on the south, and Elliott Bay on the west, as shown on Exhibit 3-1. The regional scale includes all the traffic movements occurring in King, Pierce, Snohomish, and Kitsap Counties; the regional study area is shown on Exhibit 3-2.

3.2 Applicable Regulations and Guidelines

The following laws, statutes, local ordinances, and guidelines address potential energy and resulting greenhouse gas effects:

- The National Environmental Policy Act (NEPA).
- Presidential Executive Order 13423.
- Washington State Environmental Policy Act (SEPA).
- Washington State Department of Transportation (WSDOT) *Environmental Procedures Manual* (February 2010).
- WSDOT *Guidance for Project-Level Greenhouse Gas and Climate Change Evaluations* (September 2009).
- City of Seattle Ordinance 122574, which requires City departments to evaluate climate impacts when performing environmental review of actions pursuant to SEPA (adopted in December 2007).
- City of Seattle Ordinance 122610, which calls for the reduction of greenhouse gases in Seattle by 30 percent from year 1990 levels by 2024, and by 80 percent from 1990 levels by 2050 (adopted in December 2007).



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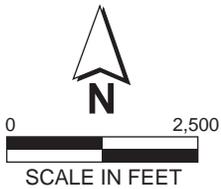
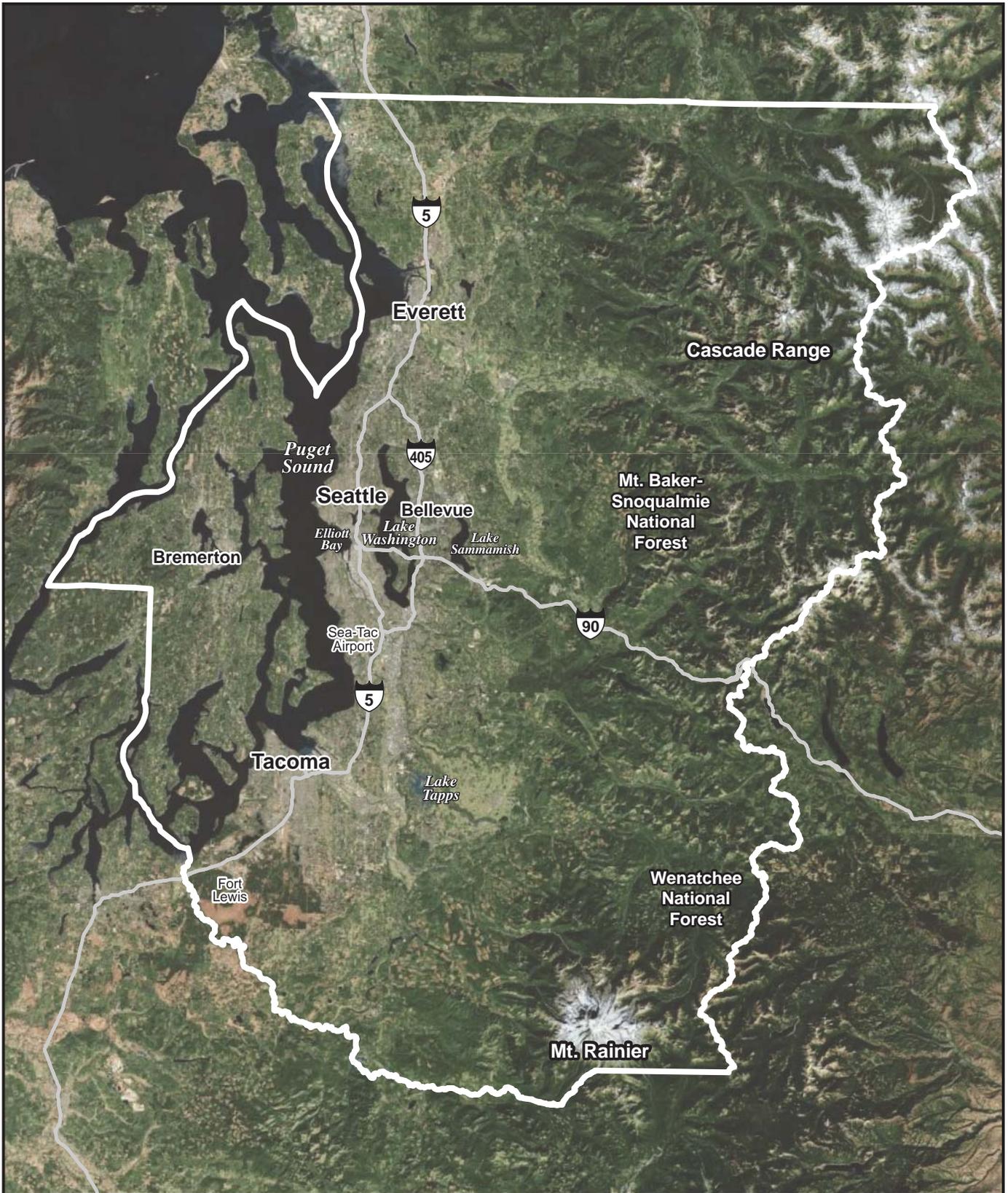


Exhibit 3-1
City Center Study Area



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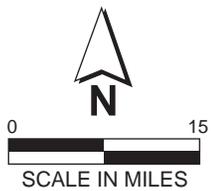


Exhibit 3-2
Regional Study Area

3.3 Data Needs and Sources

3.3.1 Traffic Data

To determine the operational energy effects of the project, data from the project's traffic demand forecasting model were used as input for this analysis. The data used included link by link estimates of vehicle miles of travel (VMT) and travel speeds. Existing condition estimates were derived from the travel demand model calibrated to traffic counts conducted by WSDOT and the City of Seattle from 2004 through 2006. Traffic volumes on SR 99 within the study area have generally remained stable in recent years, so these volume estimates can still be considered current. Some additional on-corridor traffic count data were collected in 2007 and 2008 by the City of Seattle. The data were evaluated, and existing traffic volume estimates were updated as necessary to reflect changes, if any, evident in these latest counts. For modeling purposes and documentation of the affected environment, the project team used 2005 to represent the existing conditions.

The power requirement of the ventilation and lighting equipment was also obtained from the tunnel and ventilation analysis conducted for the project. The total operational energy use of the project was calculated by combining the energy requirements of the vehicles using the roadway with the energy requirements for the ventilation and lighting.

Traffic data for the 2030 design year are not available for the Viaduct Closed (No Build Alternative). Therefore, this alternative has been qualitatively analyzed and compared to the Bored Tunnel Alternative.

3.3.2 Construction Data

To determine the construction energy requirements of the project, the following information was used:

- Estimated earth excavation and grading quantities.
- Methods for handling and transporting excavated material and debris.
- Estimated hours of operation of heavy-duty diesel- and gasoline-powered construction equipment.
- Estimated hours of operation of electrically powered construction equipment.
- Estimated hours of operation of heavy-duty diesel trucks involved in the transport of excavated material and the delivery of construction material, both within construction areas and on local streets.

3.3.3 Motor Vehicle Fuel Use and Greenhouse Gas Emission Factors

Energy estimates for vehicles using the project's roadways were calculated using the 2009 draft MOVES model (MOVES2009) from the U.S. Environmental Protection Agency (EPA). The EPA MOVES model estimates overall fuel use based on fleet characteristics such as vehicle mix, vehicle age, and speed, as well as area-specific meteorological data (EPA 2009a). MOVES2009 is EPA's new emission modeling system that has been released in draft form and was the version available at the time the analysis was conducted. Although it has not been approved for use in air quality analyses, EPA considered the MOVES2009 model to be the model of choice for estimating greenhouse gas emissions; it was recommended for use even in draft form.

