MILLENNIUM **Bulk Terminals—Longview**

EIS Environmental Impact Statement

State Environmental Policy Act
Draft Environmental Impact Statement

Volume III.c: Operations Technical Reports
Part 2

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Cowlitz County Washington

Department of Ecology State of Washington

Volume IIIc
Operations Technical Reports

Part 1

SEPA Alternatives Technical Report

SEPA Rail Transportation Technical Report

SEPA Rail Safety Technical Report

SEPA Vehicle Transportation Technical Report

SEPA Vessel Transportation Technical Report

Part 2

SEPA Noise and Vibration Technical Report

SEPA Air Quality Technical Report

SEPA Coal Technical Report

SEPA Greenhouse Gas Emissions Technical Report

SEPA Climate Change Technical Report

SEPA Coal Market Assessment Technical Report

MILLENNIUM BULK TERMINALS—LONGVIEW SEPA ENVIRONMENTAL IMPACT STATEMENT SEPA NOISE AND VIBRATION TECHNICAL REPORT

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Acronyms and Abbreviations

Applicant	Millennium Bulk Terminal—Longview, LLC
ADT	average daily traffic
BNSF	BNSF Railway Company
Cadna/A®	Computer-Aided Noise Abatement Noise Prediction Model
CFR	Code of Federal Regulations
CNEL	community noise equivalent
dBA	A-weighted decibels
FRA	Federal Railroad Administration
FRP	fiberglass reinforced plastic
FTA	Federal Transit Administration
HP	horsepower
Hz	Hertz
L_{dn}	day-night average noise level
L_{eq}	equivalent sound level
L_{max}	maximum sound level
L_v	vibration velocity level
LVSW	Longview Switching Company
mph	miles per hour
NEPA	National Environmental Policy Act
RCW	Revised Code of Washington
RMS	root mean square
SEL	sound exposure level
SEPA	Washington State Environmental Policy Act
SPL	sound pressure level
UP	Union Pacific Railroad
USC	United States Code
VdB	vibration velocity level expressed in decibels
WAC	Washington Administrative Code

Chapter 1
Introduction

This technical report assesses the potential noise and vibration impacts of the proposed Millennium Bulk Terminals—Longview project (Proposed Action) and No-Action Alternative. This report describes the regulatory setting, establishes the method for assessing potential noise and vibration impacts, presents the historical and current noise and vibration conditions in the study area, and assesses potential noise and vibration impacts.

This technical analysis is supported by the data and results provided in Appendix A, *Existing Ambient Sound Pressure Level Survey Data*; and Appendix B, *Construction Noise Impact Analysis*.

1.1 Project Description

Millennium Bulk Terminals—Longview, LLC (Applicant) proposes to construct and operate a coal export terminal in Cowlitz County, Washington, along the Columbia River (Figure 1). The coal export terminal would receive coal from the Powder River Basin in Montana and Wyoming and the Uinta Basin in Utah and Colorado via rail, then load and transport the coal by ocean-going ships via the Columbia River and Pacific Ocean to overseas markets in Asia. The coal export terminal would be capable of receiving, stockpiling, blending, and loading coal by conveyor onto ships for export. Construction of the coal export terminal would begin in 2018. For the purpose of this analysis, it is assumed the coal export terminal would operate at full capacity in 2028.

The following subsections present a summary of the Proposed Action and No-Action Alternative. For detailed information on these alternatives, see the Washington State Environmental Policy Act (SEPA) Alternatives Technical Report (ICF International 2016).

1.1.1 Proposed Action

The Proposed Action would develop a coal export terminal on 190 acres (project area). The project area is located within an existing 540-acre area currently leased by the Applicant at the former Reynolds Metals Company facility, and land currently owned by Bonneville Power Administration. The project area is adjacent to the Columbia River in unincorporated Cowlitz County, Washington near Longview city limits (Figure 2).

The Applicant currently and separately operates, and would continue to separately operate, a bulk product terminal on land leased by the Applicant. Industrial Way (State Route 432) provides vehicular access to the Applicant's leased land. The Reynolds Lead and the BNSF Spur, both operated by Longview Switching Company (LVSW),[1] provide rail access to the Applicant's leased area from a point on the BNSF Railway Company (BNSF) main line (Longview Junction, Washington) located to the east in Kelso, Washington. Ships access the Applicant's leased area via the Columbia River and berth at an existing dock (Dock 1) operated by the Applicant in the Columbia River.

[1] The Longview Switching Company (LVSW) is jointly owned by BNSF Railway Company (BNSF) and Union Pacific Railroad (UP).

