Appendix F

Vancouver Energy - Air Quality Technical Report

Important Note: Information provided in this Appendix is referenced in EFSEC's Draft Environmental Impact Statement (EIS). However this report was originally prepared to support the Applicant-prepared preliminary draft EIS. Any reference in this Appendix to "the EIS" refers to the Applicant-prepared preliminary draft EIS and not EFSEC's Draft EIS.

Vancouver Energy
Air Quality Technical Report

Prepared for:
BergerABAM
Vancouver, WA

On behalf of:
Tesoro Savage Petroleum Terminal LLC
Vancouver, Washington

Prepared by:
ENVIRON International Corporation
Lynnwood, WA

Date:
August 2014

Project Number:
29-33275A

ENVIRON

Contents

List of Tables

List of Attached Figures

Acronyms, Abbreviations, and Definitions

Note that in this section and throughout the rest of this report there are active hyperlinks that will jump to the referenced material or section. General hyperlinks are formatted like this. Hyperlinks for tables and figures are highlighted like **this**.

AERMOD	Air quality dispersion modeling system used in this analysis. The AERMOD modeling system consists of two pre-processors and a dispersion model. The meteorological preprocessor (AERMET) provides meteorological information, and a terrain pre-processor (AERMAP) characterizes terrain, and generates receptor grids for the dispersion model (AERMOD).
AESS	Automatic Engine Shutoff System, used by train locomotives to shutdown unneeded units when idling occurs for more than about 10 minutes, and when ambient temperatures exceed 40°F.
Air quality standard	Health-based standard representing a pollutant concentration in the ambient air usually over some averaging period like 1-hour, intended to protect the health and welfare of people with a margin of safety.
Ambient air	the air in outdoor locations to which the public has access, e.g., outside the property boundary of the emissions source
Area source	an emission source type defined in AERMOD. Area source emissions are released from a two-dimensional rectangular area and typically used to represent fugitive emission sources.
ASIL	Acceptable Source Impact Level – a *screening* level (as opposed to a *standard*) used to evaluate the potential impact of **TAP**s based on the estimated risk of a lifetime of exposure
Attainment/Nonattainment	a determination and classification made by EPA indicating whether ambient air quality in an area complies with (i.e., attains) or fails to meet (i.e., nonattainment) the requirements of one or more **NAAQS**
Averaging time	a specific length of time (e.g., 1 hour, 24-hours, 1 year) over which measured or model-calculated concentrations of an air pollutant are averaged for comparison with the **NAAQS** based on the same averaging period. Note that some NAAQSs are also based on multi-*year averages of certain percentiles of measured or calculated concentrations.
BACT	Best Available Control Technology
BNSF	BNSF Railroad Company
cf	cubic foot, a measure of volume
cfm	cubic feet per minute, a measure of air flow
CO	carbon monoxide, a criteria air pollutant
CO_2	carbon dioxide, a greenhouse gas
CO_2e	Greenhouse gas equivalents (emissions of all GHGs expressed in terms of their "global warning potential")
Criteria air pollutant	an air pollutant specifically governed by the Federal Clean Air Act for which ambient air quality standards have been set. Criteria air pollutants include carbon monoxide, particulate matter, sulfur dioxide, nitrogen dioxide, ozone, and lead
Dispersion model	A computerized calculation tool used to estimate pollutant concentrations in the ambient air based on numeric simulations that consider the locations and rates of pollutant emissions and the effects of meteorological conditions, usually over specific averaging times (e.g., 8-hours)
DPM	Diesel engine exhaust particulate matter

Ecology	Washington State Department of Ecology
EFSEC Application	A document prepared to allow EFSEC to consider an application for site certification for a proposed facility.
EFSEC	Energy Facility Site Evaluation Council
EPA	US Environmental Protection Agency
Facility	Vancouver Energy Facility proposal
Fugitive dust	Potential air pollutant in the form of dust (or other pollutant) emitted from a non-point or non-mobile source such as dust from a road or from a coal pile caused by wind
GHG	Greenhouse gas (e.g., carbon dioxide or methane) that contributes to the process of a gradual warming of the atmosphere that can result in global climate change
Global warming potential	a measure of the potential of a gas to have an effect in the atmosphere that could lead to climate change based on the potential of the gas to cause global warming. This is a standard measure, typically based on a 100-year time horizon, used to compare each GHG with the global warming potential of carbon dioxide (CO_2), the most abundant GHG.
hp	horsepower
Knot	a unit of speed equal to one nautical mile per hour, or approximately 1.151 mph; abbreviated kt
Long ton	also called imperial ton and equal to 2,240 pounds (1,016 kg)
Maintenance area	An area that was once designated as nonattainment that has since come into compliance with the ambient air quality standard but where air quality control measures may remain in effect (in perpetuity).
Meteorological data set	a compilation of meteorological data representing conditions over some period of time and including such things as wind speed and wind direction, and formatted as required by the dispersion model being used. This analysis used a meteorological data set covering 5 years.
Metric ton	1,000 kilograms (kg) = 2,204.6 pounds = tonne (see also short ton)
Micrometer/Micron	one millionth of a meter; typically used to distinguish particle size; typical human hair is 100 about microns in diameter
mmtpy	million metric tons per year
Modeling domain	the area included in the **dispersion-modeling** analysis, such as in this case, which used a larger than 10 kilometer by 10 kilometer domain. Modeling receptors are distributed within this domain, usually over a standard grid pattern with receptors every 100 to 500 meters.
Modeling receptor	a theoretical (i.e., often non-specific) location used in computer modeling at which air pollutant concentrations are calculated. Modeling may also use site-specific receptors representing individual locations.
Monte Carlo simulation	a mathematical procedure using repeated random sampling methods to develop sufficient test results to reach statistically valid conclusions; often applied in situations in which uncertainty or intermittent/ unpredictable occurrences prevent more specific examination of possible outcomes. Additional discussion **here** (pg. 14)
mtyp	metric tons per year
NAAQS	National Ambient Air Quality Standard
Nautical mile (nm; kt)	The nautical mile is a unit of length that is about one minute of arc of latitude measured along any meridian, or about one minute of arc of longitude at the equator. By international agreement it is exactly 1,852 meters (approximately 6,076 feet).
NO_2	nitrogen dioxide, a **criteria** air pollutant
Nonattainment area	an area delineated by regulatory agencies including US EPA and the Washington Department of Ecology in which an ambient air quality

standards have been violated and where there is a program in place designed to reduce air pollution so that the standard attained.

NOx.. oxide of nitrogen, a general class of air pollutant without a specific air quality standard but used in monitoring air quality

NSPS .... New Source Performance Standard; rules that pertain to air pollution emission sources subject to air quality permits and newly manufactured equipment

Particulate matter (PM)........... air pollutant comprised of solid or liquid particles; PM is usually characterized based on the particle size. See also PM_{10} and $PM_{2.5}$.

PM_{10} .... "Coarse" inhalable particulate matter with an aerodynamic size less than or equal to 10 micrometers (**microns**)

$PM_{2.5}$ .... "Fine" inhalable particulate matter with an aerodynamic size less than or equal to 2.5 micrometers (**microns**)

Point source .... an emission source type defined in AERMOD. Point source emissions are released from a single location.

ppm .... parts per million (a metric used in quantifying concentrations of air pollutants)

PSD .... Prevention of Significant Deterioration – an air quality assessment program intended to prevent air quality degradation from major sources (i.e., those sources exceeding specific annual emission thresholds

Receptor .... See modeling receptor

Release height........................ an AERMOD term defining the height above ground at which source emissions are released

Short ton .... 2,000 pounds (see also **metric ton** and long ton)

SO_2 .... Sulfur dioxide, a **criteria air pollutant**

Soiling .... A non-health-related effect of air pollution such as staining or deposition of a fine film typically on exterior surfaces

Stationary source.................... an air pollutant emissions source at a fixed location; typically subject to air quality review and possible permitting by local, state, or federal agencies

SWCAA.................................. Southwest Clean Air Agency; the designated local air quality control agency in the project area

TAP .... Toxic air pollutant

tonne .... **metric ton**

tpy .... tons per year, an estimate of annual emissions

$\mu g/m^3$ .... micrograms per cubic meter (a metric used in quantifying concentrations of air pollutants)

Volume source........................ an emission source type defined in AERMOD. Volume sources emit diffuse air pollutants from a three-dimensional area. Line sources, such as emissions from transiting trains, can be simulated using multiple, adjacent volume sources.

Wind rose................................ a quantitative graphical summary of wind direction and speed information for a given time span. The wind rose arms represent 24 directional points of the compass. The length of the arms represent the period of time the wind blew *from* a given direction, and the colors of the arms represent wind speed categories.

1 Introduction

Tesoro Savage Petroleum Terminal LLC, is proposing to develop the Tesoro Savage Vancouver Energy Facility (Facility), a petroleum transloading terminal, at the Port of Vancouver in Clark County, Washington.

This report documents the technical analyses of the air quality impact and mitigation assessments performed by ENVIRON International Corporation (ENVIRON) in support of the environmental review for the Facility. This report is summarized in the Draft Environmental Impact Statement for this proposal.

2 Project Description

Tesoro Savage Petroleum Terminal LLC is proposing to develop the Vancouver Energy Facility at the Port of Vancouver in Clark County, Washington (**Figure 1**, page 27). The proposed Facility would receive crude oil by rail, store it on site, and load it onto marine vessels for shipment to various consumers and end users located primarily on the west coast of the US. A depiction of the various components of the proposed Facility is presented in **Figure 2**. Unit trains would arrive at the project site and be stationed on the rail loops. At full build-out, the Facility would have the capability of loading up to 360,000 barrels/day of crude oil to marine vessels.

2.1 Terminal Design Elements

In addition to the primary components described above, the Facility would include ancillary elements to support the offloading, storage, and loading operations. The primary and ancillary elements are described in detail below. **Table 1** summarizes the primary and ancillary project elements by area.

2.2 Construction/Operations Stages

In a first stage, Tesoro-Savage expects to construct the following facilities:

- Two rail loops to receive unit trains
- The unloading building
- Administrative and support buildings
- Storage area including
- Transfer pipelines serving the concurrent unloading of unit trains staged at the 2 unloading tracks described above, and the conveyance to the marine terminal
- Transfer pipelines serving the conveyance of crude oil from the storage area to the marine terminal
- Marine terminal facilities designed to handle the conveyance of crude oil to a marine vessel at full build out
- All of the berth improvements necessary to support vessel berthing at full build-out
- Marine Vapor Combustion Units (MVCUs)
- Fire-suppression facilities

Table 1. Summary of Primary and Ancillary Project Elements

Facility Area	Primary and Ancillary Project Elements
Rail Infrastructure	Rail facility loops
200 – Unloading and Office	Rail unloading area Control rooms/E-houses Fire Pump and Foam Building Administrative and Support Buildings
300 – Storage	Crude Oil Storage Tanks Secondary Containment Berm Pump Basin Control Room/E-House Fire Pump and Foam Building
400 – Marine Terminal	Marine Vessel Loading Hoses and Equipment Control Room/E-House Crane Control Room Dock Safety Unit MVCU Vapor Blower Skid Spill Prevention, Response and Containment Equipment Dock Improvements
500 – Transfer Pipelines	Transfer Piping from Area 200 to Area 300 Transfer Piping to/from Area 300 to Area 400 Piping from vessel loading to MVCU
600 - Unloading Boilers	Boiler Building Piping to carry steam to Area 200
Source: Flint 2014	

Contingent on evolving market conditions, Tesoro-Savage would construct the following additional elements in a subsequent stage:

- The second of the support buildings
- Storage area including
- Transfer pipelines serving the concurrent unloading of unit trains staged at the 3rd unloading track
- The Unloading Boiler Building
- Additional fire-suppression facilities sufficient to meet the suppression needs of the additional facilities

In the future, the Facility would incorporate a third rail loop to be constructed by the Port for the Facility's exclusive use, serving the third unloading track. This third track would be built prior to, concurrently with, or after the construction of the Facility. Until the Facility capacity exceeds 120,000 barrels per day, this third loop track will be owned and operated by the Port for general use. Once the Facility capacity exceeds 120,000 barrels per day, use of the third rail loop would be transferred to the exclusive use of the Facility, at which time Facility would undertake maintenance of this rail third loop.

Tesoro-Savage expects a 20-year lifetime for the Facility. Such timeline could be extended if market conditions warrant. Maintenance dredging at berths 13 and 14 are part of the Marine

Terminal (Area 400). Dredging operations would continue to be conducted by the Port of Vancouver under its existing and future approvals granted by local, state and federal agencies to which such dredging is subject.

2.3 Concurrent Air Quality Permitting Assessment

The Facility would emit air pollutants and therefore must obtain certain air quality permits before construction of the Facility can commence. Air permits are required for construction and operation of the emissions units associated with the stationary sources. Emissions from mobile sources, including ships, trains, and vehicles, are regulated under other federal mobile source emission standards, and although such sources are not addressed as part of the stationary source air permitting process, they were considered as part of the more comprehensive environmental review documented in this report and summarized in the EIS.