3.3.4 Greenhouse Gas Emission Factors for Electrical Power

Emission factors are used to estimate the amount of greenhouse gases that would be released by an activity. To determine the project's effects on greenhouse gas emissions, the project team had to select an emission factor for use of electrical energy provided by one of the following three sources:

- The U.S. Department of Energy's Energy Information Administration provides state-specific emission factors for electricity use (EIA 2007). This source considers electrical power generating sources in Washington, Oregon, and Idaho. Applying the appropriate GWP, a CO₂e emission factor of 0.148 metric ton per megawatt-hour (MWh) would be used to obtain the CO₂e emissions due to the power requirements of the project.
- EPA provides Emissions & Generation Resource Integrated Database (eGRID) emission factors for electricity use (EPA 2009b). This source considers electrical power generating sources in the entire Pacific Northwest, including Washington, Oregon, Idaho, Utah, and parts of Montana, Nevada, Wyoming, northern California, and northern Arizona. Applying the appropriate GWP, a CO₂e emission factor of 0.411 metric ton/MWh would be used to obtain the CO₂e emissions due to the power requirements of the project.
- Seattle City Light uses the eGRID non-baseload emissions factor of 0.60 metric ton/MWh. This considers the marginal electrical power generating resources used to serve new electrical load.

The analysis in this document uses the eGRID baseload emissions factor for electricity use. This represents the middle of the three available factors: 0.411 metric ton/MWh, rather than 0.148 metric ton/MWh (U.S. Department of Energy 2009a) or the eGRID non-baseload factor of 0.60 metric ton/MWh. Both eGRID numbers apply specifically to the northwestern states.

3.4 Studies and Coordination

Energy methods and analysis procedures were developed for the project in coordination with WSDOT, the City of Seattle, King County, and FHWA. On March 5, 2009, an updated methodology for energy and greenhouse gas analysis was presented to WSDOT and City of Seattle staff. Input from these agencies was incorporated into this study. The final methodology was approved by WSDOT on July 28, 2009.

3.5 Operational Energy Effects

Operation effects were evaluated under three conditions. Federal and Washington State regulations require agencies to evaluate a No Build Alternative to provide baseline information about future conditions in the project area. Existing Viaduct conditions, which assume that the viaduct will still be operational, have been analyzed for the year 2015. However, the Viaduct Closed (No Build Alternative) is not a viable alternative because the existing viaduct is vulnerable to earthquakes and failure due to ongoing deterioration. At some point in the future, the roadway will need to be closed. Therefore, this report qualitatively discusses the effects of two scenarios for the 2030 Viaduct Closed (No Build Alternative).

The effects of the Bored Tunnel Alternative on transportation-related energy consumption in the study area have been quantitatively assessed. Operational energy includes all energy consumed by the annual maintenance required by the project and the energy used in vehicle propulsion.

The energy required to maintain the project includes the energy consumed for lighting, ventilation systems, and roadway maintenance (e.g., patching, crack sealing, and landscape maintenance) for the total lane-miles of the Bored Tunnel Alternative and the 2015 Existing Viaduct.

Based on the EPA MOVES2009 model, the energy consumed by vehicles using a facility is affected by vehicle volumes, vehicle mix, travel speeds, and fuel efficiency. Operational energy effects were analyzed for 2015 Existing Viaduct conditions and the 2015 and 2030 Bored Tunnel Alternative. The operational energy analysis was conducted using the following factors:

- Vehicle volumes derived for each facility segment, producing VMT per roadway link. Over 250 links were individually analyzed on the city level, and over 800 links were individually analyzed on the regional level.
- Vehicle mix (percentage of automobiles, trucks, etc.) and speed were used to identify fuel consumption rates.
- Total vehicle fuel use in the study area was estimated by combining fuel use, calculated on a link by link basis as described above, resulting in an overall vehicle fuel use value for the study area.

3.6 Construction Energy Effects

The energy required for construction was estimated based on horsepower requirements, equipment use, equipment load factors, and the construction schedule for the Bored Tunnel Alternative. Construction of the Bored Tunnel Alternative includes construction of the power supply substation for the electrically powered tunnel boring machine (TBM), electrical energy required to power the TBM, the tunnel construction (including the slurry treatment plant and operation of the TBM), and installation of the signage for the intelligent transportation systems.

3.7 Direct Greenhouse Gas Emissions

The EPA MOVES model was used to estimate greenhouse gas emission factors resulting from fossil fuel consumption using a combination of area-specific and national parameters to reflect the project conditions. The results of the MOVES2009 model and the results of the operational and construction energy analyses were used to estimate potential direct emissions of greenhouse gases for the 2015 Existing Viaduct conditions and the Bored Tunnel Alternative. The results are reported as CO₂e, which represents CO₂, nitrous oxide, and methane emissions with the appropriate GWP factors applied.

It is assumed that this project would result in CO₂, nitrous oxide, and methane emissions from the combustion of motor vehicle fuel by vehicles using the facility. In addition, emissions would result from the fuel and electricity used to construct, operate (lighting and ventilation), and maintain the facility.

3.8 Cumulative Energy and Greenhouse Gas Emission Effects

Cumulative effects are effects on the environment that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. The cumulative effects analysis focused on the combined effects of the Bored Tunnel Alternative and other roadway and non-roadway elements included in the Program. In addition, the cumulative effects of the Bored Tunnel Alternative in combination with other projects that are anticipated to contribute effects on energy and greenhouse gas emissions in the study area were evaluated.

These other roadway and non-roadway elements of the Program were qualitatively assessed for operational and construction effects on energy and greenhouse gas emissions. The roadway Program elements included in this qualitative analysis are the Alaskan Way Surface Street Improvements (on the location of the former viaduct) from S. King Street to Pike Street, the Elliott/Western Connector from Pike Street to Battery Street, and the Mercer West Project (Mercer Street improvements from Fifth Avenue N. to Elliott Avenue).

The non-roadway Program elements include the Elliott Bay Seawall Project, the Alaskan Way Promenade/Public Space to be built on the location of the existing Alaskan Way surface street, the First Avenue Streetcar Evaluation, and Transit Enhancements.

Other planned projects and developments in Seattle may add to the effects on energy and greenhouse gas emissions in the study area. The following projects were also included in the cumulative effects analysis:

- Alaskan Way Viaduct and Seawall Replacement Moving Forward projects
- Sound Transit University Link Light Rail Project
- Sound Transit North Link Light Rail Project
- Sound Transit East Link Light Rail
- Sound Transit Phases 1 and 2
- S. Spokane Street Viaduct Widening
- SR 519 Intermodal Access Project, Phase 2
- SR 520 Bridge Replacement and HOV Program
- I-5 Improvements
- South Lake Union Redevelopment

Chapter 4 AFFECTED ENVIRONMENT

The study area evaluated for energy effects includes areas likely to be affected by changes in energy use and greenhouse gas emissions as a result of the project. Current energy use and the greenhouse gas emissions were estimated for roadways in the city center area and on a regional scale.

4.1 City of Seattle

According to *Seattle's Community Carbon Footprint: An Update* (Seattle 2008), the city's carbon footprint was about 8 percent smaller in 2005 than it was in 1990. This reduction was due to energy conservation efforts and Seattle City Light's policy of achieving "net zero" greenhouse gas emissions in delivery of electricity through the use of conservation, renewable energy, and purchase of carbon offsets. Furthermore, the shift of many households and businesses from heating oil to natural gas, a less carbon-intensive fossil fuel, has resulted in lower greenhouse gas emissions.

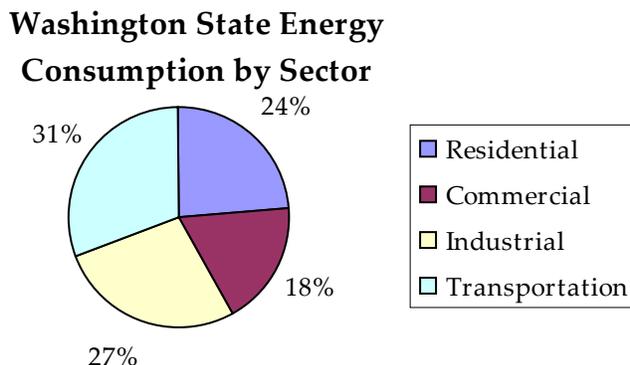
Per capita greenhouse gas emissions in Seattle were 11 percent lower in 2005 than in 1990, with per capita emissions of about 11.5 tons per year in 2005. This value compares favorably to those of Washington State (14.1 tons) and the United States (24 tons).

The emissions from transportation sources (road, rail, marine, and air), which make up roughly 60 percent of Seattle's carbon footprint, have increased about 3 percent compared to 1990. Emissions from on-road transportation (trucks, buses, vans, cars, sports utility vehicles [SUVs], and light-duty trucks), which make up roughly 40 percent of Seattle's carbon footprint, were up roughly 5 percent from 1990 levels.