Figure 1. Project Vicinity

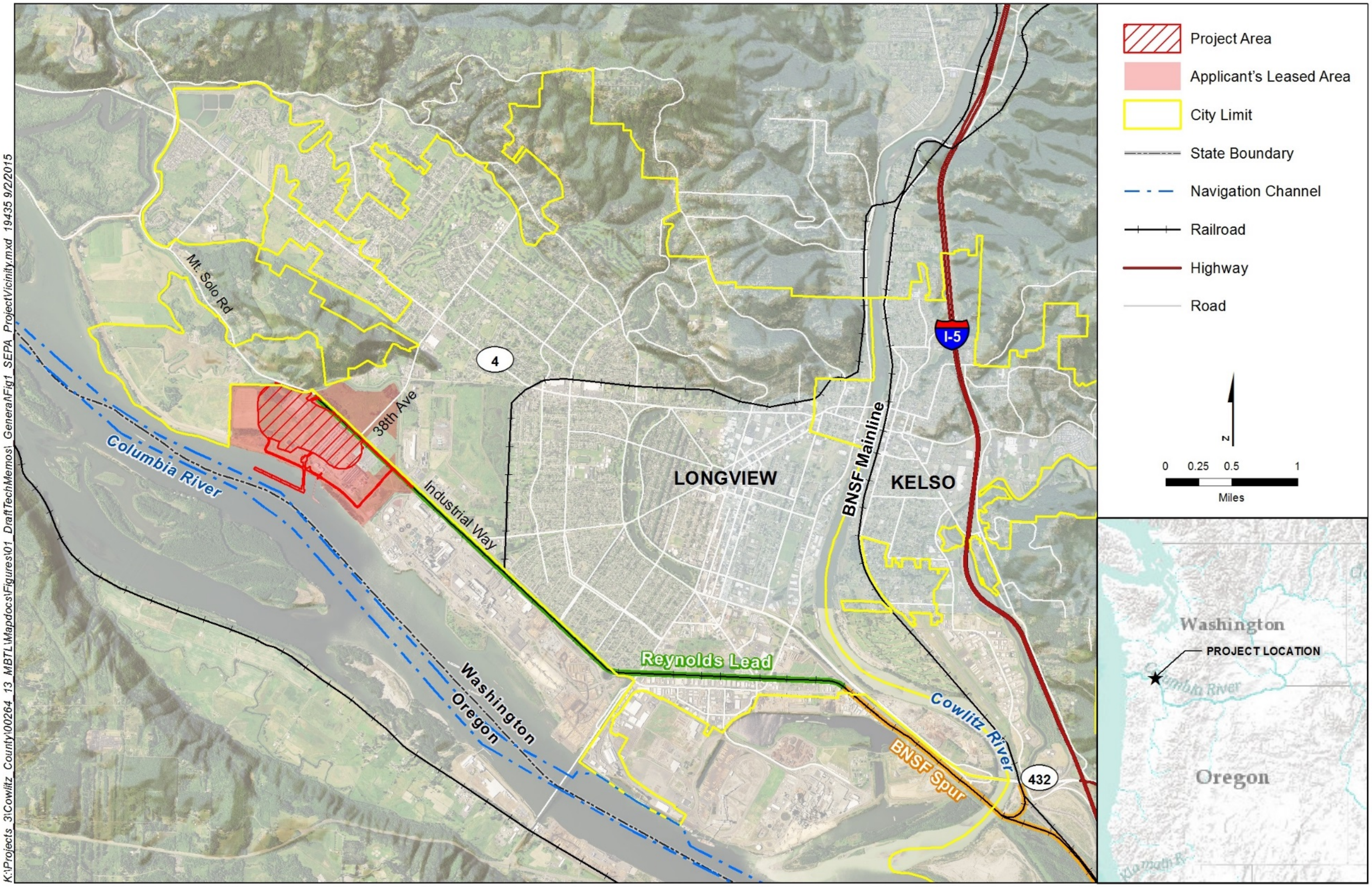
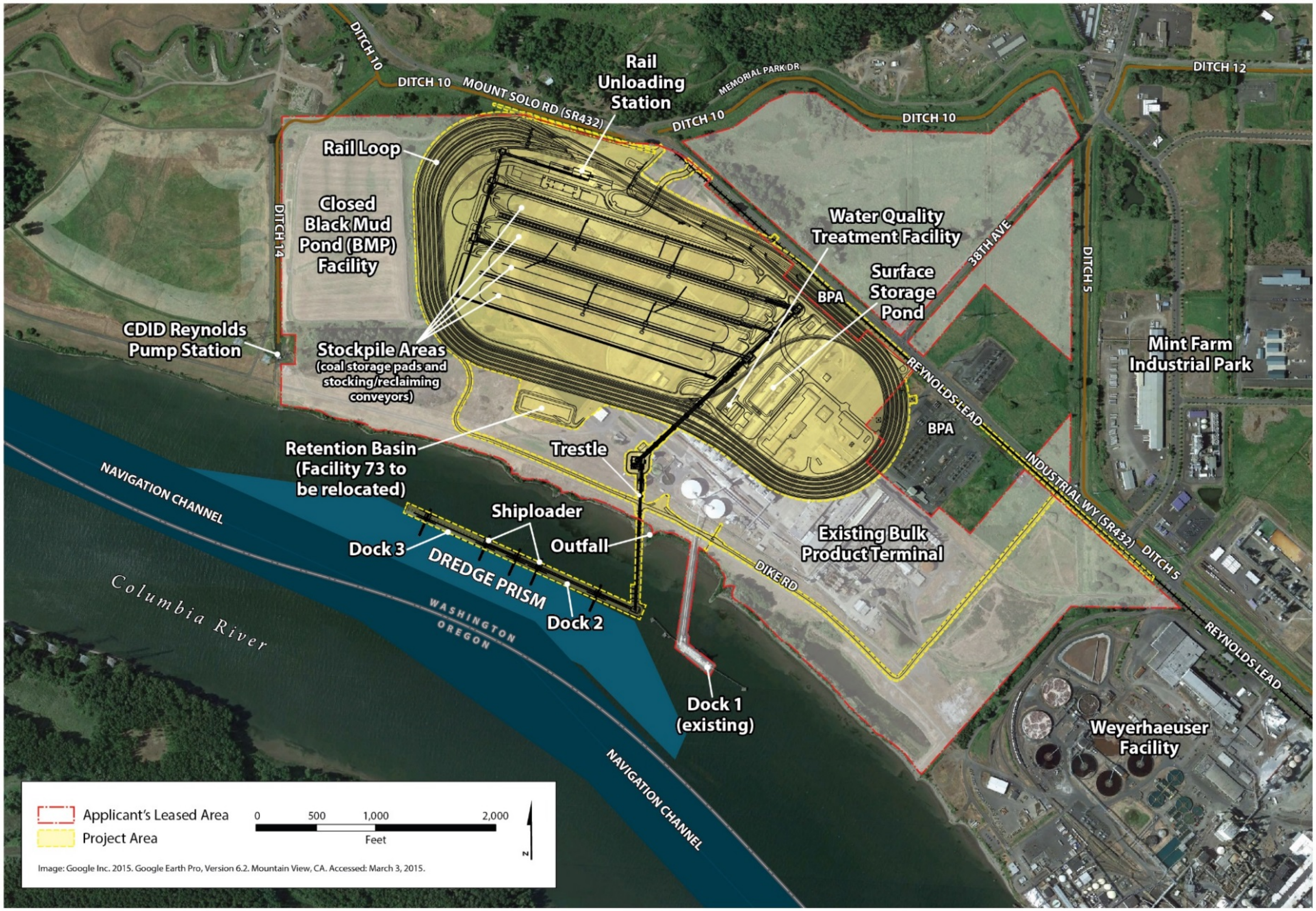