Stationary emission sources at the Facility were considered as part of a detailed air quality modeling analyses that was conducted as part of the permit application process for this project. [(1,2)] Emissions from the on-site sources subject to the Washington State Energy Facility Site Evaluation Council (EFSEC) application for site certification (ASC) process also were considered in the environmental review reported here, and results of the analyses conducted for the ASC are summarized below. Note that the Facility emission units would include emission controls achieved by virtue of the application of Best Available Control Technology.

- Emissions units at the Facility would employ Best Available Control Technology to ensure emissions of all regulated pollutants are less than major source thresholds. Consequently, all Facility emissions are addressed in a minor source Notice of Construction application.
- The Facility would comply with all federal and state emissions standards, including New Source Performance Standards and National Emissions Standards for Hazardous Air Pollutants.
- Predicted total concentrations of the criteria air pollutants emitted from the Facility are less than the National and Washington Ambient Air Quality Standards (NAAQS and WAAQS) established to protect human health and welfare. The maximum predicted concentrations attributable to the Facility were added to the existing background concentrations to ensure a conservative analysis.
- Estimated emissions or predicted concentrations of toxic air pollutants released from the Facility operation are less than the Washington Department of Ecology's Small Quantity Emissions Rates (SQER) or Ecology's Acceptable Source Impact Levels (ASIL) for all toxic air pollutants (TAPs), demonstrating that all permitted sources of the Facility emissions would be in compliance with Washington's toxic air pollutant regulations.

[(1)] EFSEC Application for Site Certification, BergerABAM, 2014
[(2)] Vancouver Energy Air Permit Application Revisions, Flint 2014

3 Analytical Methods

The air quality impact analysis included two basic steps: (1) emission inventory development to estimate emissions related to operation of the terminal facilities in 2016 with full capacity operations, and (2) dispersion modeling to estimate resulting air contaminant concentrations in the ambient air associated with full capacity operation of the Facility. The following sections discuss the methods employed and the critical assumptions involved in each portion of the analysis.

Note that portions of the air quality analysis were developed as part of an evaluation prepared for the EFSEC application for the Facility that considered project-related air pollutant emission sources subject to permitting. That analysis included detailed emission inventory development and dispersion modeling for the following stationary combustion sources:

- Natural gas-fired boilers (3) used as part of product unloading
- Eight (8) Marine Vapor Combustion Units (MVCU) used to combust vapors displaced during vessel loading
- Product-handling components (e.g., valve seals and pressure relief valves) fugitive emissions
- Crude oil storage tanks fugitive emissions
- Emergency diesel-powered fire water pump engines

The methods and findings of this previous analysis are documented in detail in the EFSEC application. Those findings are summarized but not fully duplicated in this document.[3] Instead, the analysis reported here focused on the train and vessel mobile sources not considered in the permit review combined with the stationary sources subject to air quality permitting.

3.1 Emission Inventory Methods

The proposed Facility would result in emissions from mobile sources including vessels and trains (i.e., fuel combustion sources) and from the stationary and fugitive source listed above. The stationary source emissions subject to permitting were compiled and considered in the air quality analysis conducted as part of the EFSEC permit application. The train and vessel mobile source emissions were considered in the broader analysis documented here.

3.1.1 Emission Factor Tools and Sources

The emissions estimates for project-related sources employed several standard computer tools as well as emission rate calculations using formulas published by EPA. Important assumptions employed in this portion of the assessment are summarized in **Table 2**.

[3] EFSEC Application and Revised Application (see Footnotes 1 and 2, page 3)

Table 2. Emission Factors: Tools, Sources, and Critical Assumptions

Equipment Type	Tool/Method Source and Critical Assumptions
Facility Operational Phase – GHG and Criteria Pollutant Emissions	
Oil Tanker Vessels	• Emission factors based on 1,000 ppm (0.1%) S distillate fuel (the 2015 goal for vessels in IMO ECAs) [(a)] • Oil tanker vessel average propulsion engine 8,680 kW, w/ 3 auxiliary engines at 800 kW each → 8,680 kW for mains (Savage 2013) • Load factors for engines and boilers as derived from propeller law and EPA, 2009: → Main @ cruise - 0.83 → Main maneuvering - 0.0456 → Aux @ cruise - 0.24 → Aux Maneuvering - 0.33 → Aux Hotelling - 0.26 • 2016 NOx emission factors (EFs) conservatively **not** adjusted for Tier 3 NOx • Transit speed 14 knots, 6-10 knots within Columbia River, and <5 knots during maneuvering as provided to ENVIRON through a data request
Tugs	• Tugs use ULSD • Propulsion assumed as two 710 kW engines and two auxiliary engines at 55 kW (Savage 2013) • Load factors from EPA methods (EPA, 2009) • Assumed Tier 2 engines • 2016 NOx emission factors (EFs) **not** adjusted for Tier 3 requirements • Assume 2 tugs for each tanker vessel
Locomotives	• Line-haul Locomotives → Conservatively assumed U.S. fleet average emission rates for class-I line-haul engines (typically C44s or SD70s [Savage 2013]) that reflect fuel quality requirements (EPA, 2009) → Assumed line-haul locomotives operate at idle or notch 3 (Savage 2013) → Per engine fuel consumption – 3.3 gal/hr at idle – 47 gal/hr at notch 3 → Conservatively assumed no AESS (automatic engine stop during idling) • Switch Engines → Conservatively assumed U.S. fleet average emission rates for switch engines (typically SW1500 [Savage 2013]) that reflect fuel quality requirements (EPA, 2009) → Assumed switch engines operate at notch 2
Facility Boilers, MVCU, Process Fugitives	• These sources were considered as part of the air quality review prepared for the EFSEC application for the proposed Facility. The specifics of that review are documented in the EFSEC application.
[(a)] The International Maritime Organization (IMO) has established a program to create and administer Emission Control Areas (ECA) intended to result in lower emissions within specially designated areas.	

3.1.2 Facility Operational Emissions

ENVIRON estimated combustion source (i.e., vessels and trains) emissions associated with full capacity operation of the terminal in 2016 based on the maximum expected commodity throughput at the Facility. The combustion source emissions assessment used detailed operational scenarios of both peak day and annual levels of activities developed in discussions with Tesoro Savage Petroleum Terminal LLC. Emission estimates considered the following sources: oil tanker vessels in transit over about one nautical mile down river from the Facility, vessels hotelling while at berth; tugs assisting tankers during docking and undocking; incoming loaded and outgoing empty trains traveling in the vicinity of the Facility; and trains traveling through the terminal while waiting to unload, during unloading, and while leaving. **Table 3** lists critical assumptions regarding Facility operations and basic dispersion modeling characteristics associated with project-related combustion sources.

Table 3. Facility Operations and Dispersion Modeling Critical Assumptions – Mobile Sources

Equipment Type	Source and Critical Assumptions
Oil Tankers and Tugs	**Operations** • Transit speed at 10 knots • Emissions during transit to/from dock based on travel distance of about 1 nautical mile (nm) from dock, west to common route point • Assumed 2 tugs for each tanker • Tugs escort inbound vessels starting 1 nm from dock • Maneuvering occurs with tugs assisting within 1,500 feet of dock and for one hour of activity to and from the dock • Time at berth (i.e., hotelling emissions) based on average time required for loading (17 hours) → This includes 1 hour before and 1 hour after unloading → Vessels per year: 365 **Modeling** • Transiting vessels considered series of point sources along a 400-foot wide route • Annual modeling considered total annual emissions related to transiting, maneuvering, and hotelling vessels – distributed evenly in time and space along the 1-nm transiting and maneuvering route [a] • Short-term modeling included a single vessel and two tugs maneuvering to dock [b]
Locomotives	**Operations** • 7,800-foot trains in 2016 for daily and annual emissions **Modeling** • Annual modeling based on total annual emissions from 4 trains/day evenly distributed in time and space across the entire year as emission sources located along the off and on-site rail as appropriate [a] • Annual modeling considered trains along all on-site rail routes and approximately two miles east to the Vancouver Rail Yard, south of Mill Plain Boulevard / State Route 501. • Short-term modeling considered reasonable worst-case conditions during periods up to 24-hours long (because this is the longest "short-term" ambient standard) [b] • Short-term (i.e., 1-hour) modeling considered worst-case conditions by assuming 3 trains on site during any (and every) 24-hour period as follows: → 2 trains idling during "indexed" unloading → 1 train moving into position and then idling during unloading **Train Modeling – All** • Train movements were treated as a series of volume sources, using an initial plume rise calculated with SCREEN3; see discussion here (page 13) • Idling locomotives were treated as point sources

(a) "Annual" modeling refers to the process of assessing pollutant emissions and concentrations based on expected emissions over an entire year. Calculated concentrations are compared with ambient standards based on annual statistics and/or with annual average health risk estimate criteria.
(b) "Short-term" modeling refers to assessments considering emissions and concentrations to be compared with short-term ambient standards such as 1-hour and 24-hour averages.

The combustion source emission factors applied in the analysis are listed in Table 4.

Table 4. Facility Project Mobile Source Emission Factors

Train Locomotive Emission Factors (g/gal)									
Type	**NOx**	**NO_2**	**PM10**	**PM2.5**	**HC**	**VOCs [(a)]**	**CO**	**SO_2**	**CO_2**
Line-haul	121.00		3.10	3.01	5.10	5.37	26.6	0.09	10,217
Switcher	82.08		1.22	1.18	3.95	2.63	26.6	0.09	10,217
Vessel Emission Factors (g/kW-hr) [(b)]									
Engine Type	**NOx**	**NO_2**	**PM10**	**PM2.5**	**HC**	**CH_4**	**CO**	**SO_2**	**CO_2**
Tug Mains	9.8	6.2	0.72	0.70	0.48	0.09	5.00	1.3	690
Tug Aux	6.8	6.2	0.3	0.29	0.26	0.09	5.00	1.3	690
Vessel Mains	17		0.19	0.17	0.60	0.084	1.4	0.4	589
Vessel Mains (low load)	37.5		0.6	0.5	4.63	21.8	6.8	0.7	3.28
Vessel Aux	13.9	9.61	0.18	0.17	0.4	0.084	1.1	0.42	691
Vessel Boiler [(c)]	13.9	9.61	0.18	0.17	0.4	0.084	1.1	0.42	691

[(a)] Emission factors for VOCs calculated as %HC
[(b)] Emissions factors for vessel engines used in this assessment did not vary by year because no credit was taken for future improvements in vessel emission controls. Specific emission rates varied as a function of fuel quality.
[(c)] Boiler emission factors conservatively assumed to be equivalent to auxiliary emission factors.

Sources:
Locomotive Emission Rates from USEPA Emission Factors for Locomotives, April 2009
Vessel Emission Factors from USEPA Current Methodologies in Preparing Mobile Source Port-related Emission Inventories, April 2009

3.1.3 Emission Controls included in Project Design

Air quality permitting rules governing stationary sources at the proposed Facility require the use of Best Available Control Technology (BACT) for those sources subject to an air quality permit. [(4)] A BACT review includes consideration of all reasonably available means to reduce or control emissions, and the evaluation of both feasibility (i.e., whether such controls can be physically implemented and their potential effectiveness) and cost (i.e., based on expenditures per ton of emissions avoided). A BACT submittal is prepared as part of a permit application, and ENVIRON prepared a BACT analysis as part of the EFSEC Application for Site Certification (BergerABAM 2014, Flint 2014). This analysis identified BACT for the proposed Facility sources.

In addition to the implementation of BACT for stationary emission sources, the proposed Facility would include emission controls for on-site locomotives in the form of Automatic Engine Shutoff Systems (AESS) that would sometimes shut off unneeded locomotives. When trains are on-site

[(4)] WAC 173-400-110 identifies potential emissions of criteria air pollutants and requires BACT for proposed units exceeding certain emission thresholds.

waiting to unload and while they are in the process of unloading and when temperature are greater than 40°F, the AESS would shut down all three locomotives associated with each train. Note that, in order to be conservative, the use of the AESS was *not* considered in the air quality impact analysis even though temperatures in the project area are less than 40°F less than 15% of the time, so factoring in AESS operations would result in emission reductions. [5]

3.1.4 Greenhouse Gas (GHG) Emissions

ENVIRON estimated long-term GHG emissions associated with the proposed Facility at full capacity operation beginning in 2016. This is a conservative approach because full capacity operation will not actually occur until some years later when a third rail line has been constructed. No specific schedule has been established for this construction.

The GHG emissions estimates considered stationary source emissions directly related to the operation of the Facility and indirect emissions due to mobile sources associated with the operational activities of the Facility. Indirect emissions from purchased energy were not considered, but would be minimal due to the natural gas-fired nature of most of the Facility.

Emissions related to operation of the Facility were tabulated as part of preparation of the EFSEC application. Indirect emissions from project-related mobile sources included locomotive emissions within Washington State associated with product delivery by rail and emissions from tanker vessels transiting to and from the Facility while operating in Washington State waters.