4.2 Washington State

As shown on Exhibit 4-1, transportation currently accounts for approximately 31 percent of the energy consumed in Washington. On a per capita basis, Washington's transportation energy consumption is approximately 322.2 million BTU (MMBTU), which is below the national average of 333.1 MMBTU. Petroleum (i.e., gasoline, diesel fuel, and jet fuel) is the predominant source of energy for transportation in Washington State.

Exhibit 4-1. Washington State Energy Consumption by Sector (2006)



Source: EIA 2008.

National estimates show that the transportation sector (including on-road, construction, airplanes, and boats) accounts for almost 30 percent of total domestic CO₂ emissions.¹ However, as shown on Exhibit 2-1, transportation accounts for nearly half of the greenhouse gas emissions in Washington State because the state relies heavily on hydropower for electricity generation, unlike other states that rely on fossil fuels such as coal, petroleum, and natural gas to generate electricity. The next largest contributors to total gross greenhouse gas emissions in Washington are fossil fuel combustion in the residential, commercial, and industrial sectors and in electricity generation facilities, both 20 percent.

¹ This percentage is based on 2004 data from the International Energy Administration and is consistent with 1996 guidelines on greenhouse gas emissions calculations issued by the Intergovernmental Panel on Climate Change (IPCC).

Chapter 5 OPERATIONAL ENERGY EFFECTS, MITIGATION, AND BENEFITS

As required in WSDOT procedures and guidelines, a detailed energy analysis was conducted for this project due to its scope and nature. Both the energy used to maintain the transportation facility and the energy consumed by vehicles using the facility were estimated.

Both federal and Washington State environmental regulations require agencies to evaluate a No Build Alternative to provide baseline information about existing conditions in the project area. For this project, the No Build Alternative is not a viable alternative since the existing viaduct is vulnerable to earthquakes and structural failure due to ongoing deterioration. Multiple studies of the viaduct's current structural conditions, including its foundations in liquefiable soils, have determined that retrofitting or rebuilding the existing viaduct is not a reasonable alternative. At some point in the future, the roadway will need to be closed.

The Viaduct Closed (No Build Alternative) describes what would happen if the bored tunnel or another build alternative is not implemented. If the existing viaduct is not replaced, it will be closed, but it is unknown when that would happen. However, it is highly unlikely that the existing structure could still be in use in 2030. For these reasons, this Supplemental Draft EIS compares the effects of the proposed build alternatives to a 2015 Existing Viaduct, which assumes that the existing viaduct will continue to be part of the transportation network between S. King Street and Denny Way in the year 2015. For this environmental analysis, the focus is on comparing the proposed Bored Tunnel Alternative with the 2015 Existing Viaduct in Section 5.2.

The Viaduct Closed (No Build Alternative) describes the consequences of suddenly losing the function of SR 99 along the central waterfront based on two scenarios. This report qualitatively discusses the effects of the two scenarios for the 2030 Viaduct Closed (No Build Alternative) in Section 5.1. These consequences would be short-term and would last until transportation and other agencies could develop and implement a new, permanent solution. The planning and development of the new solution would have its own environmental review.

5.1 Operational Energy Effects of the 2030 Viaduct Closed (No Build Alternative)

There are two scenarios for the 2030 Viaduct Closed (No Build Alternative):

- Scenario 1 involves the sudden unplanned closure of the viaduct.
- Scenario 2 involves the catastrophic and complete collapse of the viaduct.

5.1.1 Scenario 1: Sudden Unplanned Closure of the Viaduct

Under Scenario 1, there would be a sudden, unplanned closure of SR 99 between S. King Street and Denny Way due to some structural deficiency, weakness, or small earthquake event. The viaduct would be closed for an unknown period of time until a viaduct replacement could be built. Severe travel delays would be experienced, and utilities on the viaduct would likely require repair. Although current projections indicate a general increase in future vehicle traffic, the actual increase if the viaduct were no longer in service is unknown and depends on multiple factors, such as changed or canceled trips and changes in mode of travel.

5.1.2 Scenario 2: Catastrophic and Complete Collapse of the Viaduct

Scenario 2 considers the effects of a catastrophic failure and collapse of the viaduct. Under this scenario, a seismic event of similar or greater magnitude than the 2001 Nisqually earthquake could trigger failure of portions of the viaduct. This scenario would have the greatest effect on people and the environment. Failure of the viaduct could cause injuries and death to people traveling on or near the structure at the time of the seismic event. Travel delays would be severe. The environmental effects and length of time it would take to repair the SR 99 corridor are unknown, but the effects would be severe. Although current projections indicate a general increase in future vehicle traffic, the actual increase if the viaduct were no longer in service is unknown and depends on multiple factors, such as changed or canceled trips and changes in mode of travel.

5.1.3 Comparison of Scenarios 1 and 2

Both Scenario 1 and Scenario 2 would involve the loss of use of the viaduct, which would result in severe travel delays and unknown changes in traffic patterns. However, Scenario 2 would involve greater energy consumption due to the equipment and activities needed for the cleanup of a catastrophic and complete collapse of the viaduct.

5.2 Operational Energy Effects Under 2015 Existing Viaduct Conditions and the 2015 and 2030 Bored Tunnel Alternative

Operational energy consumption by vehicles under 2005 existing conditions, 2015 Existing Viaduct conditions, and the Bored Tunnel Alternative in 2015 and 2030 was calculated using project-specific values for VMT and average speed on a link by link basis, along with national vehicle mix information (shown in Exhibit 5-1). In addition, the fuel use factors were derived from the EPA MOVES2009 model. The resulting estimates of vehicular energy use are shown in Exhibit 5-2.

Exhibit 5-1. MOVES2009 National Average Vehicle Mix (Percentage)

Type of Vehicle	Year 2005	Year 2015	Year 2030
Motorcycles	1.9	1.9	1.7
Passenger cars	51.4	42.8	36.3
Passenger trucks	32.1	38.4	43.8
Light commercial trucks	10.7	12.9	14.0
Buses	0.4	0.4	0.4
Trucks (medium and heavy duty)	3.5	3.7	3.7

Exhibit 5-2. Daily Roadway Vehicular Energy Consumption (MMBTU)

Study Area	Existing Conditions	2015 Existing Viaduct	2015 Bored Tunnel Alternative	2030 Bored Tunnel Alternative
City Center	13,221	15,252	15,186	16,583
Regional	524,473	624,145	624,098	748,696

Note:

MMBTU = million British thermal units

In 2015, daily roadway vehicle use would consume approximately 15,186 MMBTU of energy in the city center and 624,098 MMBTU of energy under the Bored Tunnel Alternative (Exhibit 5-2). Under 2015 Existing Viaduct conditions, energy consumption is predicted to be approximately 15,252 MMBTU in the city center and 624,145 MMBTU in the region. Therefore, in 2015, the Bored Tunnel Alternative would result in energy consumption in the city center and the region that is similar to the consumption under 2015 Existing Viaduct conditions. In 2030, daily roadway vehicle use would consume approximately 16,583 MMBTU of energy in the city center and 748,696 MMBTU of energy in the region under the Bored Tunnel Alternative.

Fuel use in 2030 is estimated to increase and would, therefore, result in an overall increase in energy consumption and CO₂e emissions compared to existing conditions. Future values, however, are extremely conservative because they do not take into account the expected future shift in vehicle mix (i.e., fewer light-duty trucks and more fuel-efficient vehicles, including hybrids). New CAFE standards, which are not currently accounted for in MOVES2009, would lead to better fleetwide fuel efficiency and result in lower energy consumption and CO₂e emissions than those predicted. It is estimated that 2012–2016 CAFE regulations will reduce light-duty fleet greenhouse gas emissions by approximately 21 percent by 2030, as compared to the level that would occur without the regulations (NHTSA 2010).

Operational energy requirements for lighting, maintenance of the roadway, and operation of the ventilation buildings were based on estimated lighting and ventilation use and typical roadway maintenance requirements. The energy requirements for these elements of the project are shown in Exhibit 5-3.