Figure 2. Proposed Action



Under the Proposed Action, BNSF or Union Pacific Railroad (UP) trains would transport coal in rail cars from the BNSF main line at Longview Junction, Washington, to the project area via the BNSF Spur and Reynolds Lead. Coal would be unloaded from rail cars, stockpiled and blended, and loaded by conveyor onto ocean-going ships at two new docks (Docks 2 and 3) on the Columbia River for export.

Once construction is complete, the Proposed Action would have an annual throughput capacity of up to 44 million metric tons.[2] The coal export terminal would consist of one operating rail track, eight rail tracks for the storage of rail cars, rail car unloading facilities, stockpile areas for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks 2 and 3), and ship-loading facilities on the two docks. Dredging of the Columbia River would be required to provide access to and from the Columbia River navigation channel and for berthing at the two new docks.

Vehicles would access the project area from Industrial Way (State Route 432). Ships would access the project area via the Columbia River and berth at one of the two new docks. Terminal operations would occur 24 hours per day, 7 days per week. The coal export terminal would be designed for a minimum 30-year period of operation.

1.1.2 No-Action Alternative

Under the No-Action Alternative, the proposed export terminal would not be constructed. Current operations of the bulk product terminal, which include the storage and transport of alumina and up to 150,000 metric tons per year of coal. Importing of alumina would continue and increase in the project area using Dock 1. The Applicant could expand the existing bulk product terminal onto the 190-acre project area, developing storage and shipment facilities to bulk product terminal operations. Coal and alumina would continue to be stored, transferred, and shipped. Additional bulk product transfers activities involving products such as calcine pet coke, coal tar pitch, cement, fly ash, and sand or gravel could also be pursued, and new or revised permits could be required. These operations would involve storage and upland transfer of bulk products, which would use existing or new buildings. Construction of new buildings could involve demolition and replacement of existing buildings and new or modified permits. Any new construction would be limited to uses allowed under existing Cowlitz County development regulations and federal and state permits.

1.2 Regulatory Setting

The jurisdictional authorities and corresponding regulations, statutes, and guidelines for determining potential impacts related to noise and vibration are summarized in Table 1.

[2] A metric ton is the U.S. equivalent to a tonne per the International System of Units, or 1,000 kilograms or approximately 2,204.6 pounds.

Table 1. Regulations, Statutes, and GuidelineS for Noise and Vibration

Regulation, Statute, Guideline	Description
Federal	
National Environmental Policy Act (42 USC 4321 *et seq*.)	Requires the consideration of potential environmental effects. NEPA implementation procedures are set forth in the President's Council on Environmental Quality's Regulations for Implementing NEPA (49 CFR 1105).
Noise Control Act of 1972 (42 USC 4910)	Protects the health and welfare of U.S. citizens from the growing risk of noise pollution, primarily from transportation vehicles, machinery, and other commerce products. Increased coordination between federal researchers and noise control activities; established noise emission standards; and presented noise emission and reduction information to the public.
Federal Transit Administration Transit Noise and Vibration Impact Assessment (FTA-VA-90-1003-06, May 2006)	Provides procedures and guidance for analyzing the level of noise and vibration, assessing the resulting impacts, and determining possible mitigation for most federally funded transit projects .
FRA High-Speed Ground Transportation Noise and Vibration Impact Assessment (October 2012)	Provides guidance and methods for "the assessment of potential noise and vibration impacts resulting from proposed high-speed ground transportation projects".
U.S. Environmental Protection Agency Railroad Noise Emission Standards (40 CFR 201)	Established final noise emission standards for surface carriers engaged in interstate commerce by railroad. This rulemaking is pursuant to Section 17 of the Noise Control Act of 1972 .
FRA Railroad Noise Emission Compliance Regulations (49 CFR 210)	These regulations indicate the minimum compliance regulations necessary to enforce EPA's Railroad Noise Emission Standards.
FRA Final Rule on the Use of Locomotive Horns at Highway-Rail Grade Crossings (49 CFR 222 and 229)	Requires the sounding of locomotive horns at public highway rail grade crossings. Considers the allowance of quiet zones when the increase risk is mitigated with supplementary grade crossing safety measures.
State	
Washington State Environmental Policy Act (197-11 WAC, RCW 43.21C)	Requires state and local agencies in Washington to identify potential environmental impacts that could result from governmental decisions.
Washington Administrative Code Chapter 173-60	Establishes maximum environmental noise levels. However, noise from surface carriers engaged in interstate commerce by railroad are exempt from these regulations.
Local	
Cowlitz County SEPA Regulations (CCC 19.11)	Provide for the implementation of SEPA in Cowlitz County.
Cowlitz County Code Nuisance Noises (CCC 10.25)	Regulates excessive intermittent noise that interfere with the use, value and enjoyment of property and which pose a hazard to the public health, safety and welfare.