ENVIRON calculated GHG emissions using standard protocols and inventory methods published by the EPA, California Air Resources Board, the Intergovernmental Panel on Climate Change, and the Washington Department of Ecology. The emissions are estimated using the base equation:

$$CO_2e \text{ emissions} = \text{activity rate-duration X intensity X emission factor}$$

The emission factors used in this analysis and the critical assumptions employed in both the development of emissions and in estimating levels of construction equipment activities for the emission inventory tabulation are presented in **Attachment A**.

3.2 Dispersion Modeling

ENVIRON used air quality dispersion modeling simulations to estimate air pollutant concentrations due to emissions from ships, trains, and on-site emission sources associated with the operations at the Facility. This section discusses the methods used to develop these simulations to assess potential future pollutant concentrations in the area surrounding the Facility.

3.2.1 Model Used

ENVIRON reviewed regulatory modeling techniques to select the most appropriate air quality model to simulate dispersion of air pollutants emitted by sources associated with the proposed

(5) Data from the National Weather Service TD-3505 at Portland International Airport (45.591N & 122.600W) from January 1, 1973 through July 20, 2014 indicated hourly temperatures were less than 4.4445°C (40°F), 14.2% of the 363,518 valid hours (99.8%) during the time period.

project to estimate air pollutant concentrations. ENVIRON selected AERMOD to perform this modeling analysis because this tool is approved for air quality permitting purposes and it is capable of handling the potential for exhaust plume downwash. The modeling considered emissions downwash related to the permanent physical structures on the site (i.e., not the vessels or the trains).

The U.S. EPA has designated AERMOD as the preferred guideline air dispersion model for air dispersion modeling (EPA "Guideline on Air Quality Models," codified as Appendix W to 40 CFR Part 51) for complex source configurations and for sources subject to exhaust plume downwash. AERMOD incorporates numerical plume rise algorithms (the PRIME algorithms) that implicitly include the downwash effects a structure may have on an exhaust plume rather than using the wind tunnel based empirical algorithms of ISCST3. The PRIME algorithm also treats the geometry of upwind and downwind structures and their relationship to the emission point.

3.2.2 Mobile Source Modeling Procedures and Parameters

ENVIRON applied AERMOD to consider criteria pollutants using the regulatory defaults in addition to the options and data discussed in this section.

Model Setup and Application

ENVIRON employed the most recent version of AERMOD (Version 14134) with the default options for dispersion that depend on local meteorological data, regional upper air data, and the local physical characteristics of land use surrounding the Facility. The Facility site is located within an existing industrial area with nearby industrial and commercial activities but limited residential uses in the vicinity.

Elevation Data and Receptor Network

Terrain elevations for receptors and emission sources were prepared using digital elevation models developed by the United States Geological Survey (USGS) and available on the USGS Seamless Server system. These data have a horizontal spatial resolution of approximately 10 meters (m). The base elevation and hill height scale for each receptor were determined using the EPA terrain processor AERMAP (Version 11103). AERMAP generates a receptor output file that is read by AERMOD.

The dispersion modeling analyses used modeling receptors spaced 500 meters apart covering the 10 kilometer (km) by 10 km simulation domain, with a 5-km by 5-km nested receptor grid at 200-m spacing, a 4-km by 4-km nested receptor grid at 50-m spacing, and a 3-km by 3-km nested receptor grid at 25-m spacing. All five receptor grids were centered on the Facility site. The modeling receptor locations are depicted in Figure 3. All modeling receptors were located at and beyond the boundaries of Port of Vancouver property.

Meteorological Data

ENVIRON constructed a 5-year meteorological data set for use in the AERMOD dispersion model using surface and upper air data for the period of 2008 through 2012 after conducting a survey of available and complete meteorological data for use in the modeling simulations. For surface meteorological data, the closest and most representative National Weather Service (NWS) station was Pearson Field, located in Vancouver, Washington. A wind rose presenting wind speed and wind direction data for the five year period is shown in Figure 6. The wind rose indicates that the winds are predominantly from the northwest and east-southeast directions.

The average wind speed during the 5-year meteorological period was 2.3 meters per second (m/s; 5.1 mph), and calm conditions occurred less than 2 percent of the time.

Upper air data from McNary Field Airport, in Salem Oregon were also used for the 5-year meteorology data set. The McNary upper air data were compiled from the National Oceanic and Atmospheric Administration (NOAA) Forecast Systems Laboratory Radiosonde Database. [(6)]

EPA guidance indicates that surface parameters (albedo, Bowen ratio, and surface roughness) surrounding the primary meteorological site should be used in AERMET to construct the meteorological profiles used by AERMOD. Seasonal surface parameters were determined for the Pearson Field meteorological site using the AERMET preprocessor, AERSURFACE (Version 13016).

Daily versus Annual Operations

Operations of the proposed terminal are generally expected to occur over 24-hours per day, 365 days per year. The air quality modeling scenarios used to simulate daily and annual levels of operations are described further below.

ENVIRON developed modeling scenarios for the Facility to reflect both maximum daily through-put and maximum annual throughput in 2016 with complete buildout and full operation. The short-term (1-hour) scenario was used to estimate 1-hour concentrations, and this profile was considered with modeling simulation using every day in the 5-year meteorological database.

The daily and annual operations scenarios for stationary and mobile emission sources used a profile of hourly emissions throughout the year, reflecting a realistic operational schedule for full capacity operations. Note again that full capacity operations are not actually expected to occur until the development of a third rail line, so the modeling scenarios reflect a conservative (i.e., over-protective) approach to the impact analysis.

Averaging Periods

Pollutant concentrations predicted by the model were averaged over annual and short-term (1, 3, 8, and 24-hour) periods, as appropriate for a given pollutant's ambient standards or screening level. The modeling assessments for the CO standards and the short-term SO_2, $PM_{2.5}$, and NO_2 standards were based on the peak-day modeling described above. The assessments for comparison with the ambient standards for PM_{10}, $PM_{2.5}$, and the annual SO_2 and NO_2 concentrations were all based on the annual operations modeling scenarios due to the statistical techniques required for assessing compliance. [(7)]

---

(6) http://esrl.noaa.gov/raobs/

(7) For example, the $PM_{2.5}$ 24-hour standard is based on the 3-year average of the 98th percentile of daily concentrations, which eliminates one or more of the highest concentrations each year and requires averaging the results. These calculations can be completed with the AERMOD model based on the realistic annual operations scenario, and cannot be based on the worst-case day modeling process used to evaluate not-to-exceed short-term standards. Thus, the annual operations modeling scenario was used to consider $PM_{2.5}$ and PM_{10} which are subject to statistical ambient standards.

NO_2 Modeling – PVMRM

In accord with EPA guidance, ENVIRON applied the Plume Volume Molar Ratio Method (PVMRM) within AERMOD to allow the model to consider factors that affect both NO_2 emission rates and resulting concentrations in the ambient air. The PVMRM method accounts for both direct NO_2 emissions from stacks (e.g., locomotive exhausts) as well as atmospheric transformations that create NO_2 in the presence of estimated concentrations of ozone. Atmospheric formation of NO_2 from NOx sources in the project study area is almost certainly limited due to the lack of ozone. For this portion of the analysis ENVIRON assumed 10% of exhaust emissions from mobile sources were NO_2 and up to 80% of NOx could be converted to NO_2 in the atmosphere. [(8)] For stationary sources including the unload boilers, marine vapor combustion units, and emergency fire water pumps, ENVIRON conservatively assumed the default 50% of exhaust emissions were NO_2 (EPA 2011).

Hourly ozone monitoring data from the entire modeling period (2008-2012) from Vancouver, Washington's ozone monitor (ID 530-11-0011) were considered in the modeling. For periods when hourly ozone data were missing, the highest annual average ozone value throughout the 5 year period (i.e., 25 ppb) was used instead.

Emission Source Locations, Characterization, and Release Parameters

Ship stack emissions from vessels in transit and hotelling at the dock were represented in the model as a series of **point sources**. Emissions from trains transiting on and near the site were represented by series of **volume sources**, while stationary idling trains were considered as **point sources**. Additional discussion of these sources follows.

Vessels in transit, harbor assist vessels (i.e., tugs), and vessels hotelling at the wharf during loading were considered as point sources in the AERMOD analysis. For point sources, AERMOD calculates thermal buoyancy and downwash effects on source emissions. Thermal buoyancy causes warmer plumes to rise and downwash effects push plumes downward as wind travels over buildings. **Table 5** (page 13) provides specific information regarding the modeling parameters for these sources. See also **Table 3** (page 7) for additional information regarding the assumptions and methods employed in the dispersion modeling.

Trains traveling on and near the site were considered as a series of equally spaced volume sources that represented the variable emission conditions along these curvilinear paths of travel. In AERMOD, volume sources are represented as a 3-dimensional Gaussian distribution of emissions. The model disperses the starting distribution of pollutant according to the meteorological conditions occurring in a given hour. Parameters describing the location and initial horizontal distribution of each volume source were determined using a series of equally spaced volumes that followed the rail alignment onto and around the Facility site. Unlike point sources, AERMOD does not consider the effects of thermal buoyancy or downwash on volume source emissions, and this approach is not entirely appropriate for representing the heated

(8) In-stack NO_2 to NOx emission ratio from P G Boulter, I S McCrae, and J Green, Transportation Research Laboratory, *Primary NO_2 Emissions From Road Vehicles in the Hatfield and Bell Commons Tunnels*, July 2007 as reported in the San Joaquin Valley Air Pollution Control District Air Modeling Guidance for NO_2.

emissions from a locomotive stack. ENVIRON therefore employed an additional adjustment to compensate for this limitation in the AERMOD model.

In 2004, as part of the Roseville Rail Yard Study, the California Air Resources Board (CARB) developed a method to estimate initial locomotive plume rise adjustments from buoyancy and downwash effects using the EPA SCREEN3 model. [9] Consistent with the ARB's adjustment calculations, ENVIRON estimated initial plume height using SCREEN3 based on typical in-stack temperature and flow rates based on average notch settings and approximate speed of the trains during transit. [10] Thus, the release height and vertical dimension of emissions from transiting trains take into account not only the height of the locomotive emission sources, but the buoyancy of the emission gasses and downwash effects generated by the train's movement. ENVIRON used the resulting estimated stack and release heights (Table 5) in the AERMOD assessment.

Idling locomotives were considered in the dispersion modeling as point sources with stack exhaust temperature, flow rate, and diameter based on stack testing for an idling GE ES44DC model locomotive engine. The ES44DC is a reasonable representation of the C44 locomotives expected to service the proposed Facility. Stack testing data provided by the Southwest Research Institute's Locomotive Technology Center did not include typical stack heights for locomotives with an ES44DC engine. Therefore, stack heights used for idling locomotives were estimated using the Roseville Rail Yard Study.

Table 5. Combustion Source Modeling Parameters

POINT Sources	Stack Height (m)	Stack Temp. (K)	Exit Velocity (m/s)	Exit Diam. (m)
Vessels	30	673.15	20	0.5
Idling Locomotives	4.52	374.15	1.85	0.6
VOLUME Sources				
VOLUME Sources	**Release Height (m)**	**Initial Lateral Dimension (m)**	**Initial Vertical Dimension (m)**	
Transiting Trains	5.5	7.1	2.1	

3.2.3 Permitted Emissions Sources

All on-site project-related stationary emission sources subject to air quality permitting under EFSEC rules were considered in a separate air quality modeling assessment conducted during preparation of the permit application. The emissions and dispersion modeling parameters

[9] State of California Air Resources Board, 2004, *Roseville Rail Yard Study*; this method does not consider variability in ambient meteorological conditions and wind speeds because as a screening-level model, SCREEN3 assumes fairly basic, static conditions in estimating dispersion. This technique represents a reasonable and previously applied method for representing plume rise associated with locomotive emissions.

[10] ENVIRON received notch-specific temperature and flow rates from Steve Fritz of the Southwest Research Institute's Locomotive Technology Center.

applied in that analysis are explained in detail in the EFSEC application materials. [11] Identical modeling parameters were assumed in the combined stationary source/mobile source modeling conducted for the air quality impact assessment described here.

3.3 Modeling Post-Processing: Transiting Trains Monte Carlo Simulations

The AERMOD assessment of 1-hour NO_2 concentrations from trains traveling on the project site were based on worst-case operations when locomotives would be idling in close proximity to one another and to the property boundaries. While such circumstances could occur once in a while, the worst-case conditions assumed in the modeling would be rare, and would at most be expected to occur more or less randomly over about one hour a day.

To address this issue, the analysis used a two-step process that began by performing AERMOD modeling that applied worst-case conditions in every hours of every day of the entire 5-year meteorological data set. The second step involved randomly selecting output from the first-step modeling results in a Monte Carlo probability analysis to allow worst-case conditions to occur only one hour each day.

The Monte Carlo simulations involved post-processing the hourly modeling results for each day of the 5 years analyzed to randomly select hours during which the locomotives would be idling in close proximity to one another during product unloading. Data from the hours selected for each day were considered for each modeling receptor. This process was repeated 1,000 times for each year. Results of this selection process were then used to compute the median hourly NO_2 concentrations for comparison with the 1-hour ambient air quality standard. This analysis process was consistent with the approach developed by Clint Bowman of the Washington State Department of Ecology for addressing compliance assessments of intermittent (or randomly occurring) emission sources (Ecology 2011b).