Exhibit 5-3. Daily Maintenance Energy Consumption (MMBTU)

Energy Segment	Existing Conditions	2015 Existing Viaduct	2015 Bored Tunnel Alternative	2030 Bored Tunnel Alternative
Ventilation and lighting	0	0	239	239
Roadway maintenance	9	9	9	9
Total	9	9	248	248

Note:

Values have been rounded to the nearest whole number.
MMBTU = million British thermal units

The combined energy requirements for vehicles, maintenance, lighting, and ventilation are indicated in Exhibit 5-4. As shown, the total operational energy requirement of the Bored Tunnel Alternative in 2015 would be similar to the total under 2015 Existing Viaduct conditions. The total operational energy requirement of the Bored Tunnel Alternative in 2030 would be higher than those under existing conditions and 2015 Existing Viaduct conditions.

Exhibit 5-4. Total Daily Operational Energy Consumption (MMBTU)

Energy Segment	Existing Conditions	2015 Existing Viaduct	2015 Bored Tunnel Alternative	2030 Bored Tunnel Alternative
Ventilation and lighting	0	0	239	239
Roadway maintenance	9	9	9	9
Regional vehicles using the roadway	524,473	624,145	624,098	748,696
Total	524,482	624,153	624,345	748,944

Note:

Values have been rounded to the nearest whole number.
MMBTU = million British thermal units

Although current projections indicate a general increase in future (2030) vehicle traffic, the actual increase if the viaduct were no longer in service is unknown and depends on multiple factors, such as changed or canceled trips and changes in travel mode.

5.3 Operational Energy Mitigation

To further optimize energy requirements, measures to reduce operational energy consumption (reduce fuel or electricity use) could include but are not limited to the following:

- Encourage use of carpools and transit to reduce VMT on roadways.
- Encourage land use strategies that minimize roadway travel.
- Use energy-efficient ventilation equipment, lighting, signals, and signage.
- Use low-maintenance or maintenance-free vegetation along roadways.
- Use variable-message signs to help drivers avoid congested areas.

5.4 Energy Benefits of the Project

In 2015, the Bored Tunnel Alternative would result in a similar consumption of energy by vehicles in both the city center and the region compared to the energy consumption under 2015 Existing Viaduct conditions. Although current projections indicate a general increase in future (2030) vehicle traffic, the actual increase if the viaduct were no longer in service is unknown and depends on multiple factors, such as changed or canceled trips and changes in travel mode.

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Chapter 6 CONSTRUCTION ENERGY EFFECTS AND MITIGATION

Construction energy consumption for the Bored Tunnel Alternative would result from the following major activities:

- Earth excavation and grading.
- Handling and transport of excavated material and debris.
- Operation of heavy-duty diesel and gasoline-powered construction equipment.
- Operation of electrically-powered equipment (including TBM).
- Operation of heavy-duty diesel trucks involved in the transport of excavated material and the delivery of construction material, both within the construction areas and on local streets. Additionally, the transport of construction material and excavated materials via barge is likely, particularly for the tunnel excavation spoils.

A wide variety of construction equipment, including specialized and custom-made machinery, would be needed for the construction associated with the Bored Tunnel Alternative and the demolition of the existing viaduct structure.

Throughout construction, materials and equipment would be stored primarily within the project area and existing road right-of-way.

Throughout construction, crews would use the following types of equipment:

- TBM
- Extended-arm trackhoes with concrete-pulverizing attachment (concrete muncher)
- Cranes
- Trucks and dump trucks
- Air compressors
- Bulldozers
- Backhoe loaders
- Front loaders
- Excavators
- Drilling rigs (including oscillator drills)
- Vibratory pile-driving equipment
- Loaders
- Forklifts and manlifts
- Jackhammers

- Various pumps
- Grading and paving equipment
- Compressors
- Generators
- Welding equipment

For viaduct demolition activities, work crews would most likely use crunching/shearing attachments, concrete saws, concrete splitters, and cutting torches.

For soil improvements, work crews would need specialty equipment such as drilling rigs for tunnel wall work, drilling rigs with mixing augers, and slurry processing equipment.

Construction may also require additional equipment such as barges, conveyor belts and hoppers, and slurry separation pumps. Whether this equipment is needed would be determined by the contractor. Whether a concrete batching plant is needed would also be determined by the contractor. Other equipment such as settlement and pretreatment storage tanks would be needed for dewatering processes.

Depending on the type of TBM used, a slurry separation plant may be needed. If so, this would likely be located on the Washington-Oregon Shippers Cooperative Association (WOSCA) site in the south end of the project area.

6.1 Construction Energy Effects of the Bored Tunnel Alternative

The energy required for each construction area was estimated based on the horsepower requirements, equipment use, equipment load factors, and construction schedule. The construction energy requirements for the Bored Tunnel Alternative are provided in Exhibit 6-1.

Exhibit 6-1. Construction Energy Consumption

Construction Area	Energy Consumption (MMBTU)
South portal	27,178
Bored tunnel	176,364
North portal	30,745
Viaduct demolition	14,985
Total	249,271
Total annual average¹	41,545

Note:

MMBTU = million British thermal units

¹ Annual average based on 66-month (5.5-year) project construction duration.

6.1.1 South Portal

The major project elements and construction activities in the south portal area are summarized in Exhibit 6-2. The major activities associated with construction in the south portal area include earth excavation and grading, handling and transport of excavated material and debris, operation of heavy-duty diesel- and gasoline-powered equipment, and trucking activities. Surface streets in the south portal area would be restored in the final phase of construction.

Exhibit 6-2. Construction Elements and Major Activities

Area	Project Element	Major Activities
South portal	<ul style="list-style-type: none"> - Relocate utilities and set up staging yard - Construct power supply substation for TBM - Construct structure to connect tunnel and viaduct - Excavate the TBM assembly pit - Construct south access point structure and tunnel operations building - Demolish the WOSCA detour - Restore and construct surface roadways 	<ul style="list-style-type: none"> - Earth excavation and grading - Handling and transport of excavated material and debris - Operation of heavy-duty diesel- and gasoline-powered equipment - Trucking activities
Bored tunnel	<ul style="list-style-type: none"> - Construct cut-and-cover portion of structure - Drive the TBM - Install interior tunnel structures and systems installation - Remove the TBM 	<ul style="list-style-type: none"> - Earth excavation and grading - Handling and transport of excavated material and debris - Operation of heavy-duty diesel- and gasoline-powered equipment - Operation of electrically powered equipment (including TBM) - Trucking activities
North portal	<ul style="list-style-type: none"> - Relocate utilities - Construct north detour roadway - Construct north access point structure and tunnel operations building - Remove north detour roadway and restore surface streets 	<ul style="list-style-type: none"> - Earth excavation and grading - Handling and transport of excavated material and debris - Operation of heavy-duty diesel- and gasoline-powered equipment - Trucking activities
Viaduct demolition	<ul style="list-style-type: none"> - Demolish viaduct 	<ul style="list-style-type: none"> - Operation of heavy-duty diesel- and gasoline-powered equipment - Trucking activities

Note:

- MMBTU = million British thermal units
- TBM = tunnel boring machine
- WOSCA = Washington-Oregon Shippers Cooperative Association

6.1.2 Bored Tunnel

The major activities required to construct the bored tunnel are summarized in Exhibit 6-2 and include earth excavation (including operation of the TBM) and grading, handling and transport of excavated material and debris, operation of heavy-duty diesel- and gasoline-powered equipment, and trucking activities.

6.1.3 North Portal

Construction in the north portal area includes construction and later removal of the north portal detour, utility relocation, construction of the north access point structure and tunnel operations building, and surface street improvements. The major activities include earth excavation and grading, handling and transport of excavated material and debris, operation of heavy-duty diesel- and gasoline-powered equipment, and trucking activities (Exhibit 6-2).

6.1.4 Viaduct Demolition and Battery Street Tunnel Decommissioning

After the construction of the bored tunnel is completed, the existing viaduct would be demolished and the debris would be removed. All utilities that are attached to the viaduct and expected to remain in service would need to be relocated before the viaduct is demolished. The Battery Street Tunnel would be closed (the current proposal is to fill the tunnel with crushed rubble recycled from the existing viaduct). The major activities include operation of heavy-duty diesel- and gasoline-powered equipment and trucking activities (Exhibit 6-2).