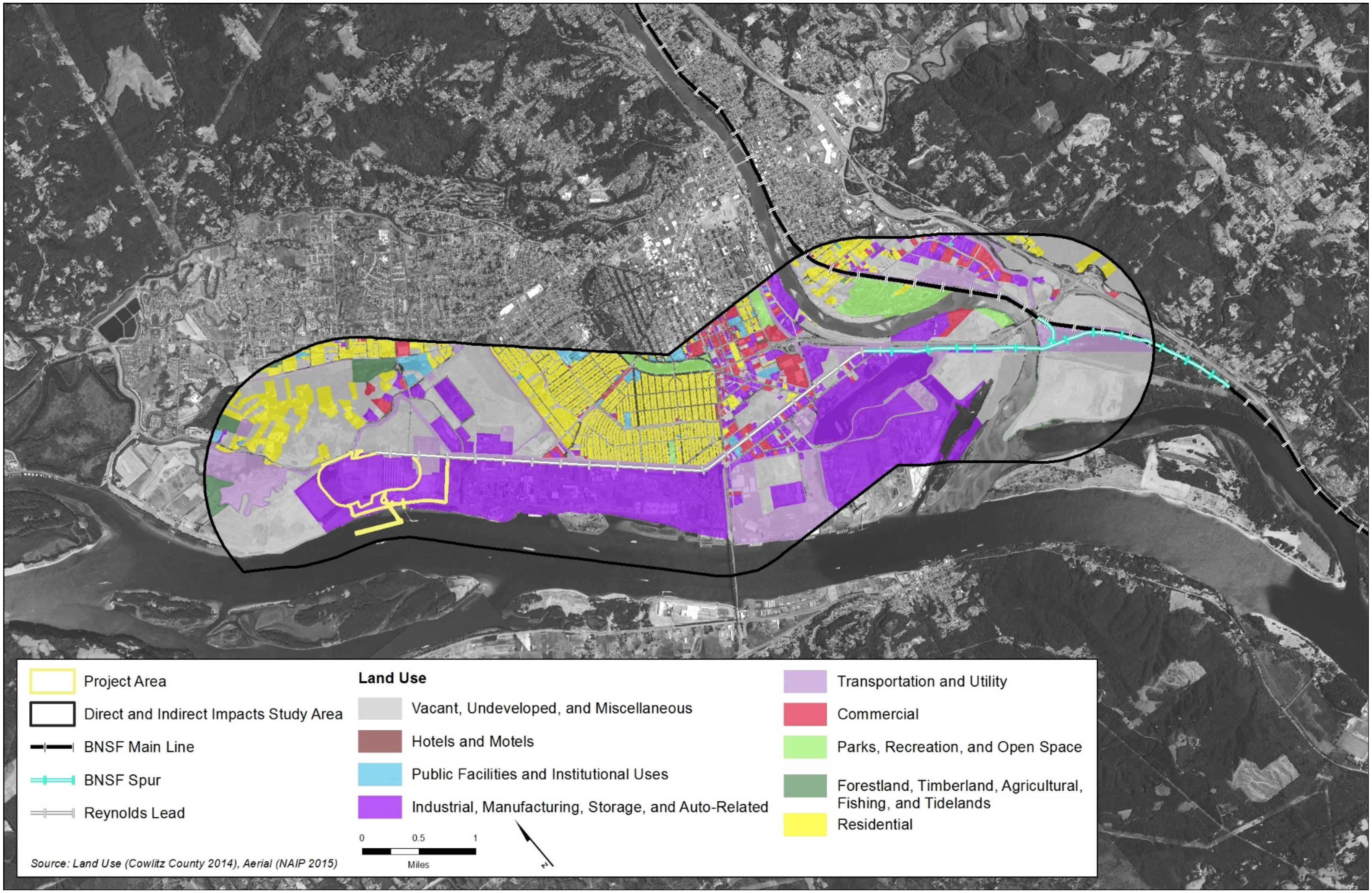
Notes:
USC = United States Code;, NEPA = National Environmental Policy Act;, CFR = Code of Federal Regulations; FTA = Federal Transit Administration; mph = miles per hour;, FRA = Federal Railroad Administration; RCW = Revised Code of Washington; SEPA = Washington State Environmental Policy Act ; CCC = Cowlitz County Code

1.3 Study Area

The study area for noise and vibration direct impacts is within 1 mile of the project area. The study area for noise and vibration indirect impacts is the area within 1 mile (from centerline) of the Reynolds Lead and BNSF Spur. Figure 3 illustrates the combined study area.

An assessment of potential noise and vibration indirect impacts is also included for the rail routes in Washington State for Proposed Action-Related trains and Proposed Action-Related vessel traffic along the Columbia River between the project area and 3 nautical miles offshore.

Figure 3. Study Area



Chapter 2
Existing Conditions

This chapter explains the methods for assessing the existing conditions and determining impacts, and describes the existing conditions in the study area as they pertain to noise and vibration.

2.1 Methods

This section describes the sources of information and methods used to characterize the existing conditions and assess the potential impacts of the Proposed Action and No-Action Alternative on noise and vibration.