3.4 Off-Site Traffic Impact Assessment

The analysis of potential air quality impacts of off-site project-related traffic operating near signalized intersections was conducted in accord with EPA guidance (EPA 1992b). The analysis was based on a qualitative review of intersection operation information compiled in the traffic impact assessment report for the project (Kittelson 2013).

[11] EFSEC Application for Site Certification and Revised Application (Footnotes 1 and 2, page 3)

4 Potential Impacts of the Proposed Project

4.1 General Air Quality Conformity Review

The federal General Conformity rules (40 CFR Part 93, Subpart B) require actions within air quality nonattainment or maintenance area that are taken or approved by federal agencies not cause new violations of the NAAQSs or prolong the time required to attain these standards. The Facility project site is within CO and ozone air quality maintenance areas, and the project requires approvals by the Army Corps of Engineers (USACE) and the US Coast Guard (USCG). As a result, the project is subject to consideration under the federal General Conformity rules.

The General Conformity review process is a stepped process beginning with consideration of project-related air pollutant emissions and comparison of those emissions with *de minimis* levels defined in the federal rule. Emissions subject to inclusion in this review are those directly and indirectly related to the action approved by a federal agency for which the agency has both jurisdiction *and* the ability to control emissions from the subject sources. For example, the USACE controls in-water activities and can impose requirements such as using clean fuels to reduce emissions. But the USACE has no jurisdiction to control emissions from any related land-side emission sources (e.g., trucks) because these sources are not subject to permit conditions, and in the case of trucks, are subject to emission limits adopted by US EPA. As a result, in-water work emission sources are subject to consideration under the General Conformity rules but related land operations emission sources are not. Similarly, although vessel operations are subject to USGC safety regulations, USGC has no jurisdiction to control vessel engine emissions, so vessel emissions are not subject to consideration as part of the General Conformity review. In addition, operational emission sources subject to other federal permits need not be considered as part of the General Conformity review because these sources are evaluated in other ways (e.g., via an EFSEC application review).

Facility-related in-water work subject to requirements of the USACE permit would be limited both in terms of the types of equipment involved and in the duration of use. It is therefore possible to assess General Conformity by qualitatively comparing project-related emissions with previously conducted emissions tabulations. Such a comparison reveals that construction of the proposed Facility would comply with General Conformity requirements.

ENVIRON prepared a detailed emissions inventory for equipment and activities associated with the construction of a 4-berth container terminal within the Port of Tacoma, Washington. That project, the Puyallup Tribal Terminal will involve multiple years of construction including in-water work such as dredging, excavation to reshape the shoreline, and both sheet pile and straight pile driving. ENVIRON quantified emissions associated with the single highest year of construction-related emissions due to sources subject to permitting by the USACE. As shown in **Table 6**, construction-related emissions associated with this larger project are much lower than the General Conformity *de minimis* levels. Because this larger project would involve much more in-water work than would be required for the Facility, this comparative analysis indicates the Facility project will comply with federal General Conformity requirements.

Table 6. Puyallup Tribal Terminal 3-Berth Construction Emissions in 2012 Subject to General Conformity Review – For Comparison Purposes

Emissions Category	Emissions (tons/year)				
	$PM_{2.5}$	NOx	SO_2	VOC	CO
Total In-Water Related Construction Emissions	1.14	23.44	0.18	1.50	5.92
General Conformity *de minimis* levels for $PM_{2.5}$, CO, and Ozone Maintenance Areas (CFR 40 § 93.153)	100	100	100	100	100
Source: ENVIRON 2010					

4.2 Operational Air Quality Impacts

4.2.1 Projected Annual Emissions

The estimated annual emissions of criteria air pollutants from full capacity operation of the Facility in 2016 are presented in the next two tables. **Table 7** lists the emissions from permitted stationary sources at the Facility as they were considered in the EFSEC application analyses. **Table 8** shows the emissions associated with mobile sources associated with transport of crude oil to the Facility on trains and transported away from the Facility on vessels. Note that the emissions listed were distributed both spatially across the Facility and temporally across each day of an entire year to provide the basis of the air quality dispersion modeling.

Table 7. Estimated Annual Operational Emissions (Permitted Stationary Sources)

Pollutant	Emission Rate (tons/year)					
	Unload Boilers	MVCUs	Component Fugitives	Tanks Fugitives	Fire-Water Pumps	Total
NO_X	5.95	8.04	--	--	0.00632	14.0
CO	19.5	3.49	--	--	0.0302	23.0
SO_2	1.99	6.59	--	--	0.000130	8.57
PM	4.06	2.62	--	--	0.00321	6.68
VOC	2.70	8.64	0.822	23.6	0.00689	35.7
GHG (CO_2e)	44,170	50,530	11.9	261	13.5	94,980
Source: Flint 2014						

Table 8. Estimated Annual Operational Emissions (Mobile Sources)

Criteria Air Pollutant	Operational Sources	Operational Emissions (tons/year)
Inhalable Coarse Particulate Matter (PM_{10})	Vessels	1.36
	Trains	0.03
Inhalable Fine Particulate Matter ($PM_{2.5}$)	Vessels	1.29
	Trains	0.02
Sulfur Dioxide (SO_2)	Vessels	3.11
	Trains	0.0008
Carbon Monoxide (CO)	Vessels	8.54
	Trains	0.21
Nitrogen Dioxide (NO_2)	Vessels	98.70
	Trains	0.99
Total Annual Emissions		
Inhalable Coarse Particulate Matter (PM_{10})		1.39
Inhalable Fine Particulate Matter ($PM_{2.5}$)		1.31
Sulfur Dioxide (SO_2)		3.11
Carbon Monoxide (CO)		8.76
Nitrogen Dioxide (NO_2)		99.68

Assumes 100% of NOx emissions are NO_2

Vessels in Transit include tug assists during maneuvering

Train emissions without AESS; produces conservative results; including AESS would reduce emissions – see **Table 2**

4.2.2 Projected Off-Site Air Pollutant Concentrations

The results of the air quality dispersion modeling analysis of Facility sources are summarized in Table 9, which presents the model-calculated future concentrations for criteria pollutants at the maximum impact locations affected by Facility emissions. As shown, model-predicted project-related criteria air pollutant concentrations at the maximum impact locations with full capacity operations are all less than the levels allowed by all the short and long-term ambient air quality standards.

Table 9. Modeling Results: Criteria Pollutant Maximum Concentrations (μg/m^3)

Criteria Air Pollutant	Averaging Time	B/G Conc. [(a)]	Project-Related Concentration [(b), (c)]	Project Plus B/G	Ambient Standard [(d)]
CO	1-hour	3,550	348.1	3,898	40,000
	8-hour	2,519	69.0	2,588	10,000
NO_2	1-hour	Varies [(e)]	Based on Monte Carlo Simulations	175	188
	Annual	16.9	29.6	46	100
$PM_{2.5}$	24-hour	20.5	5.4	26	35
	Annual	7 [(f)]	0.7	8	12
PM_{10}	24-hour	34	10.5	45	150
	Annual	13 [(f)]	0.7	14	50 [(g)]
SO_2	1-hour	12.8	43.8	57	196
	3-hour	7.1	16.0	23	1,310
	24-hour	4.5	12.6	17	365 [(h)]
	Annual	3.9 [(f)]	0.3	4	52 [(h)]

(a) Background concentrations (expressed as μg/m^3) based on measured levels.

(b) Reported pollutant concentrations are those occurring at the maximum impact location for each pollutant. Concentrations at all other locations are less than those reported here.

(c) Except as noted below, all short-term concentrations are based on modeling that considered maximum hourly activity during every hour of the 5-year meteorological data set, which is not a possible actual level of activity. These results therefore represent intentionally conservative conditions. Note that consistent with USEPA guidance, the annual modeling results are based on 5-year averages from the 5-year meteorological data set instead of 3-year as per the NAAQSs.

(d) All ambient concentrations are expressed in terms of micrograms per cubic meter (μg/m^3); sometimes the ambient air quality standards, includes some concentrations reported in parts per million (ppm).

(e) Variations hourly by season were considered in the dispersion modeling as explained in Seasonal/ Hourly Background Concentrations. Thus the modeling included background concentrations. Refer to Monte Carlo Post-Processing Simulations discussion for additional information.

(f) Value represents maximum measured concentrations; do not reflect statistical treatment, therefore conservative

(g) Denote SWCAA ambient air quality standard (only, i.e., no federal or Washington State standard)

(h) Denote Washington State ambient air quality standard (only, i.e., no federal standard)

4.3 Off-Site Traffic Air Quality Impacts

4.3.1 Surface Street Intersections

EPA guidance regarding potential traffic-related air quality impacts suggests considering the most congested signalized intersection(s) that would be affected by a project's traffic, and recommends possibly conducting dispersion modeling of the most adversely affected intersections. In this context, "adversely affected" refers to projected deterioration in an intersection's level of service (LOS) to a degree that might impact air quality nearby. [(12)]

EPA suggests modeling the most congested intersections that would be directly affected by traffic to the degree that LOS would be degraded to a LOS "D" or worse due to a project. [(12)] Consistent with EPA guidance, signalized intersections that would be affected by the proposed Facility project were screened for possible modeling analysis by reviewing the intersection LOS data provided by Kittelson (2013). Based on these traffic data, none of the signalized intersections in the project study area would be adversely affected by project-related vehicle traffic to the extent that the LOS would degrade to LOS D or worse. These data are summarized in **Table 10**. As a result of the traffic projections, because no intersections fall to an LOS of D or worse due to the project, no additional analysis is required to conclude that project-related operational vehicle traffic would not result in air quality impacts due to increased congestion near off-site intersections.

Table 10. Facility Forecast 2025 Total Traffic Conditions Summary

Intersection	Peak Commute Period	Level of Service	Volume to Capacity Ratio
Old Lower River Rd/ Lower River Rd (SR 501)	AM	B	0.10
	PM	A	0.13
Gateway Ave/Lower River Rd (SR 501)	AM	A	0.08
	PM	A	0.07
Fourth Plain Blvd/Mill Plain Blvd (SR 501)	AM	B	0.75
	PM	B	0.38
Old Lower River Rd/Old Alcoa Facility Access Rd	AM	B	NA
	PM	A	NA
Source: Kittelson and Associates, Inc. 2013			

4.3.2 Traffic Delays Caused by Project/Related Trains

ENVIRON also considered the potential for air quality impacts due to increases in vehicle delays near railroad/street crossings that occasionally would be obstructed by project-related trains.

[(12)] Level of service (LOS) is a measure of the relative efficiency of the operation of an intersection based on the amount of congestion that occurs, usually during a peak commute hour. The LOS for signalized intersections is the weighted average vehicle delay represented by a scale from A to F, with "A" representing little if any delay, and "F" representing congestion due to an intersection being over capacity. LOS "D," which is used as a threshold of *potential* for air quality impacts, results in delays of between 35 and 55 seconds per vehicle.

This review was based on a qualitative comparison of potential traffic delays with findings from a previous quantitative analysis.

At full capacity operation the proposed project would result in an average of four train trips to and from the Facility each day. The inbound transit trips within Washington State are expected to be via the "southern" route (i.e., Spokane-Pasco-Vancouver). The outbound "return" trips are expected to be via the "central" route (i.e., Tacoma-Pasco-Spokane). Inbound loaded trains trips are expected to cause up to about 10-minute delays at roadway crossings; outbound empty trains are expected to cause up to about 5-minute delays. For the anticipated 7,800-foot trains, this is equivalent to an inbound travel speed through rail crossings of about 9 mph and outbound speeds of about 18 mph. Trains traveling through controlled crossings in uncongested areas are likely to have higher travel speeds and cause less delay.

ENVIRON recently conducted a detailed air quality analysis of a very congested (i.e., peak-hour LOS = F) 4-way signalized intersection in Tukwila, Washington. This analysis used dispersion modeling (with EPA CAL3QHC model) based on emission rates calculated using the latest EPA emissions calculator tool (MOVES2010). Based on comparison with this previous quantitative analysis it is possible to assess the relative air quality implications of the train-related traffic delays due to Facility trains.

Review of the railroad alignment for inbound trains suggests that at highways and large roads the rail line is grade separated so there are no major rail/road crossings that would be delayed by train traffic. Consideration of the outbound return routes first reviewed the northern route then the central route (see **Figure 7**). Along the northern route, the largest single rail/road crossing for which there are reasonably available traffic volume estimates is the crossing of SR-516 in Kent. There is no similarly large rail/road crossing along the central route. So to provide a conservative assessment of potential impacts, the rail/road crossing of SR-516 in Kent was considered more closely.