6.2 Energy Mitigation

The traffic management plan for the Bored Tunnel Alternative includes detours and strategic construction planning (e.g., weekend work, parking restrictions, and signal timing enhancements) to continue moving traffic through the area and reduce backups for the traveling public to the extent possible. Construction areas, staging areas, and material transfer sites could be set up in a way that reduces standing wait times for equipment and the associated engine idling and blockage of movements necessary for other activities on the site. Fuel consumption could be reduced by minimizing wait times and ensuring that construction equipment is operated efficiently. Due to space constraints in the project area (i.e., limited parking) and the benefit of additional emissions reductions, ridesharing and other commute trip reduction efforts could be promoted for employees working on the project.

In addition to the strategies detailed above, other measures to reduce energy consumption during construction could include the following:

- Use of electrical equipment as feasible.
- Use of relatively new, well-maintained equipment.

- Coordination of construction activities with other projects in the area to reduce the cumulative effects of concurrent construction projects.
- Traffic mitigation measures, as discussed in Appendix C (Transportation Discipline report), to potentially reduce energy consumption.

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Chapter 7 GREENHOUSE GAS EFFECTS

This section qualitatively discusses the greenhouse gas effects of the two scenarios for the 2030 Viaduct Closed (No Build Alternative), and it compares the greenhouse gas effects of the Bored Tunnel Alternative to those under 2015 Existing Viaduct conditions.

7.1 Greenhouse Gas Effects of the 2030 Viaduct Closed (No Build Alternative)

7.1.1 Scenario 1: Sudden Unplanned Closure of the Viaduct

Under Scenario 1, there would be a sudden, unplanned closure of SR 99 between S. King Street and Denny Way due to some structural deficiency, weakness, or smaller earthquake event. SR 99 would be closed for an unknown period of time until a viaduct replacement could be built. Although current projections indicate a general increase in future vehicle traffic and corresponding greenhouse gases, the amount that traffic and greenhouse gas emissions would actually increase if the viaduct were no longer in service is unknown and depends on multiple factors, such as changed or canceled trips and changes in travel mode.

7.1.2 Scenario 2: Catastrophic and Complete Collapse of the Viaduct

Scenario 2 considers the effects of a catastrophic failure and collapse of SR 99. Under this scenario, a seismic event of similar or greater magnitude than the 2001 Nisqually earthquake could trigger failure of portions of the viaduct. This scenario would have the greatest effect on people and the environment. This type of event could cause buildings to be damaged or collapse and cause extensive damage to utilities. The environmental effects and length of time it would take to repair the SR 99 corridor are unknown, but the effects would be severe. The direct greenhouse gas effects of the cleanup and reconstruction of damaged or collapsed roadways and buildings would likely be greater than the effects of a sudden shutdown of the viaduct, as in Scenario 1.

7.2 Greenhouse Gas Effects of the 2015 Existing Viaduct and 2015 and 2030 Bored Tunnel Alternative

The two sources of operational greenhouse gas emissions are vehicles using the facility or otherwise affected by the project and the power requirements for maintaining the facility (e.g., ventilation, lighting, and facility maintenance). Vehicles using the facility constitute the major operational source of greenhouse gases. Ventilation and other power requirements constitute a minor source of

project-related operational greenhouse gases. Both of these sources have been included in the calculation of greenhouse gas emissions.

The estimates of operational CO_{2e} emissions for the project are presented in Exhibits 7-1 and 7-2. Under the 2015 Bored Tunnel Alternative, roadway CO_{2e} emissions in both the city center and the region would be similar to those under 2015 Existing Viaduct conditions (Exhibit 7-1). When combined with the ventilation, lighting, and maintenance emissions, the CO_{2e} emissions resulting from the 2015 Bored Tunnel Alternative would be similar to those under 2015 Existing Viaduct conditions. In 2030, the CO_{2e} emissions resulting from the Bored Tunnel Alternative are predicted to be higher than those under existing conditions and those estimated for 2015. This increase is due to projected increases in future vehicle traffic and fuel use, which would result in an overall increase in CO_{2e} emissions relative to the existing conditions.

The estimates provided in Exhibit 7-1 are extremely conservative and are based on the national average vehicle mix shown in Exhibit 5-1. The 2015 and 2030 national averages do not take into account the expected future shift in vehicle mix (i.e., fewer light-duty trucks and more fuel-efficient vehicles, including hybrids), which would lead to better fleetwide fuel efficiency and result in lower CO_{2e} emissions than those currently predicted.

Exhibit 7-1. Daily CO_{2e} Roadway Emissions Estimates (Metric Tons per Day)

Study Area	Existing Conditions	2015 Existing Viaduct	2015 Bored Tunnel Alternative	2030 Bored Tunnel Alternative
City Center	988	1,137	1,133	1,236
Regional	39,189	46,557	46,554	55,806

Note:

CO_{2e} = carbon dioxide equivalents, representing an amount of greenhouse gas

Exhibit 7-2. Daily CO_{2e} Emissions Estimates Based on Ventilation, Lighting, and Maintenance Energy Estimates (Metric Tons per Day)

Energy Segment	Existing Conditions	2015 Existing Viaduct	2015 Bored Tunnel Alternative	2030 Bored Tunnel Alternative
Ventilation and lighting	0	0	29	29
Maintenance	1	1	1	1

Note:

CO_{2e} = carbon dioxide equivalents, representing an amount of greenhouse gas

Exhibit 7-3 highlights the combined results of the operational greenhouse gas emissions analysis. In 2015, the greenhouse gas emissions resulting from the Bored Tunnel Alternative are similar to those for the 2015 Existing Viaduct. Due

to future projected increases in VMT, the greenhouse gas emissions for the Bored Tunnel Alternative are greater in 2030 than in 2015.

Exhibit 7-3. Total Regional Operational Daily CO₂e Emissions (Metric Tons per Day)

Energy Segment	Existing Conditions	2015 Existing Viaduct	2015 Bored Tunnel Alternative	2030 Bored Tunnel Alternative
Ventilation and lighting	0	0	29	29
Maintenance	1	1	1	1
Roadways	39,189	46,557	46,554	55,806
Total	39,190	46,558	46,584	55,836

Note:

CO₂e = carbon dioxide equivalents, representing an amount of greenhouse gas

Construction of the Bored Tunnel Alternative is currently planned to last approximately 5.5 years from 2011 to 2017. The traffic management plan includes detours and strategic construction timing (like night work) to continue moving traffic through the area and reduce backups to the traveling public to the extent possible. WSDOT will seek to set up active construction areas, staging areas, and material transfer sites in a way that reduces standing wait times for equipment. WSDOT will work with our partners to promote ridesharing and other commute trip reduction efforts for employees working on the project.

Estimates of CO₂e emissions based on construction energy consumption are presented in Exhibit 7-4. The values presented in Exhibit 7-4 represent the total and annual (averaged over a 66-month period) construction emissions for the Bored Tunnel Alternative.

Exhibit 7-4. CO₂e Emissions Estimates for the Bored Tunnel Alternative Based on Construction Energy Estimates

Alternative	Total Metric Tons CO ₂ e	Average Annual Total Metric Tons CO ₂ e ¹
Bored Tunnel Alternative	48,875	8,146

Note:

Values have been rounded to the nearest whole number.

CO₂e = carbon dioxide equivalents, representing an amount of greenhouse gas

¹. Annual average based on a 66-month project construction duration.

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Chapter 8 INDIRECT GREENHOUSE GAS EFFECTS

The Bored Tunnel Alternative would result in indirect greenhouse gas emissions, which are not released by the project, but are nonetheless caused by the project. Greenhouse gases would be emitted during the production and disposal of materials used for project-related construction. For example, emissions would be released during the production of the concrete used in construction or the manufacture of the equipment used during construction.

Indirect emissions are also known as embodied and lifecycle emissions. At this time, there is no consistent and standardized method for calculating the embodied and lifecycle emissions for transportation projects. There are no tools currently available for clearly and meaningfully discerning which emissions are attributable to a specific project and which emissions would have occurred without the project. However, as with all environmental disciplines, vendors that produce equipment and materials used in project construction are subject to regulation at their facilities.

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Chapter 9 CUMULATIVE EFFECTS

Cumulative effects are effects on the environment that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. The focus of the cumulative effects analysis is the combined effects of the Bored Tunnel Alternative, the other Program elements, and other past, present, and reasonably foreseeable future projects that could contribute to energy effects in the study area.