2.1.1 Data Sources

The following sources of information were used to evaluate the noise and vibration characteristics of the study area. Citations are provided in the methods discussion where appropriate.

- Information provided by the Applicant, including project design features and a list of typical construction and operation equipment.
- Lists of typical construction and operation equipment provided from reference projects and typical corresponding sound pressure and vibration levels.
- Data on locomotive and train noise levels.
- Existing and future rail traffic estimates for the BNSF Spur and the Reynolds Lead provided by LVSW and the Applicant.
- Reference sound level for rail equipment.
- Ambient noise monitoring data collected during field surveys in the study area.

2.1.1.1 Field Surveys of Ambient Sound Pressure Levels

Field surveys were performed from October 28 through November 10, 2014, and from January 11 through January 16, 2015, to measure existing outdoor ambient sound levels at representative noise-sensitive receptors (ambient noise levels). The surveys focused on locations in the study areas where noise-sensitive receptors (mostly residential properties) could be exposed to noise from project activities and where receptors are close to railroad grade crossings. Institutional noise-sensitive receptors, such as schools and churches, were also considered during the selection of the ambient survey locations. Figure 4 illustrates the location of noise-sensitive receptors in the study area (residential land uses and institutional sensitive receptors).

Prior to the field survey, the project team coordinated with the City of Longview and the Cowlitz County Public Utilities District to identify and access representative noise-sensitive receptors where short-term (10-minute) and long-term (24-hour) sound level meters could be set up for sound pressure level (SPL) measurements. The project team also obtained contact information from the Applicant for owners of private property where the Applicant's contractors had previously measured noise. The project team worked directly with the property owners to obtain rights of entry to private property. Selected locations appear in Figure 5.