The estimated daily traffic volume through the SR-516 crossing in Kent is 21,500 vehicles). [(13)] This compares with a daily volume through the Tukwila intersection of South 180th Street with the West Valley Highway of 25,000 vehicles. Assuming the same ratio of daily to afternoon peak-hour volumes applies, the respective intersection volumes are about 5,400 in Tukwila and 4,600 in Kent. The cumulative intersection delay at the Tukwila intersection (based on projections for 2030) was 455 hours). [(14)] In comparison, a 5-minute train-crossing delay of SR-516 would cause a cumulative delay of 386 hours, or about 85% of the cumulative delay found at the Tukwila intersection, conservatively assuming the delay occurs during the p.m. peak hour (i.e., when there would be maximum hourly volumes).

A detailed air quality modeling analysis of the Tukwila intersection indicated that carbon monoxide (CO) concentrations near this very congested intersection would be about 15% of the level allowed by the 1-hour CO standard and about 42% of the level allowed by the 8-hour CO

[(13)] Based on the average of count location to the west (28k) and the one to the east (15k) from WSDOT website http://www.wsdot.wa.gov/mapsdata/tools/traffictrends/.

[(14)] Cumulative peak-hour delay is the average per vehicle delay times the total peak-hour volume.

standard (including background concentrations); (ENVIRON 2013). Using these results as an indicator and CO as a representative pollutant for vehicle sources it is clear that the occasional 5 to 10-minute delays caused by project-related trains would not comprise a significant threat to air quality in the vicinity of rail/road crossings due to vehicle emissions.

4.4 GHG Emissions

Long term (operational) GHG emissions were estimated to provide an indication of the potential for significant emissions as defined in SEPA. The sources and the extent of the area considered operational emissions plus vessel and rail emissions within Washington State.

The rail routes for which emissions were tabulated were as follow (see **Figure 7** regarding rail routes):

- Beginning at the state line east of Spokane, follow Columbia River Route south to Pasco and on to Vancouver on the incoming trip, then
- Starting in Vancouver, travel north through Tacoma and Auburn, then follow the Central Stampede alignment return route back to Pasco and then back to Spokane

GHG emissions from vessels were estimated based on docking, hotelling, and departure activities occurring near the Facility (see **Table 3**, page 7), along with emissions during inbound and outbound vessel transits within the waters of Washington State.

Details of the GHG calculations are included in **Attachment A**.

As shown in **Table 11**, total estimated annual Facility GHG emissions exceed the 10,000 metric ton CO_2e value Ecology suggests as an indicator of the need to quantify project-related GHG emissions during SEPA review, including "new" direct and "proximate" direct and indirect emissions (Ecology 2011a). This guidance also indicates projects with annual emissions of more than 25,000 metric tons CO_2e should provide a quantitative assessment of GHG emissions and an evaluation of the potential for impacts of changing climate on the project's new infrastructure. Note that at this time, the extent to which transportation-related GHG emissions should be included in such an analysis is "an unsettled question under SEPA case law" (Ecology 2011a). Facility-related GHG emissions are dominated by those from transportation sources.

Table 11. Summary of GHG Emissions

Operational Emissions	Annual Emissions CO_2e (metric tons)
Rail product delivery [(a)]	
Transiting within Washington [(b)]	156,684
On-site [(c)]	3,257
Vessel product export [(d)]	
Transiting within Washington [(e)]	17,232
On-site [(f)]	6,829
Total product transport emissions	184,002
Facility operations stationary sources [(g)]	86,184
Total annual Facility-related greenhouse gas emissions	**270,186**

(a) GHG emission factors taken or calculated from the 2009 USEPA "Emission Factors for Locomotives" and 2008 USEPA "Greenhouse Gas Inventory Protocol Core Module Guidance - Direct Emissions from Mobile Combustion Sources," USEPA Climate Leaders, Table A-6.

(b) Transiting emissions assume route along the Columbia River while loaded and along US-2 when empty

(c) On-site activity data provided by Savage (2013)

(d) GHG emission factors taken or calculated from the 2009 USEPA "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories" and 2204 IVL "Methodology for calculating emissions from ships. 1. Update of emission factors."

(e) Vessel transit operations assumed to occur between the Facility and the mouth of the Columbia River

(f) On-site vessel activities include maneuvering with tugs and hotelling with boilers

(g) From revised EFSEC application (Flint 2014)

5 References

BergerABAM. 2014. *Tesoro Savage Vancouver Energy Distribution Terminal EFSEC Application*. No. 2013-01 Supplement-UTC Docket No. EF 131590 Application Supplement. BergerABAM, Vancouver, WA. February 25, 2014.

ENVIRON International Corporation

2008. *Draft Report, Diesel Particulate Matter Mitigation Plan for the BNSF Railroad Hobart Rail Yard*, September 26, 2008 found at **http://www.arb.ca.gov/railyard/hra/hra.htm** (dated on web page as October 16, 2008)

2010. *Puyallup Tribal Terminal Air Quality Technical Report*. Prepared on behalf of SSA Containers, Inc. Seattle, WA. March 26, 2010

2013. 2013, Memo to Lynn Miranda, City of Tukwila documenting the air quality review of the Tukwila Subarea Plan, August 8, 2013

Flint, K. 2014. *Revised Air Permit Application and Notice of Construction for Tesoro/Savage Vancouver Energy Distribution Terminal* ("Vancouver Energy"), EFSEC Application No. 2013-01; Docket: EF-131590. August 8, 2014.

Kittelson and Associates, Inc. 2013. *Tesoro Savage Vancouver Energy Distribution Terminal Transportation Impact Analysis*. Project #: 13574.0. August 22, 2013

Savage. 2013. Several phone conferences between Savage and ENVIRON. Involved Savage personnel were Ben Lieberman, Gerry Farrell, and David Corpron. October 2013.

US Environmental Protection Agency (EPA)

1992a. *Guideline for Modeling Carbon Monoxide from Roadway Intersections*. Office of Air Quality Planning and Standards. Technical Support Division. Research Triangle Park, North Carolina. EPA-454/R-92-005

1992b. Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised. Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. EPA-454/R-92-019

2002. Health Assessment Document for Diesel Engine Exhaust. National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC. EPA/600/8-90/057F. May 2002

2006. *Current Methodologies and Best Practices in Preparing Port Emission Inventories*. USEPA Office of Policy, Economics and Innovation. January 2006 and updates April 2006

2008. NONROAD2008a Model, USEPA Office of Transportation and Air Quality. Model posted at http://www.epa.gov/oms/nonrdmdl.htm. July 2009

2011. *Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard.* USEPA Office of Air Quality Planning and Standards. March 2011

2014. *User's Guide for the AMS/EPA Regulatory Model – AERMOD*. Version 14134 Addendum. EPA-454/B-03-001. May 2014

Washington Associated General Contractors (AGC). Undated. *Guide to Handling Fugitive Dust from Construction Projects*. Washington Associated General Contractors

Washing State Department of Ecology (Ecology)

2008. *Concerns about Adverse Health Effects of Diesel Engine Emissions White Paper*. Harriet Ammann and Mathew Kadlec. Publication 08-02-032. December 3, 2008

2010. Washington State Greenhouse Gas Emissions Inventory 1990-2008. Publication no. 10-02-046. December 2010

2011a. *Guidance for Ecology Including Greenhouse Gas Emissions in SEPA Reviews*. June 3, 2011. http://www.ecy.wa.gov/climatechange/docs/sepa/20110603_SEPA_GHGinternalguidance.pdf

2011b. *A Monte Carlo Approach to Estimating Impacts from Highly Intermittent Sources on Short Term Standards*. Clint Bowman and Ranil Dhammapala, State of Washington, Department of Ecology. Presentation at the Northwest International Air Quality Environmental Science and Technology Consortium; June 1, 2011

2014. *Washington State 2011 County Emissions Inventory*. Air Quality Program, Washington State Department of Ecology, Olympia, Washington. April 25, 2014

6 Attached Figures

Page

Note that figures are formatted for printing on the "front" side of double-sided pages, and the "back" sides of these pages are unnumbered, but nonetheless included in the page count.