This chapter discusses the following topics:

- Current energy trends
- Effects of the roadway elements of the Program
- Effects of the non-roadway elements of the Program
- Cumulative effects of the Bored Tunnel Alternative when combined with the effects of the other Program elements
- Cumulative effects of the Bored Tunnel Alternative when combined with the effects of the other Program elements and the effects of other past, present, and reasonably foreseeable future projects

A more detailed analysis of cumulative effects is presented in Attachment A.

9.1 Trends Leading to Present Energy Condition

Throughout the history of Seattle, various entities have attempted to provide transportation options for getting to and from the city as well as through the city to points beyond. Cutting forests and creating roads on land and traveling across Elliott Bay are a big part of Seattle's history. The energy requirements of the past were largely provided through manual labor, harnessed animals such as horses and mules, and a variety of engines powered by steam or diesel. Cars, trucks, and trains that ran on petroleum products replaced horses, leading to the need for new roads constructed of modern materials such as asphalt and concrete. The introduction of the highway system led to further development of long-distance travel and the need for more roads. Expansion of import and export commodities have also required additional infrastructure for ocean-going vessels at ports and transportation away from the ports by train and truck. These activities all led to an increased use of and dependence on petroleum-based fuels such as gasoline and diesel.

Since the 1970s, the efficiency of engines has increased and has resulted in a reduction of energy requirements for the construction and operation of transportation systems. However, transportation remains a major contributor to energy consumption and greenhouse gas emissions. Improvements to fleet fuel

efficiency through programs such as the CAFE standards and consumer selection of more efficient vehicles, alternative energy availability, and high-occupancy transportation modes such as buses and commuter trains are intended to further reduce energy consumption and greenhouse gas emissions. Additionally, land use and growth management strategies such as *VISION 2040* are intended, in part, to further reduce energy consumption and greenhouse gas emissions by reducing and/or eliminating trips, reducing congestion, and improving public transportation alternatives (PSRC 2008, 2010).

9.2 Effects From Other Roadway Elements of the Program

9.2.1 Alaskan Way Surface Street Improvements – S. King to Pike Streets

The new Alaskan Way surface street would be six lanes wide between S. King and Columbia Streets (not including turn lanes), transitioning to four lanes between Marion and Pike Streets. Generally, the new Alaskan Way would be located on the east side of the right-of-way where the viaduct is located today. The new street would include new sidewalks, bicycle lanes, parking and loading zones, and signalized pedestrian crossings at cross streets.

Construction of these improvements would result in a short-term increase in energy consumption. The operation and maintenance of the newly constructed facility over the long term would likely require less energy than that required for the older, existing facility. Furthermore, these improvements are expected to decrease congestion and increase travel speeds (see Appendix C, Transportation Discipline Report), which would decrease fuel use. This would result in an overall decrease in operational energy consumption and greenhouse gas emissions in 2030, as compared to 2030 conditions without the improvements (Viaduct Closed [No Build Alternative]).

9.2.2 Elliott/Western Connector – Pike Street to Battery Street

The new roadway connecting Alaskan Way to Elliott and Western Avenues (in the area between Pike and Battery Streets) would be four lanes wide and would provide a grade-separated crossing of the BNSF mainline railroad tracks. The new roadway would include bicycle and pedestrian facilities. The effects would be similar to those described in Section 9.2.1.

9.2.3 Mercer West Project – Fifth Avenue N. to Elliott Avenue

Mercer Street would be restriped and resignalized between Fifth Avenue N. and Second Avenue W. to create a two-way street with turn pockets. The effects would be similar to those described in Section 9.2.1.

9.3 Effects From Non-Roadway Elements of the Program

9.3.1 Elliott Bay Seawall Project

The Elliott Bay Seawall needs to be replaced to protect the shoreline along Elliott Bay, including Alaskan Way. It is at risk of failure due to seismic and storm events. The seawall currently extends from S. Washington Street in the south to Bay Street in the north, a distance of about 8,000 feet. The Elliott Bay Seawall Project limits extend from S. Washington Street in the south to Pine Street in the north (also known as the central seawall). The southernmost third of the central seawall was built in 1916 and rebuilt in 1987. The northern two-thirds of the central seawall were constructed in 1934–1936.

Construction of these improvements would result in a short-term increase in energy consumption. The operation and maintenance of the newly constructed facilities over the long term would likely require less energy than that required for the older, existing facilities.

9.3.2 Alaskan Way Promenade/Public Space

A new expanded waterfront promenade and public space would be provided to the west of the new Alaskan Way surface street between S. King Street and Pike Street. This space would be approximately 70 to 80 feet wide along the central waterfront. The effects would be similar to those described in Section 9.2.1.

9.3.3 First Avenue Streetcar Evaluation

A new streetcar is currently planned to run along First Avenue between Yesler Way and Republican Street. To the extent that congestion would be reduced, travel speeds would increase and fuel use would decrease. Furthermore, the mode shift from the use of gasoline-powered personal vehicles to electrically powered transit would result in the consumption of less fuel. This would result in an overall decrease in operational energy consumption and greenhouse gas emissions, as compared to future conditions without the streetcar. Construction and maintenance of these improvements would result in an increase in energy consumption.

9.3.4 Transit Enhancements

A variety of transit enhancements would be provided to support the planned transportation improvements associated with the Program. Development of the specific improvements is underway. Additional service routes and service hours would be provided by King County Metro's RapidRide bus rapid transit program to serve the West Seattle and Ballard areas. To the extent that congestion would be reduced, the increase in travel speeds and decrease in fuel use would result in an overall decrease in operational energy consumption and greenhouse gas

emissions compared to future conditions without the transit enhancements. There would be little effect on construction energy consumption.

9.4 Cumulative Effects of the Project and Other Program Elements

Considering all of the improvements provided by the Bored Tunnel Alternative and the other Program elements, construction of these improvements would result in a short-term increase in energy consumption. The operation and maintenance of the newly constructed facilities over the long term would likely require less energy than that required for the older, existing facilities. Furthermore, the improvements would lead to decreased congestion and increased travel speeds, resulting in a decrease in fuel use and an overall decrease in operational energy consumption and greenhouse gas emissions as compared to the future conditions without the Program.

9.5 Cumulative Effects of the Project, Other Program Elements, and Other Actions

Generally, cumulative effects refer to effects that may occur as a result of the Bored Tunnel Alternative and other Program elements, combined with the effects of other past, present, and reasonably foreseeable future projects. Other key projects located within the study area include the following:

- Alaskan Way Viaduct and Seawall Replacement Moving Forward projects
- Sound Transit projects
- S. Spokane Street Viaduct Widening
- SR 519 Intermodal Access Project, Phase 2
- SR 520 Bridge Replacement and HOV Program
- I-5 Improvements
- South Lake Union Redevelopment

Considering all of the improvements provided by the Bored Tunnel Alternative and the other elements of the Program as well as other projects taking place in or near the study area, the following effects are likely:

- Construction of these improvements would result in a short-term increase in energy consumption and greenhouse gas emissions.
- To the extent that congestion would be reduced, travel speeds would increase and fuel use and greenhouse gas emissions would decrease. The operation and maintenance of the newly constructed facilities over the long term would likely require less energy than that required for the older, existing facilities.

Chapter 10 REFERENCES

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ATTACHMENT A

Cumulative Effects Analysis

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CUMULATIVE EFFECTS ANALYSIS

This cumulative effects analysis follows *Guidance on Preparing Cumulative Impact Analyses*, published by Washington State Department of Transportation (WSDOT) in February 2008. The guidance document was developed jointly by WSDOT, Federal Highway Administration (FHWA) – Washington Division, and U.S. Environmental Protection Agency – Region 10. The guidance can be used for FHWA’s National Environmental Policy Act (NEPA) compliance (Code of Federal Regulations, Title 23, Part 771) and fulfillment of Washington State Environmental Policy Act (SEPA) requirements for evaluation of cumulative effects (Washington Administrative Code, Section 197-11-792).