Figure 4. Sensitive Receptors in the Study Area

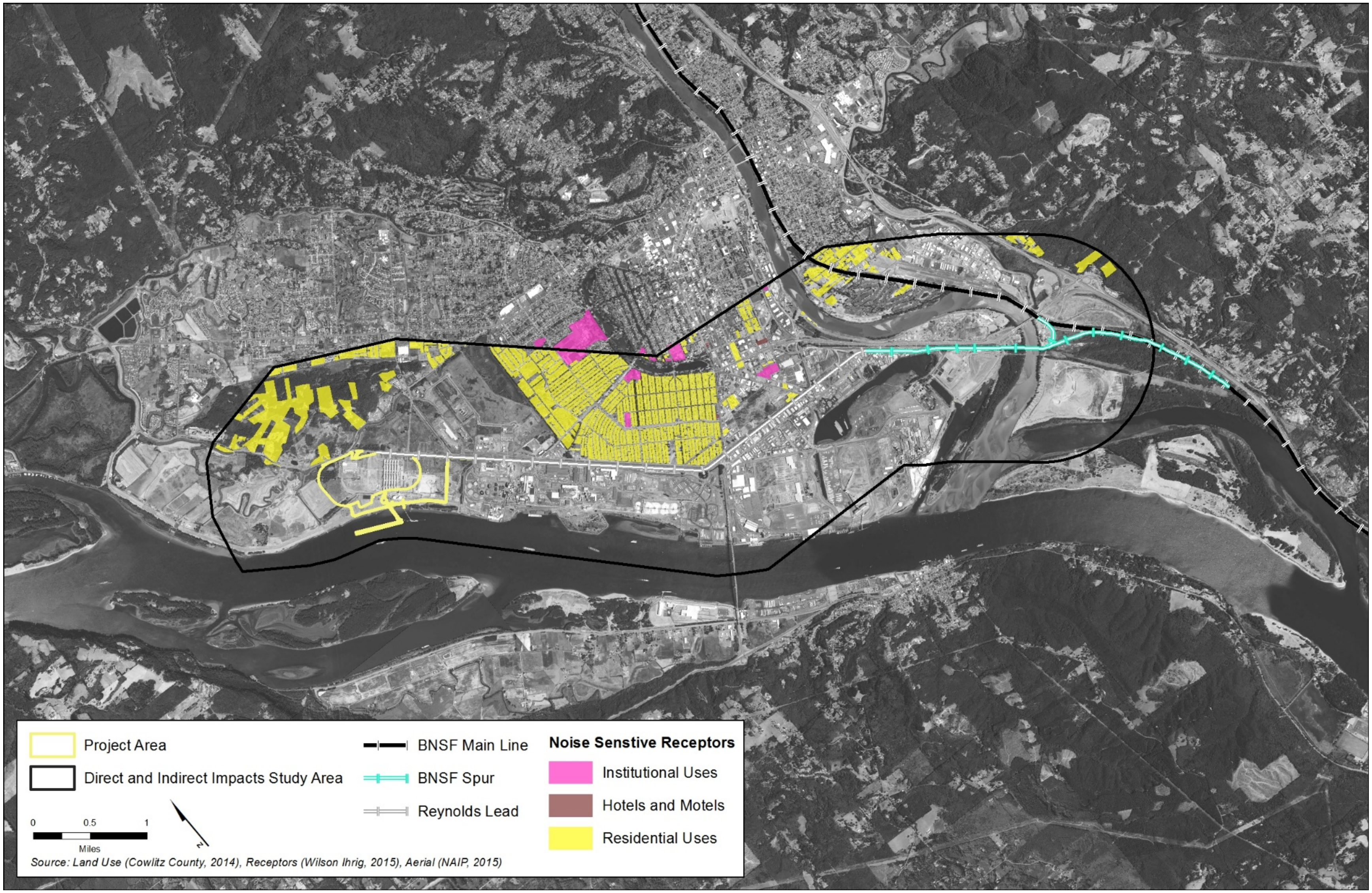
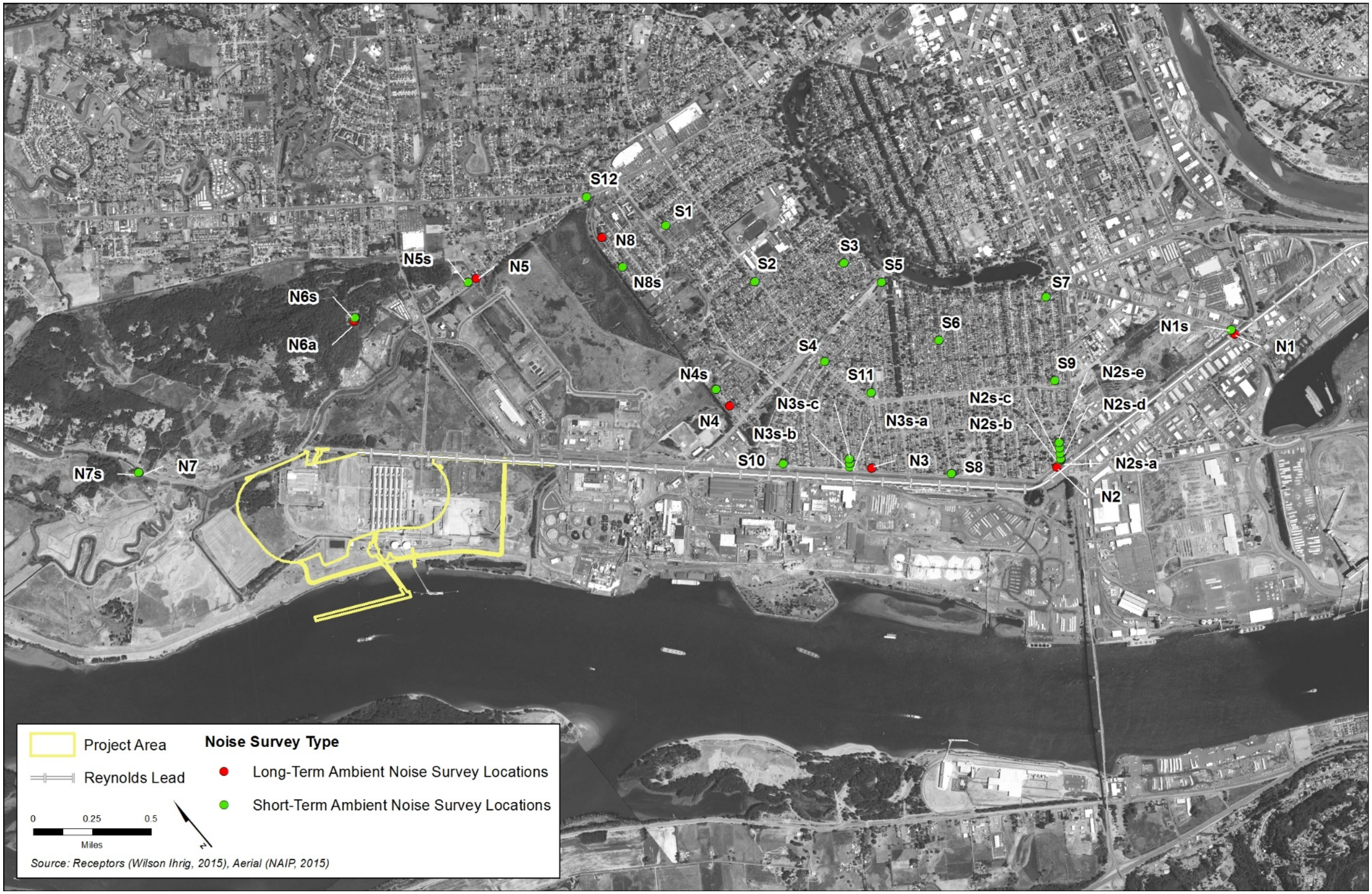


Figure 5. Ambient Sound Pressure Level Survey Locations



Photographs of the long-term survey locations are provided in Photographs 1 through 7.

Photograph 1. Location N1, 602 California Way, Longview, WA

Photograph 2. Location N2, 111-15th Avenue, Longview, WA

Photograph 3. Location N3, 221 Beech Street, Longview, WA

Photograph 4. Location N4, 875 34th Avenue, Longview, WA (survey equipment not shown)

Photograph 5. Location N5, 3600 Memorial Park Drive, Longview, WA

Photograph 6. Location N6, 420 Rutherglen Drive, Longview, WA

Photograph 7. Location N7, 4723 Mt. Solo Road, Longview, WA

Photograph 8. Location N8, 1719 Dorothy Avenue, Longview, WA

Four calibrated, precision, digitally logging sound level meters were deployed on the afternoon of October 27, 2014, then relocated on the evening of November 2, 2014, providing at least 6 full days of data collected at each of eight locations, N1 through N8 (Photographs 1 through 8). All noise monitors included Larson Davis Model 812 logging sound level meters and were mounted on safely accessible wood utility poles or metal light poles with the microphone at a height of approximately 10 feet above the ground surface. The one exception to this installation was location N6, where the monitor was strapped to a patio railing because no poles were available (Photograph 613).