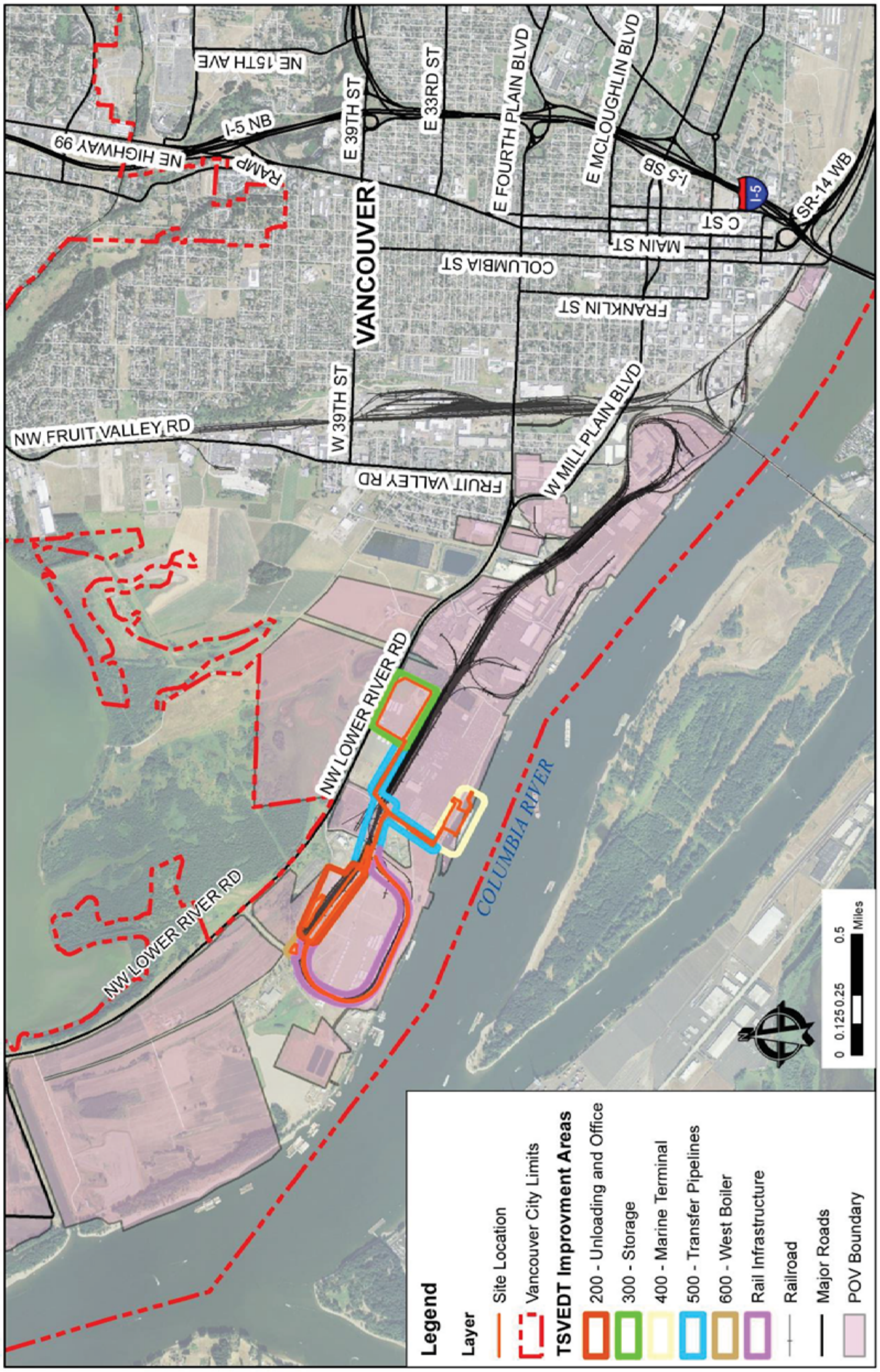

Figure 1. Project Vicinity Map

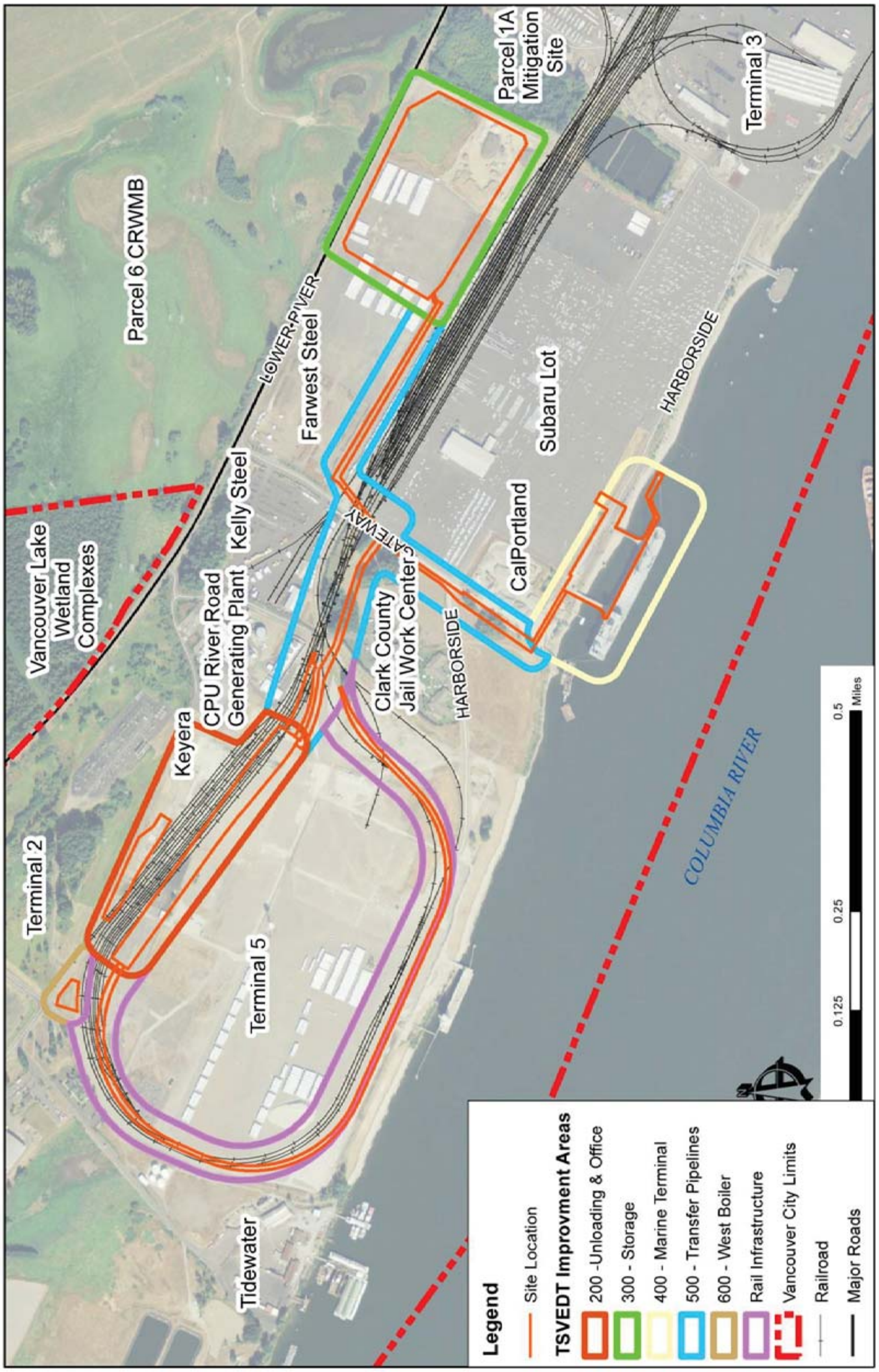

Figure 2. Facility General Layout

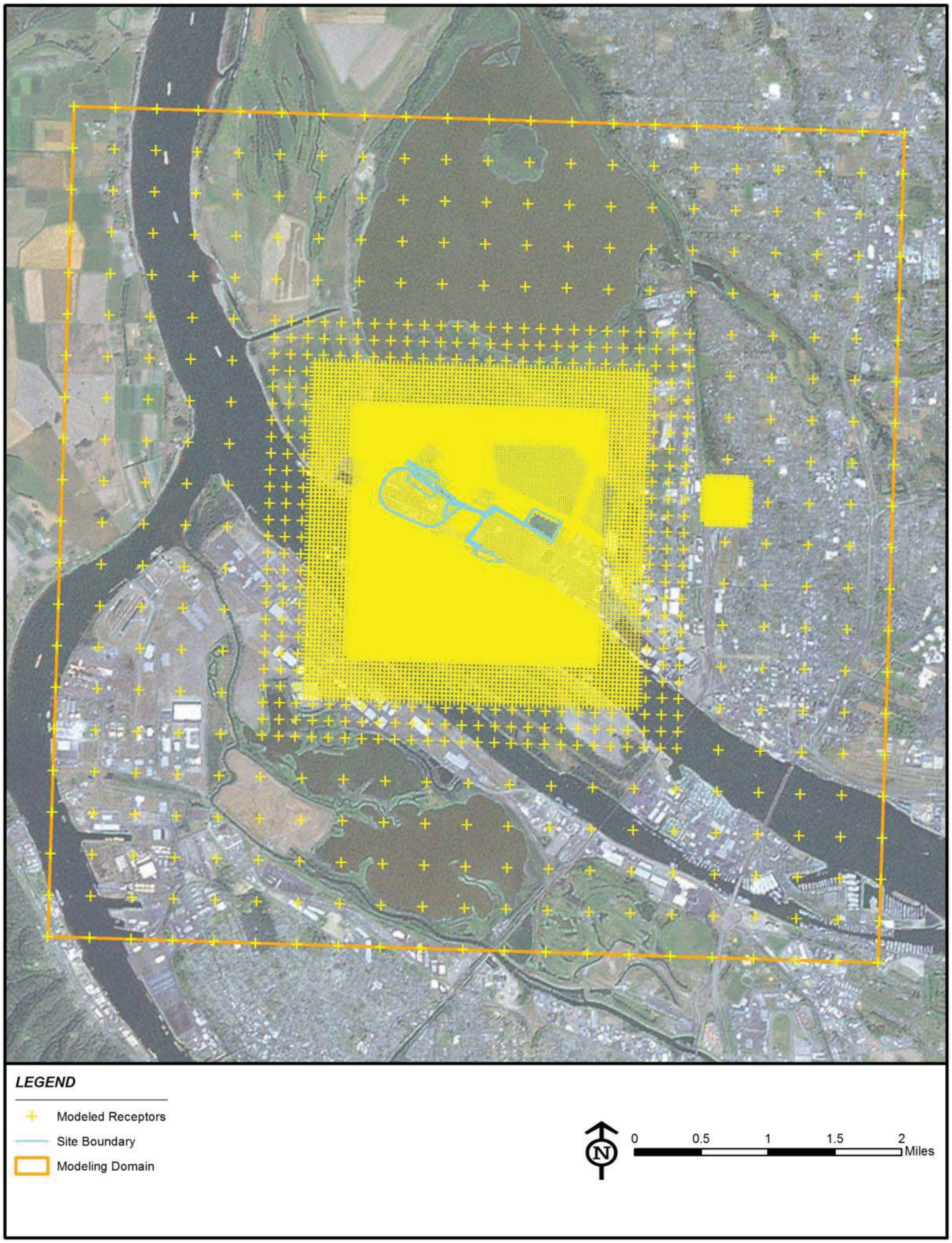

Figure 3. AERMOD Modeling Domain and Modeling Receptor Grids

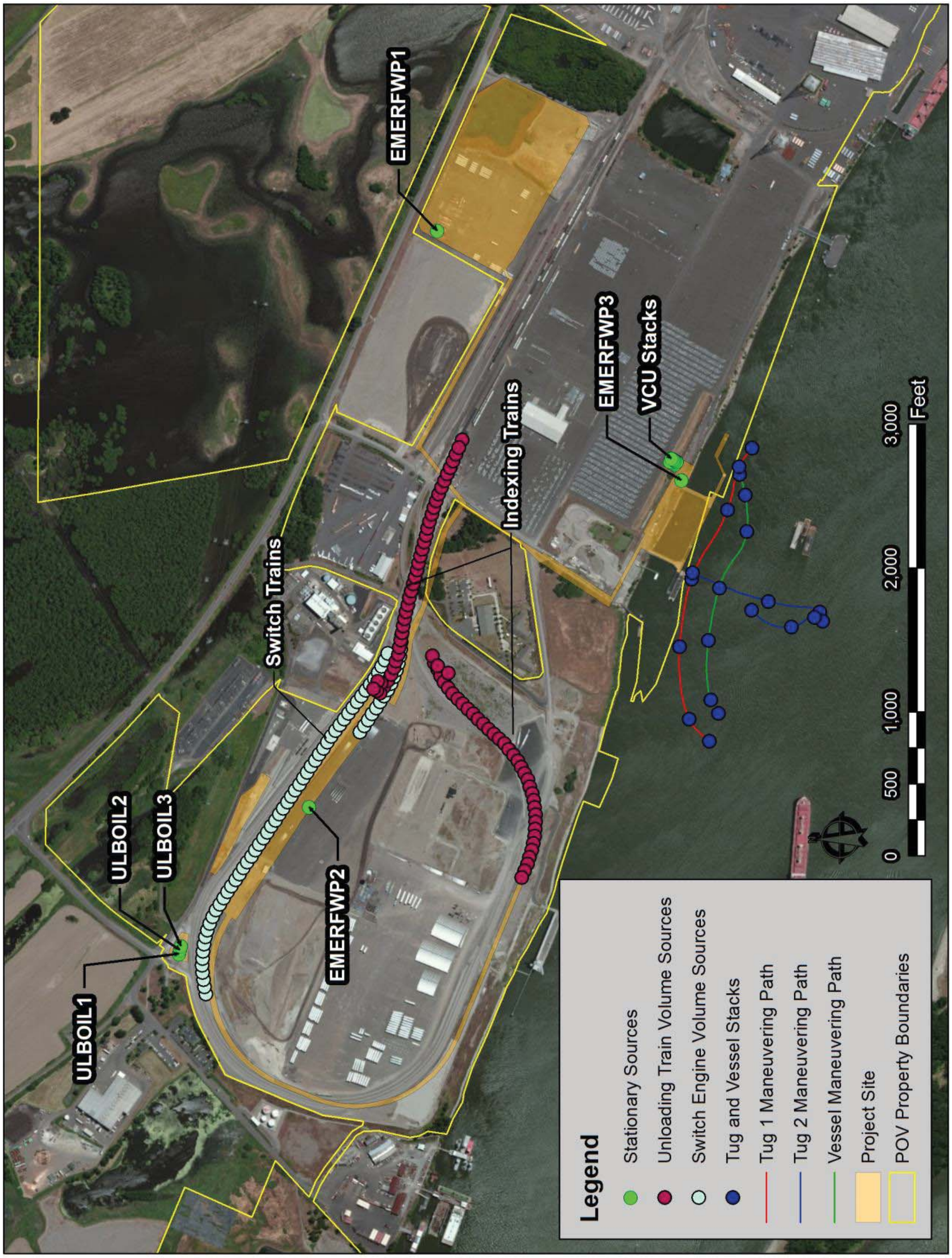

Figure 4. Short-term Modeling Scenario Sources

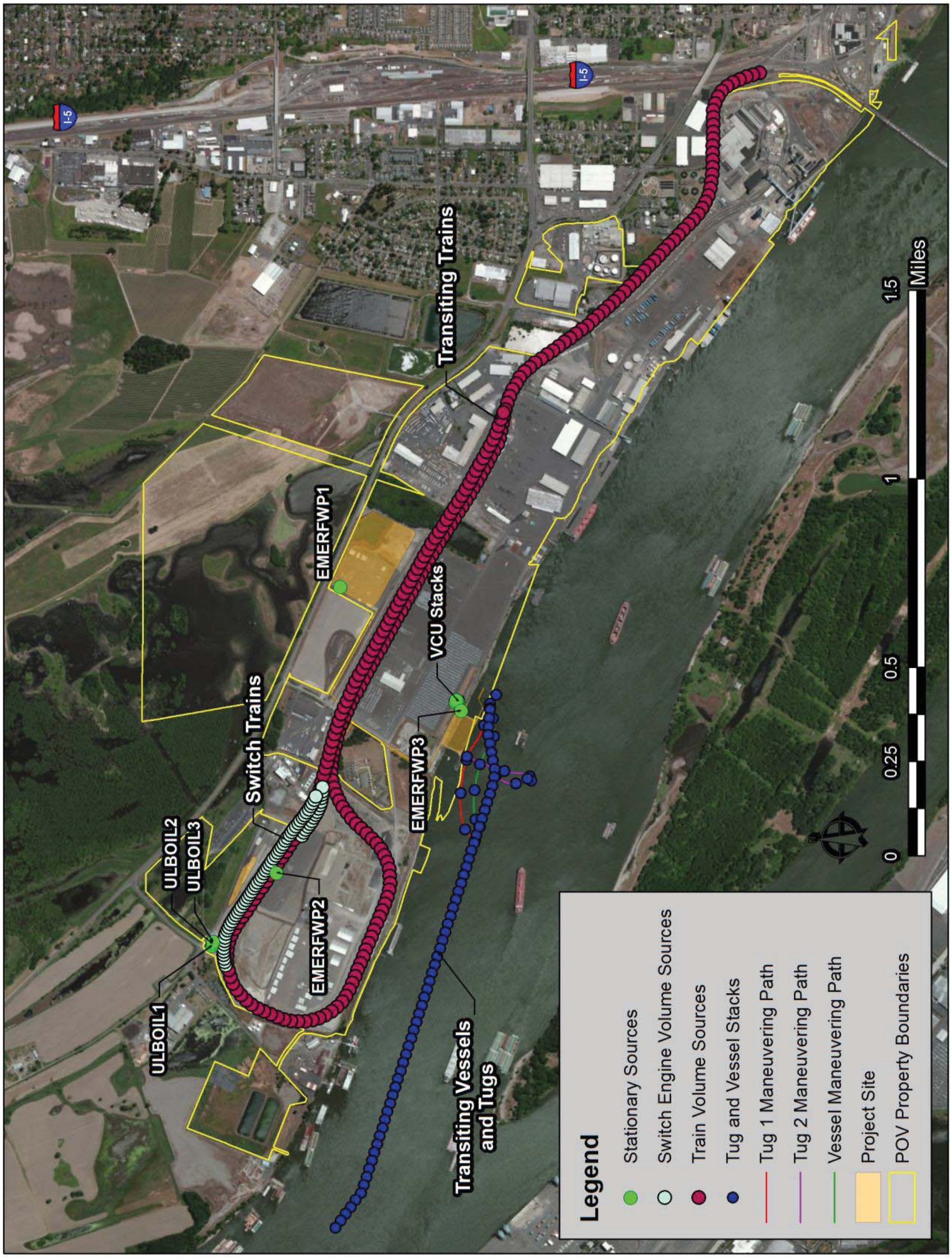

Figure 5. Long-term Modeling Scenario Sources

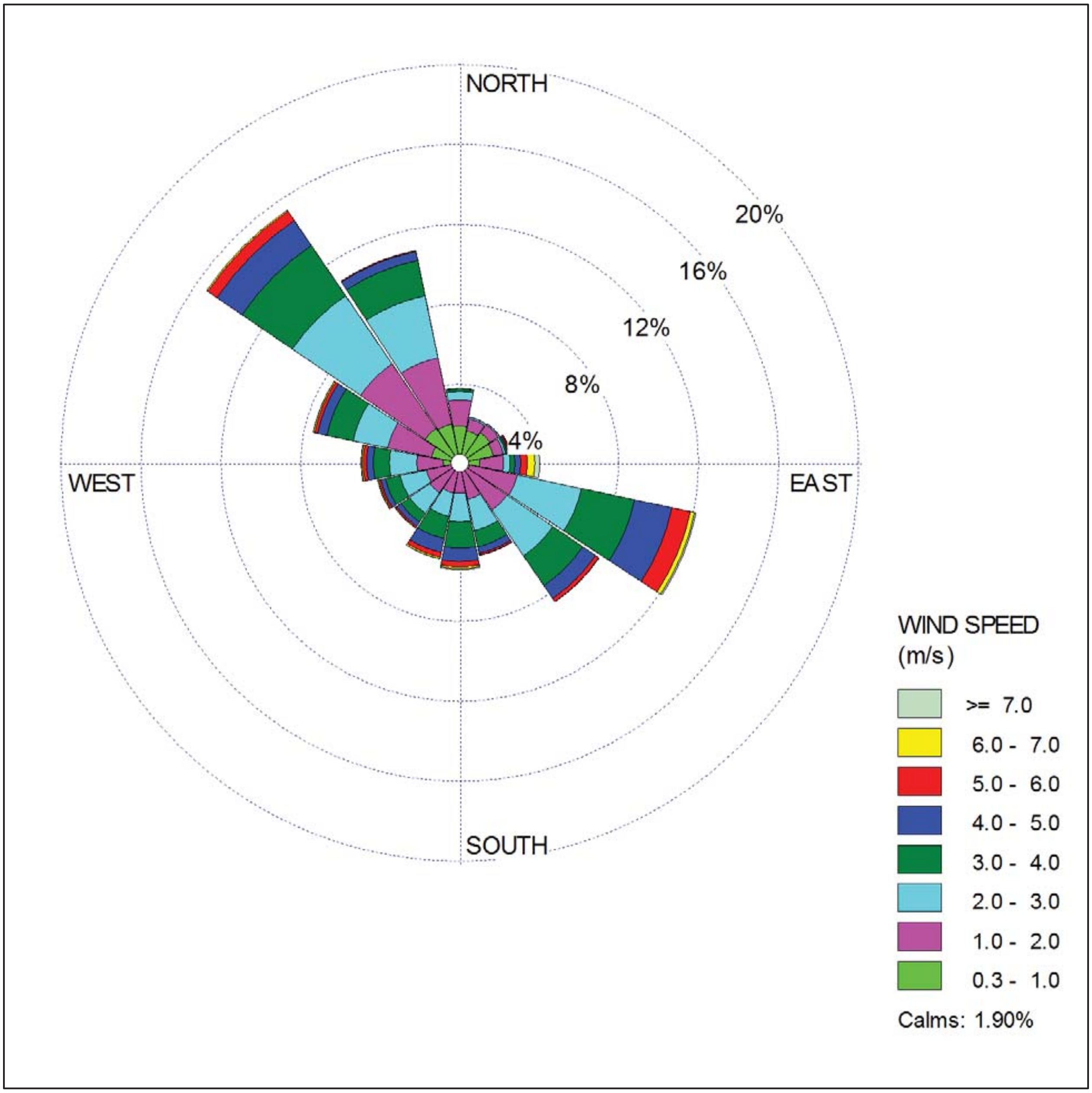

Figure 6. 5-Year Meteorological Data Set Wind Rose

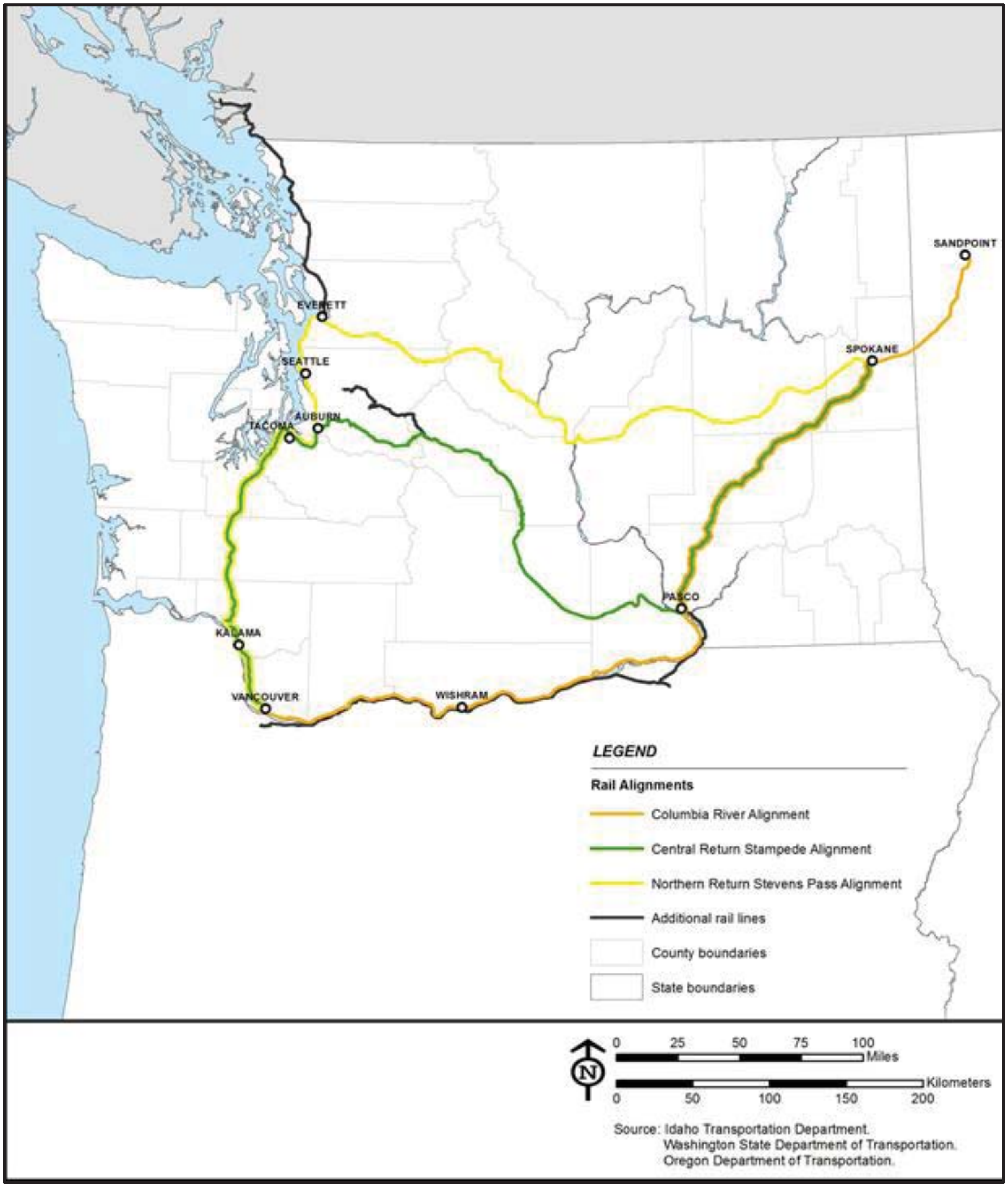

Figure 7. Primary Rail Routes in Washington State

Attachment A: GHG Emissions Inventory

Attachment A
GHG Emissions Calculations

Project-Related GHG Emissions: Summary

Operational Emissions	Annual Emissions CO_2e - Metric Tons
Rail Product Delivery [a]	
Transiting (within Washington) [b]	156,684
On-Site [c]	3,257
Vessel Product Export [d]	
Transiting (within Washington) [e]	17,232
On-Site [f]	6,829
Total Product Transport Emissions	184,002
Facility Operations Stationary Sources	86,184
Total Annual Facility-Related GHG Emissior	**270,186**

Source: ENVIRON International Corporation 2014

[a] GHG emission factors taken or calculated from the 2009 EPA "Emission Factors for Locomotives" and 2008 EPA "Greenhouse Gas Inventory Protocol Core Module Guidance - Direct Emissions from Mobile Combustion Sources" , EPA Climate Leaders, Table A-6.

[b] Transiting emissions assume route along the Columbia River while loaded and along central rail route when empty

[c] On-site activity data provided by Savage, 2013

[d] GHG emission factors taken or calculated from the 2009 EPA "Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories" and 2004 IVL "Methodology for calculating emissions from ships. 1. Update of emission factors".

[e] Vessel transit operations assumed to occur between the facility and the mouth of the Columbia River

[f] On-site vessel activities include maneuvering with tugs and hotelling with boilers

On-site Locomotive Activity							
Action	Notch	Time (min)	Distance (feet)	Speed (mph)	Distance (miles)	Time @ 10 mph	Gallons Consumed (gal)[a]
Spur to facility	Notch 3[b]	15	10685.8	10	2.02	12.14	35.25
Wait for switch at facility yard	Idle[c]	10	0	0	-	-	1.65
Proceed forward to personell switch	Notch 3	10	6585.3	10	1.25	7.48	23.50
Switch personnel BNSF > Savage	Idle	10	0	0	-	-	1.65
Proceed forward to unloading	Notch 3	5	2956	10	0.56	3.36	11.75
Unload	Idle	120	0	0	-	-	19.80
Proceed forward 1800 feet	Notch 3	3	1800	10	0.34	2.05	7.05
Unload	Idle	120	0	0	-	-	19.80
Proceed forward 1800 feet	Notch 3	3	1800	10	0.34	2.05	7.05
Unload	Idle	120	0	0	-	-	19.80
Proceed forward 1800 feet	Notch 3	3	1800	10	0.34	2.05	7.05
Unload	Idle	120	0	0	-	-	19.80