The approach provided in the WSDOT guidance calls for early consideration of cumulative impacts while direct and indirect effects are being identified, preferably as part of the scoping process. For analysis, the guidance recommends the use of environmental documents such as discipline reports, as well as other relevant information such as local comprehensive plans, zoning, recent building permits, and interviews with local government. The guidance also advocates a partnership approach among agencies that includes early collaboration and integrated planning activities.

The guidance established eight steps to serve as guidelines for identifying and assessing cumulative impacts. These eight steps have been used in the following cumulative effects evaluation for the Bored Tunnel Alternative of the Alaskan Way Viaduct Replacement Project (the project). A matrix that identifies projects with the potential for cumulative effects with this project and an assessment of likely contributions to cumulative effects is also included.

Step 1. Identify the resource that may have cumulative impacts to consider in the analysis

Energy and resulting greenhouse gas emissions.

Step 2. Define the study area and timeframe for the affected resource

Operational energy benefits and effects are assessed as they relate to the transportation energy use of the project.

- During construction, the area of effect includes all areas of project construction.
- The timeframe for construction-related (temporary) effects is the approximately 5.5-year construction duration for the Bored Tunnel Alternative (2011 through 2017).
- Operational effects were assessed for the design year of the project (2030).

Step 3. Describe the current health and historical context for each affected resource

Transportation energy is the energy required to move people and goods from place to place. Operational energy includes both the energy used by the vehicles and the energy used to maintain the transportation facility. Construction energy includes the energy used to construct the facility.

Historic transportation energy needs were met with manual labor and animals in the mid-nineteenth century, with the use of steam and diesel engines coming into use around the turn of the twentieth century. The need to move people and goods more efficiently throughout cities as well as between cities, and also to facilitate travel between countries, led to an increased use and dependence on fossil fuels, with resulting increases in greenhouse gas emissions. Beginning in the 1970s, fuel efficiency standards and policies that encouraged the reduction of energy consumption led to more efficient fuel standards. In the 1990s, there was recognition of the cumulative dangers of greenhouse gases, such as damage to the earth's protective atmosphere. Increases in the fuel efficiency of modern fleets through Corporate Average Fuel Economy (CAFE) standards, consumers opting for more efficient vehicles, increased access to public transportation, as well as growth management policies and regulations such as *VISION 2020* and *VISION 2040*, all contribute to further reductions in energy consumption and greenhouse gas emissions.

Transportation accounts for approximately 31 percent of the energy consumed in Washington State. On a per capita basis, Washington's transportation energy consumption is approximately 322.2 million British thermal units (MMBTU), which is below the national average of 333.1 MMBTU. Fossil fuels (e.g., gasoline, diesel fuel, jet fuel) are the predominant source of energy for transportation in Washington.

Step 4. Identify the direct and indirect impacts that may contribute to a cumulative impact

Other projects were qualitatively assessed to consider how their construction effects would contribute to traffic congestion resulting in additional cumulative energy use. The other projects were also qualitatively assessed to consider how their operational benefits and effects would affect congestion and how resulting travel speeds would then affect fuel use and cumulative energy use.

Step 5. Identify other historic, current, or reasonably foreseeable actions that may affect resources

The project team considered 39 projects (shown in the matrix at the end of this attachment) for potential activities that could have a cumulative effect on energy use in Seattle. The projects below would have minor negative cumulative effects

during project construction. The projects below are expected to result in a decrease in energy consumption during operation and maintenance, when comparing future conditions with the project (Build) to future conditions without the project (No Build).

- **A.1.** Alaskan Way Surface Street Improvements – S. King Street to Pike Street
- **A.2.** Elliott/Western Connector – Pike Street to Battery Street
- **A.3.** Mercer West Project – Mercer Street becomes two-way from Fifth Avenue N. to Elliott Avenue, and Roy Street becomes two-way from Aurora Avenue to Queen Anne Avenue N.
- **B.1.** Elliott Bay Seawall Project
- **B.2.** Alaskan Way Promenade/Public Space
- **B.4.** First Avenue Streetcar Evaluation
- **E.1.** Gull Industries on First Avenue S.
- **E.2.** North Parking Lot Development at Qwest Field
- **E.3.** Seattle Center Master Plan (EIS) (Century 21 Master Plan)
- **E.4.** Bill and Melinda Gates Foundation Campus Master Plan
- **E.5.** South Lake Union Redevelopment
- **E.6.** U.S. Coast Guard Integrated Support Command
- **E.7.** Seattle Aquarium and Waterfront Park
- **E.8.** Seattle Combined Sewer System Upgrades
- **F.1.** Bridging the Gap Projects
- **F.2.** S. Spokane Street Viaduct Widening
- **F.3.** SR 99/East Marginal Way Grade Separation
- **F.4.** Mercer East Project from Dexter Avenue N. to I-5

Step 6. Assess potential cumulative impacts to the resource; determine the magnitude and significance

Cumulative energy effects can occur when there is a change in energy consumption (or supply) due to more than one project taking place at the same time or projects being constructed at some time in the foreseeable future.

Simultaneous construction activity could occur in the same areas in which the Bored Tunnel Alternative would be implemented. Energy consumption would increase, and fuel use could increase as congestion increases and travel speeds decrease.

Once construction is completed, the improvements to the roadway network in the study area are expected to have a net beneficial cumulative effect on transportation-related measures of effectiveness. These improvements to the

roadway network should result in a net positive effect on energy use in the study area.

Step 7. Report the results

The cumulative effects on energy would be regional due to the global nature of fuel production and the worldwide impact of greenhouse gas emissions (see the matrix below). Improvements to the roadway network resulting from the project and other nearby projects would have a net positive effect on energy use due to reduced congestion and increased transit use.

Step 8. Assess and discuss potential mitigation issues for all adverse impacts

No mitigation measures for cumulative effects on energy are proposed.

The following matrix identifies project-specific potential cumulative effects.

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX

PROJECT	POTENTIAL CUMULATIVE EFFECTS
<i>A. Roadway Elements</i>	
A1. Alaskan Way Surface Street Improvements – S. King Street to Pike Street	<p>Construction of the improvements would result in a minor adverse cumulative effect on energy consumption and greenhouse gas emissions through increased fuel consumption due to additional congestion and vehicles using more fuel to get through the area.</p> <p>During operation, a minor beneficial cumulative effect on energy consumption and greenhouse gas emissions would be experienced through a decrease in congestion and an increase in travel speeds. Fuel use would decrease, resulting in an overall decrease in energy use as compared to the existing conditions. A new facility would also require less energy for maintenance.</p>
A2. Elliott/Western Connector – Pike Street to Battery Street	<p>Construction of the improvements would result in a minor adverse cumulative effect on energy consumption and greenhouse gas emissions through increased fuel consumption due to additional congestion and vehicles using more fuel to get through the area.</p> <p>During operation, a minor beneficial cumulative effect on energy consumption and greenhouse gas emissions would be experienced through a decrease in congestion and an increase in travel speeds. Fuel use would decrease, resulting in an overall decrease in energy use as compared to the existing conditions. A new facility would also require less energy for maintenance.</p>

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX (CONTINUED)

PROJECT	POTENTIAL CUMULATIVE EFFECTS
<p>A3. Mercer West Project – Mercer Street becomes two-way from Fifth Avenue N. to Elliott Avenue, and Roy Street becomes two-way from Aurora Avenue to Queen Anne Avenue N.</p>	<p>Construction of the improvements would result in a minor adverse cumulative effect on energy consumption and greenhouse gas emissions through increased fuel consumption due to additional congestion and vehicles using more fuel to get through the area.</p> <p>During operation, a minor beneficial cumulative effect on energy consumption and greenhouse gas emissions would be experienced through a decrease in congestion and an increase in travel speeds. Fuel use would decrease, resulting in an overall decrease in energy use as compared to the existing conditions. A new facility would also require less energy for maintenance.</p>
<p><i>B. Non-Roadway Elements</i></p>	
<p>B1. Elliott Bay Seawall Project</p>	<p>Construction of these improvements would result in minor adverse cumulative effects on energy consumption and greenhouse gas emissions due to a temporary increase in fuel consumption from traffic congestion related to construction from S. Washington Street to Pine Street.</p> <p>The operation and maintenance of the facility would not affect energy consumption and greenhouse gas emissions.</p>
<p>B2. Alaskan Way Promenade/Public Space</p>	<p>Construction of these improvements would result in minor adverse cumulative effects on energy consumption and greenhouse gas emissions due to a temporary increase in fuel consumption from traffic congestion related to construction along the new Alaskan Way surface street between S. King Street and Pike Street.</p> <p>The operation and maintenance of the facility would not affect energy consumption and greenhouse gas emissions.</p>
<p>B3. Transit Enhancements –</p> <ul style="list-style-type: none"> 1) Delridge RapidRide 2) Additional service hours on West Seattle and Ballard RapidRide lines 3) Peak hour express routes added to South Lake Union and Uptown 4) Local bus changes to several West Seattle and northwest Seattle routes 5) Transit priority on S. Main and/or S. Washington Streets between Alaskan Way and Third Avenue 6) Simplification of the electric trolley system 	<p>Construction is not part of the improvements. Operation of the improvements would result in a minor beneficial cumulative effect due to a decrease in congestion, an increase in travel speeds, and a decrease in fuel use as compared to the existing conditions.</p>