The meters were programmed to store data at 1-hour intervals including statistical levels of L_2, L_8, L_{25}, and L_{90}, where L_n is the SPL that is exceeded n% of the time within the 1-hour interval. The L_2, L_8 and L_{25} metrics were selected to correspond with allowable noise limit exceedance durations of 1.5, 5, and 15 minutes specified in Washington Administrative Code (WAC) 173-60-040. The meters were calibrated with a Brüel & Kjær Type 4230 Sound Level Calibrator prior to each deployment and the calibration was checked at the completion of each measurement period. All calibration checks were within 0.5 decibels of the premeasurement calibration level. The measurements were deemed sufficiently accurate and no data were discarded.

Short-term measurements were conducted during the same time period as the long-term survey, typically while deploying, relocating, or recovering the long-term survey equipment. The short-term measurements were conducted using a Brüel & Kjær Type 2230 Precision Integrating Sound Level Meter with the electrical signal from the microphone recorded on a digital recorder for data analysis upon return to the office. The sound level meter and digital recording were calibrated at the start and end of each day the short-term measurements were conducted using the same calibrator used for the long-term survey. For all short-term measurements, the calibration checks were within 0.1 decibel of the initial calibration. The microphone of the short-term equipment was located 5 feet above ground surface and the SPL was measured and recorded for a period of 10 minutes at each short-term survey location, providing the 10-minute equivalent sound level for (L_{eq})[3] at each short-term location.

2.1.2 Impact Analysis

The following methods were used to evaluate the potential impacts of the Proposed Action and No-Action Alternative on noise and vibration. For the purposes of this analysis, construction impacts are based on the peak construction period and operations impacts are based on maximum throughput capacity (up to 44 million metric tons per year), which is assumed to be in 2028.

2.1.2.1 Construction—Project Area

The methods for analyzing noise and vibration impacts related to construction on the project area are described in this subsection.

Noise

Daytime construction is exempt from Washington State noise limits and the Applicant is not proposing nighttime construction. However, to establish a reasonable benchmark for evaluating potential impacts, construction noise was evaluated on an average aggregate daytime L_{eq} basis over an 8-hour shift per guidelines established by the Federal Transit Administration (FTA) (2006) and

[3] Equivalent sound level (L_{eq}) is generally referenced to one hour unless otherwise indicated.

the Federal Railroad Administration (FRA) (2012) (referred to as the FTA/FRA guidance). The 8-hour L_{eq} was estimated at the noise-sensitive receptors in the study area using detailed information about the anticipated roster of construction equipment to be used, based on the construction of a similar terminal project (URS Corporation 2014a) and the assumptions described in this section of this report.

Because a monthly schedule of construction activities was not available, the construction noise analysis conservatively assumed that the maximum amount of equipment would be operating concurrently for three areas of construction activity (Table 2).

- Rail infrastructure and rotary car dumper
- Conveyors, transfer towers, and surge bins
- Shiploader, dock, and trestles

Table 2. Anticipated Roster of Construction Equipment

Construction Equipment Type	Util. Factor[a] (%)	L_{max} at 50 feet[b] (dBA)	Rail Infrastructure & Rotary Car, Dumper		Conveyors, Transfer Towers, & Surge Bins		Shiploader, Dock, & Trestles	
			Max. Qty. per Month	Months	Max. Qty. per Month	Months	Max. Qty. per Month	Months
Mobile crane[c]	16	83	5	18	5	18	5	18
Elevated work platform	20	85[a]	2	3	4	18	2	12
Water truck[d]	40	88	1	12	1	12	NA	NA
Dump truck	40	88	3	12	1	12	NA	NA
Dozer	40	85	1	5	NA	NA	NA	NA
Excavator[c]	40	85[a]	1	9	2	12	1	3
Roller	20	85	2	9	2	12	1	3
Grader	40	85	2	9	NA	NA	1	3
Compactor	20	82	2	9	2	12	1	3
Track laying machine	50	85	1	6	NA	NA	NA	NA
Drill rig	20	84[a]	1	2	2	6	NA	NA
Impact pile driver	20	101	2	6	2	6	2	6
Loader[c]	40	85	1	12	1	12	1	9
River barge	50	85[e]	NA	NA	NA	NA	2	18
Generator	50	81	2	18	2	18	2	18
Air compressor	40	81	2	18	2	18	2	18
Construction labor (e.g., misc. Pneumatic tools)	50	85[a]	6	18	6	18	6	18

Notes:
[a] Source: Federal Highway Administration 2006
[b] Source: Federal Transit Administration 2006, except where noted
[c] Shared between all three areas of construction activity
[d] Shared between the two areas of land construction
[e] Source: Federal Highway Administration 2006 for "All other equipment >5 HP"
L_{max} = maximum sound level; dBA = A=weighted decibels

For purposes of this analysis, and because the exact locations of these activities (or the involved equipment and processes) are either unknown at this time or could vary during the course of construction, noise was treated as originating from the acoustic center of the geographic locations described in Table 3.

Table 3. Equipment Quantities and Acoustic Centers for Each Phase of Construction

Equipment[a]	Geographic Acoustic Center of Activity
Rail Infrastructure & rotary car dumper with two mobile cranes, no pile driver	Centerline of perimeter track loop closest to receptors
Conveyors, transfer towers, & surge bins with two mobile cranes, one excavator, no water truck, no loader, no pile driver	Midpoint of Stage 1 reclaim travel path
Shiploader, Dock & Trestles w/ 1 mobile crane, no excavator, no loader, no pile driver	Transfer tower TT-08
Pile driver (one)	Closest pile to receptor from rotary car dumper or Stage 1 reclaim travel path

Notes:
[a] Accounting for equipment shared between areas.