Exit Unloading area	Notch 3	3	1800	10	0.34	2.05	7.05
Switch personnel Savage > BNSF. Inspection	Idle	60	0	0	-	-	9.90
Proceed to Spur	Notch 3	10	5376	10	1.02	6.11	23.50
Wait for track alignment	Idle	10	0	0	-	-	1.65
					Total Gallons of Fuel		**216.25**

[a] *Assumes 3 locomotives per train*

[b] *Notch 3 fuel consumption estimated by Savage to be 47 gallons per hour (Savage, 2013)*

[c] *Idle fuel consumption estimated by Savage to be 3.3 gallons per hour (Savage, 2013)*

Locomotive GHG Emissions				
Pollutant	Global Warming Potential[a]	Emission Factor[b] (g/gal)	Emissions (metric tons)	CO_2 Equivalent (metric tons)
CO_2	1	10217.28	3225.85	3225.85
CH_4	25	0.80	0.25	6.31
N_2O	298	0.26	0.08	24.46
			Total CO_2 Equivalents	**3256.63**

[a] *Global warming potentials taken from U.S. Code of Federal Regulations, Title 40, Part 98, Subpart A, Table A-1.*

[b] *GHG emission factors taken or calculated from the 2009 EPA "Emission Factors for Locomotives" and 2008 EPA "Greenhouse Gas Inventory Protocol Core Module Guidance - Direct Emissions from Mobile Combustion Sources", EPA Climate Leaders, Table A-6*

Gross Train Weights

Variables	Weight (metric tons)	Loaded Weight[d] (metric tons)	Unloaded Weight[e] (metric tons)
Weight of Crude Oil[a]	11444.57	15616.22	4171.65
Weight of Tanker Cars	3631.51		
Weight of Locomotives	540.14		

[a] Assumes crude oil specific gravity of 0.8 (http://www.cenovus.com/contractor/docs/CenovusMSDS_BakkenOil.pdf); water density of 8.345 lb/gal; 90,000 bbl moved per train

[b] Assumes maximum loaded car weight of 286,000 lbs (http://www.law.cornell.edu/cfr/text/49/179.13) minus the weight of crude oil; 116 cars per train (expected barrels moved divided by car capacity of 32,500 bbl)

[c] Assumes average weight of C44-9 (http://www.thedieselshop.us/DataC44-9.HTML) and SD70 (http://www.thedieselshop.us/Data%20EMD%20SD70.HTML) locomotives; 3 locomotives per train

Alignment-Specific Fuel Consumption

Route Alignment	Basis	Length[a] (mi)	Gross ton-miles	Fuel Consumption[b] (gal)
Columbia	Loaded	432.9	6,760,261	7,436.3
Central	Unloaded	648.4	2,704,895	2,975.4

[a] Calculated in ArcGIS using the ESRI Data and Maps U.S. Rail dataset

[b] Fuel consumption rate of 0.0011 gal/GTM calculated ffrom BNSF activity in the 2008 American Association of Railroads analysis data

GHG Emissions

Pollutant	Global Warming Potential[a]	Emission Factor[b] (g/gal)	Loaded Emissions (metric tons)	Unloaded Emissions (metric tons)
CO_2	1	10,210	75.92	30.38
CH_4	25	0.80	0.006	0.002
N_2O	298	0.26	0.002	0.001
CO_2e	--	10,307	76.65	30.67
		Annual CO_2e (metric tons)		**156,684**

a Global warming potentials taken from U.S. Code of Federal Regulations, Title 40, Part 98, Subpart A, Table A-1.