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX (CONTINUED)

PROJECT	POTENTIAL CUMULATIVE EFFECTS
B4. First Avenue Streetcar Evaluation	<p>Construction of these improvements would result in minor adverse cumulative effects on energy consumption and greenhouse gas emissions due to a temporary increase in fuel consumption from traffic congestion related to construction along the project corridor.</p> <p>Operation of the improvements would result in a minor beneficial cumulative effect due to a decrease in congestion, an increase in travel speeds, and a decrease in fuel use as compared to the existing conditions.</p>
<i>C. Projects Under Construction</i>	
C1. S. Holgate Street to S. King Street Viaduct Replacement Project	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
C2. Transportation Improvements to Minimize Traffic Effects During Construction	No cumulative effects on energy consumption and greenhouse gas emissions are anticipated during construction or operation. Construction will be completed before construction of the Bored Tunnel Alternative begins.
<i>D. Completed Projects</i>	
D1. SR 99 ;Yesler Way Vicinity Foundation Stabilization (Column Safety Repairs)	Construction of this project is already completed, so no cumulative effects on energy and greenhouse gas emissions are anticipated.
D2. S. Massachusetts Street to Railroad Way S. Electrical Line Relocation Project (Electrical Line Relocation Along the Viaduct's South End)	Construction of this project is already completed, so no cumulative effects on energy and greenhouse gas emissions are anticipated.
<i>E. Seattle Planned Urban Development</i>	
E1. Gull Industries on First Avenue S.	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation.
E2. North Parking Lot Development at Qwest Field	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation.

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX (CONTINUED)

PROJECT	POTENTIAL CUMULATIVE EFFECTS
E3. Seattle Center Master Plan (EIS) (Century 21 Master Plan)	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation.
E4. Bill and Melinda Gates Foundation Campus Master Plan	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation.
E5. South Lake Union Redevelopment	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation.
E6. U.S. Coast Guard Integrated Support Command	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation.
E7. Seattle Aquarium and Waterfront Park	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation.
E8. Seattle Combined Sewer System Upgrades	Possible minor cumulative effects on energy and greenhouse gas emissions during construction. No cumulative effects on energy and greenhouse gas emissions are expected during operation.
<i>F. Local Roadway Improvements</i>	
F1. Bridging the Gap Projects	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
F2. S. Spokane Street Viaduct Widening	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX (CONTINUED)

PROJECT	POTENTIAL CUMULATIVE EFFECTS
F3. SR 99/East Marginal Way Grade Separation	Possible minor cumulative effects on energy consumption and greenhouse gas emissions during construction. No cumulative effects on energy consumption and greenhouse gas emissions are expected during operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
F4. Mercer East Project from Dexter Avenue N. to I-5	Possible minor cumulative effects on energy and greenhouse gas emissions during construction. No cumulative effects on energy and greenhouse gas emissions are expected during operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative energy and greenhouse gas emissions analysis.
<i>G. Regional Roadway Improvements</i>	
G1. I-5 Improvements	No cumulative effects on energy consumption and greenhouse gas emissions are anticipated during construction or operation. Operational effects of the improvements were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
G2. SR 520 Bridge Replacement and HOV Program	No cumulative effects on energy consumption and greenhouse gas emissions are anticipated during construction or operation. Operational effects of the improvements were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
G3. I-405 Corridor Program	No cumulative effects on energy consumption and greenhouse gas emissions are anticipated during construction or operation. Operational effects of the improvements were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
G4. I-90 Two-Way Transit and HOV Operations, Stages 1 and 2	No cumulative effects on energy consumption and greenhouse gas emissions are anticipated during construction or operation. Operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX (CONTINUED)

PROJECT	POTENTIAL CUMULATIVE EFFECTS
<i>H. Transit Improvements</i>	
H1. First Hill Streetcar	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
H2. Sound Transit University Link Light Rail Project	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
H3. RapidRide	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
H4. Sound Transit North Link Light Rail Project	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
H5. Sound Transit East Link Light Rail Project	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
H6. Washington State Ferries Seattle Terminal Improvements	No cumulative effects on energy are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy analysis.
<i>I. Transportation Network Assumptions</i>	
I1. HOV Definition Changes to 3+ Throughout the Puget Sound Region	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
I2. Sound Transit Phases 1 and 2	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX (CONTINUED)

PROJECT	POTENTIAL CUMULATIVE EFFECTS
I3. Other Transit Improvements	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
<i>J. Completed but Relevant Projects</i>	
J1. Sound Transit Central Link Light Rail (including the Sea-Tac Airport extension)	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
J2. South Lake Union Streetcar	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.
J3. SR 519 Intermodal Access Project, Phase 2	No cumulative effects on energy consumption and greenhouse gas emissions are expected during construction or operation. The operational effects were included in the 2030 Bored Tunnel Alternative energy consumption and greenhouse gas emissions analysis.

ATTACHMENT B

Calculations

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Energy and Greenhouse Gas Calculations for the Alaskan Way Viaduct Replacement Project, Bored Tunnel Alternative Construction Phase

The following is a summary of the methods used for the energy and greenhouse gas calculations. The calculations discussed in the body of the discipline report are available upon request. (The file containing the calculations is too large—in length and file size—to include as an attachment to the Energy Discipline Report). However, a basic description of the methodology used to develop the calculations is outlined below.

Step 1 – A schedule of activities and equipment is provided for each construction area. For the Bored Tunnel Alternative, there are four major elements of construction:

1. South Portal area
2. Bored Tunnel
3. North Portal area
4. Demolition of the existing viaduct structure

Each piece of equipment proposed for use in the construction segments listed below has a utilization rate and load factor applied to it to determine the average horsepower used throughout the day. The number of pieces proposed for use is multiplied by the average equipment usage horsepower to determine the total horsepower.

1. Tunnel Boring machinery
2. South Portal area
3. North Portal area
4. Demolition of the existing viaduct structure

Step 2 – Once the total horsepower is calculated, it is distributed into a month-by-month calendar using the start and end dates given in the construction schedule.

Step 3 – Steps 1 and 2 are repeated for each activity within each construction area, with the resultant energy use distributed into the correct calendar timeframe. The energy is summed up on a month to month basis.

Step 4 – The results in Step 3 are brought forward to the Energy Summary worksheet. The total energy utilized is summarized and placed in the Energy Summary Table, and shown in the Energy Summary tab of the spreadsheet.

Step 5 – Greenhouse gas emissions were estimated in the workbook entitled “CO2 Construction emissions 3-25-10 with electric TBMreport.xlsx”. The estimate of greenhouse gases uses steps similar to those detailed above, except for an emission factor in terms of grams/horsepower hour is applied to the total horsepower calculated

in Step 2. The emission factor for carbon dioxide (CO₂) was derived from the U.S. Environmental Protection Agency's NONROAD Model for diesel vehicles. These factors are shown in the Emission Rates tab.

As the project was concerned only with total greenhouse gases generated, actual dates were not applied; only the construction duration was used. The results of the analysis are summarized in the CO₂-Schedule in the workbook. The emissions of all the equipment, with the exception of the tunnel boring machine (TBM), which is electrically powered, were calculated using diesel fuel emission rates. For the TBM, the power requirement was separated out and eGRID factors were applied to determine the TBM emission burden, as recommended by the Washington State Department of Transportation.