[b] GHG emission factors taken or calculated from the 2009 EPA "Emission Factors for Locomotives" and 2008 EPA "Greenhouse Gas Inventory Protocol Core Module Guidance - Direct Emissions from Mobile Combustion Sources" , EPA Climate Leaders, Table A-6.

Vessel Engine Specifications[a]

Vessel Type	Engine Type	Power (kW)
Tanker	Main	8,680
	Auxiliary[b]	2,400
	Boiler[c]	371
Tugs	Main	1,420
	Auxiliary	110

[a] Vessel specifications provided by Savage (2013)
[b] 3 Auxiliary engines at 800 kW each
[c] Boiler rating selected from "Current Methodologies in Preparing Mobile Source Emission Inventories", EPA 2009. Assumes a boiler for a loading tanker operates at the same rating as maneuvering.

Vessel Emission Factors[a]

Vessel Type	Engine	CO_2 (g/kWh)	CH_4 (g/kWh)	N_2O (g/kWh)
Tanker	Main	588.79	0.012	0.031
	Auxiliary	690.71	0.008	0.031
	Boiler	690.71	0.008	0.031
Tugs	--	690	0.02	0.09

[a] GHG emission factors taken or calculated from the 2009 EPA "Current Methodologies in Preparing Mobile Source Emission Inventories" and 2008 EPA "Greenhouse Gas Inventory Protocol Core Module Guidance - Direct Emissions from Mobile Combustion Sources" , EPA Climate Leaders.

Vessel Engine Load Factors[a]

Vessel Type	Engine	Mode	Load	Low-Load Adj.[d]
Tanker	Main	Cruise Outer	83.0%	--
		Cruise Inner[b]	36.4%	--
		Maneuver	4.6%	2.01
	Auxiliary[c]	Cruise	24.0%	--
		Reduced Speed Zon	28.0%	--
		Maneuver	33.0%	--
		Hotelling	26.0%	--
Tugs	Main	All	85.0%	--
	Auxiliary	All	56.0%	--

[a] GHG emission factors taken or calculated from the EPA, 2009 "Current Methodologies in Preparing Mobile Source Emission Inventories" and 2008 EPA "Greenhouse Gas Inventory Protocol Core Module Guidance - Direct Emissions from Mobile Combustion Sources" , EPA Climate Leaders.
[b] Cruise within the Columbia River is assumed to be limited to a maximum of 10 knots.
[c] With the cruise speed within the Columbia limited, the reduced speed zone load for auxiliary engines is used during cruising.
d Low-Load adjustment applied to CO_2 calculations based on information provided in the EPA, 2009 "Current Methodologies in Preparing Mobile Source Emission Inventories". These low-load adjustments are not applied to CH_4 and N_2O

On-Site Emissions

Mode	Engine	Time in Mode[a] (hr)	CO_2 (g)	CH_4 (g)	N_2O (g)	CO_2e[e] (metric tons)
Transit[b]	Main	0.2	372,500	7.59	19.61	0.38
	Auxiliary	0.2	92,831	1.08	4.17	0.09
	Boiler					
	Tug - Main	0.2	166,566	4.83	21.73	0.17
	Tug - Auxiliary	0.2	8,501	0.25	1.11	0.01
Maneuvering[c]	Main	2	935,906	9.49	24.52	0.94
	Auxiliary	2	1,094,085	12.67	49.10	1.11
	Boiler	2	512,507	5.94	23.00	0.52
	Tugs - Main	2	3,331,320	96.56	434.52	3.46
	Tugs - Auxiliary	2	170,016	4.93	22.18	0.18
Hotelling[d]	Main					
	Auxiliary	17	7,327,052	84.86	328.85	7.43
	Boiler	17	4,356,308	50.46	195.52	4.42
					Daily CO_2e (metric tons)	**18.71**
					Annual CO_2e (metric tons)	**6829.00**

[a] Time in mode for each activity was determined based on communications with Savage and their expected activity operations. For the transit and maneuvering time-in-mode values, it is assumed that activities occur both inbound and outbound.
[b] Transiting is assumed to occur for 1 nautical mile at 10 knots within the on-site region during inbound and outbound operations. This is also associated with tug movements to meet or depart the vessel.
[c] Maneuvering is expecetd to occur for one hour inbound and one hour outbound. These activities are assumed to utilize two tugs to aid in positioning or turning the vessel.
[d] Hotelling is expected to occur for 17 hours each day; 15 hours of crude oil exchange and an hour each for setup and dismantel.
[e] Global warming potentials (CO_2 = 1, CH_4 = 25, N_2O = 298) taken from U.S. Code of Federal Regulations, Title 40, Part 98, Subpart A, Table A-1.

Transiting Emissions[a]

Mode	Trasit Distance[b] (nautical miles)	Transit Speed[c] (knots)	Transit Time (hr)	Engine	CO_2 (g)	CH_4 (g)	N_2O (g)	CO_2e[e] (metric tons)
Transit	99.89	10	9.989	Main	18,604,502	379.17	979.53	18.91
				Auxiliary	4,636,465	53.70	208.09	4.70
				Boiler				
							Daily CO_2e[d] (metric tons)	**47.21**
							Annual CO_2e (metric tons)	**17232.16**

[a] Emissions, off-site, between the facility and the mouth of the Columbia River.
[b] Transit distance calculated using USGS navigation charts and ESRI ArcGIS software.
[c] transit speed within the Columbia River for the tanker vessels is expected to not exceed 10 knots (Savage, 2013)
[d] Within a 24-hour period the transiting emissions are expected to occur twice; one in and one out.
[e] Global warming potentials (CO_2 = 1, CH_4 = 25, N_2O = 298) taken from U.S. Code of Federal Regulations, Title 40, Part 98, Subpart A, Table A-1.

Attachment B: Pasco to Vancouver Rail Versus Tug/Barge Emissions Inventory

Barge Alternative Emissions Comparison (tons/day)[1]

Pollutant	Rail[2]	Barge and Tug[3]
NO_x	2.62	3.66
$PM_{2.5}$	0.07	0.21
CO_2e	223.25	314.39

[1] Distance between Pasco and Vancouver calculated as approximately 250 miles. Same distance applied for rail and marine calculations.

[2] Emissions from three locomotives per train based on estimated gross-ton miles traveled for 90,000 barrels of crude per train, 4 trains per day, BNSF-specific fuel consumption per gross-ton mile, and emission factors from EPA, 2009.

[3] Barge and Tug emissions based on 30,000 barrel capacity barges, one tug with 2,208 kW propulsion engine and 150 kW auxiliary engine, 0.31 propulsion and 0.43 auxiliary load factors, 24 barge trips per day (12 load deliveries), and 80 minutes of maneuvering per transit (40 minutes each of arrival and departure). Vessel characteristics taken from Chevron, 2014.

Conversions/Basis		
Variables	Value	Units
galPerBbl	42	gal/bbl
SpecGravFuel	0.8	
WaterDensity	8.345	lb/gal
FuelDensity	3200	g/gal
FuelDensityLbs	6.676	lb/gal
lbsPerTon	2000	lb/ton
Trips_per_day	4	#
gramsperton	907185	

Route Gross Ton Mileage		
Route	Length (mi)	GTM
Pasco2Van	250	4308907.5
--		

Calculations		
Variables	Value	Units
bblMoved	90000	bbl
MaxCarWeight	286000	lbs
CarCapacity	32500	gal
WeightC44	425000	lbs
WeightSD70	394000	lbs
AvgLocoWeight	409500	lbs
CarCount	116	#
LocoCount	3	#

Emission Factors		
Pollutant	Emission Factor [1]	Units
NOx	121	g/gal
PM10	3.1	g/gal
HC	5.1	g/gal
CO_2	10210	g/gal
CH_4 [2]	0.80	g/gal
N_2O [2]	0.26	g/gal
CO_2e	10307.48	g/gal
Fuel Consumption [3]	0.00114	gal/gtm

[1] Taken from "Emission Factors for Locomotives", Office of Transportation and Air Quality, U.S. EPA, April 2009 (EPA-420-F-09-025)

[2] Taken from "Direct Emissions from Mobile Combustion Source", Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, U.S. EPA, May 2008.

[3] Calculated BNSF specific fuel consumption rate from "AAR Analysis of Class I Railroads, 2008", Association of American Railroads, published 2009.

Gross Train Weight		
Variables	Value	Units
CrudeOil	12,618	tons
Cars	4,004	tons
Loco	614	tons
Gross Tons Loaded	**17,236**	**tons**
Gross Tons Unloaded	**4,618**	**tons**

Emissions (per trip)		
Pollutant	Columbia	Units
NOx	0.6552	tons
PM10	0.0168	tons
HC	0.0276	tons
CO_2	55.2843	tons
CH_4	0.0043	tons
N_2O	0.0014	tons
CO_2e	55.81	tons

Daily Emissions	Pasco2Van	Units
NOx	2.62	tons/day
PM10	0.07	tons/day
HC	0.11	tons/day
CO2e	223.25	tons/day

Tug and Barge Characteristics[1]							
Barge Type	Build Date	Barge Aux. Power	Tug Hull Build Date	Tug Power (kW) Propulsion	Tug Power (kW) Auxiliary	Service Speed	Capacity (bbls)[1]
Barge 1D	2005	80	1976	2208	150	12	30,000

[1] *ICF, 2014 Table 3-1*

[2] *ICF, 2014 Reported average capacity of 28,862 bbls. Here, we assume an even 30,000 bbls.*

Engine Load Factors (Tugs Pushing Barges)[1]	
Propulsion	Auxiliary
0.31	0.43

[1] *ICF, 2014 Table 3-9*

Fuel Correction Factors[1,2]	
NOx	PM
0.93	0.72

[1] *ICF, 2014 Table 3-10*

[2] *Assumes Model Year <1996, power >130 kW*

GIS Distance	250 miles 217.2 nm
Speed	12 knots
One-Way Transit Time (hr)	18.1
Maneuvering Time/trip (hr)	1.3
Total Time (hr)	19.4
Tug Trips/Day	24

24 trips per day (12 up and 12 down)

Emission Factors (g/kWh)

	NOx	PM10	PM2.5	CO	ROG	SOx	CO2	BSFC	CH4	N2O
Tug Propulsion	9.35	0.56	0.54	2.75	0.72	0.01	789	247	0.02	0.09
Tug Auxiliary	11.15	0.71	0.69	4.88	1.17	0.01	789	247	0.02	0.09

Emission Factors (g/h)

	NOx	PM10	PM2.5	CO	ROG	SOx	CO2	BSFC	CH4	N2O
Tug Propulsion	6,400	383	370	1,882	493	7	540,055	169,067	14	62
Tug Auxiliary	719	46	45	315	75	1	50,891	15,932	1	6

Pasco to Vancouver Emissions (tons/day)

	NOx	PM10	PM2.5	CO	ROG	SOx	CO2	BSFC	CH4	N2O	CO2e
Tug Propulsion	3.29	0.20	0.19	0.97	0.25	0.004	277.70	86.94	0.01	0.03	287.32
Tug Auxiliary	0.37	0.02	0.02	0.16	0.04	0.000	26.17	8.19	0.001	0.003	27.07
Total	**3.66**	**0.22**	**0.21**	**1.13**	**0.29**	**0.004**	**303.87**	**95.13**	**0.01**	**0.03**	**314.39**