The L_{eq} from each piece of equipment, with the exception of the pile driver, was calculated using the following formula from the FTA/FRA guidance.

$$L_{eq}(\text{equip}) = \text{E.L.} + 10\log_{10}(\text{U.F.}) - 20\log_{10}(D/50) - 10G\log_{10}(D/50)$$

Where:

- L_{eq}(equip) is the L_{eq} at a receptor resulting from the operation of a single piece of equipment over a specified time period.
- E.L. is the noise emission level of the particular piece of equipment at the reference distance of 50 feet, taken from Table 2 for this analysis.
- U.F. is a usage factor that accounts for the fraction of time that the equipment is in use over the specified time period, i.e., 8-hours in this analysis and taken from Table 2.
- D is the distance from the receptor to the piece of equipment.
- G is a constant that accounts for topography and ground effects, assumed to equal zero in this analysis for a conservative estimate of the construction noise at the receptors; i.e., ignoring reduction due to topography or ground effects.

Pile driving is often the dominant source of noise complaints during construction. A conservative approach was taken by calculating the maximum sound level (L_{max}) that would result from driving a single pile at the location closest to the noise-sensitive receptor. The L_{max} is unaffected by the number of pile drivers operating at a given time because the impacts are discrete, short duration events that typically do not overlap in time. However, the 8-hour L_{eq}, calculated for all other equipment as described above, was added to the L_{max} calculated for pile-driving noise to get the total construction noise for comparison to the noise criteria.

Vibration

Impact pile driving would be the dominant source of ground vibration during construction. The vibration velocity level (L_v) during pile driving was calculated using the following formula from the FTA/FRA guidance.

$$L_v(D) = L_v(25\text{ ft}) - 30\log_{10}(D/25)$$

Where:

- L_v is the root mean square (RMS) vibration velocity level expressed in decibels (VdB) referenced to 1 microinch/second.
- L_v(25 feet) is the reference vibration velocity level for the piece of equipment. In this case, a value of 112 VdB was used, which represents the upper range of vibration level generated by an impact pile driver.
- D is the distance from the receptor to the piece of equipment.

A list of reference vibration velocity levels for typical construction equipment is provided in Table 4.

Table 4. Vibration Source Levels for Construction Equipment

Equipment	Peak Particle Velocity at 25 feet (inches per second)	Approximate L_v[a] at 25 feet
Pile driver (impact)	1.518	112
Vibratory roller	0.210	94
Hoe ram	0.089	87
Large bulldozer	0.089	87
Loaded trucks	0.076	86
Jackhammer	0.035	79
Small bulldozer	0.003	58

Notes:

[a] RMS velocity in decibels (VdB) are 1 micro-inch/second

Source: Federal Railroad Administration 2012

L_v = vibration velocity level;, RMS = root mean square;, VdB = vibration decibel

The FTA/FRA guidance recommends a slightly different formula to assess potential for structural damage due to ground vibration. However, human annoyance occurs at much lower vibration levels than vibration levels that may cause cosmetic damage to structures so this lower threshold was used to assess impacts.

2.1.2.2 Operations—Project Area

The methods for analyzing noise and vibration impacts related to operations on the project area are described in this subsection.

Noise

The Computer-Aided Noise Abatement (Cadna/A®) Noise Prediction Model (Version 4.4.145) was used to estimate the propagation of sound from aggregate project operations at the project area. Cadna/A® is a Windows-based software program that predicts and assesses noise levels near industrial noise sources using standardized algorithms for noise propagation calculations (International Organization for Standardization 1996). The software can accept sound power levels (in dB re: 1 picoWatt) in octave-band center frequency resolution to describe the multiple sound propagation sources of the site processes or activity to be modeled. The calculations account for classical sound wave divergence plus attenuation factors resulting from air absorption, basic ground effects, and barriers or shielding. The advantage of using Cadna/A® is that it helps handle the three-dimensional sound propagation complexity of considering realistic intervening natural and human-made topographical barrier effects, including those resulting from terrain features (e.g., Mount Solo) and from structures such as major buildings, storage tanks, and large equipment. The model predicted SPLs at all noise-sensitive receptors in the study area and generated noise contours of equal $L_{eq,}$ 50 A-weighted decibels (dBA) and 60 dBA, for comparison to the Washington State regulatory noise criteria.

A detailed Cadna/A® model for the Proposed Action (URS Corporation 2014b) was reviewed and found to be reasonable. Minor modifications included the addition of calculation points at each of the noise-sensitive receptors. Table 5 and Table 6 list the point-type and line-type sound sources, respectively, that were included in the model, and the assumptions for each source are described following the tables. The Applicant has stated that several of the line-type sources would have corrugated fiberglass-reinforced plastic (FRP) panels as exterior cladding material (Table 7) (URS Corporation 2014b). Atmospheric conditions of no wind and no temperature inversions were assumed for all predictions. (Historical information indicates the likelihood of a temperature inversion in the area is approximately 5% [City of Portland 1955].)

Table 5. Modeled Point-Type Sound Sources for Operations

Noise Source	Sound Power Level (dBA)[a]	Attenuation Applied	Height Above Ground (feet)[b]
Idling Train North1	109	—	6.56
Idling Train North2	109	—	6.56
Idling Train North3	109	—	6.56
Idling Train North4	109	—	6.56
Idling Train North5	109	—	6.56
Idling Train North6	109	—	6.56
Idling Train North7	109	—	6.56
Idling Train South1	109	—	6.56
Idling Train South2	109	—	6.56
Idling Train South3	109	—	6.56
Idling Train South4	109	—	6.56
Idling Train South5	109	—	6.56
Idling Train South6	109	—	6.56
Idling Train South7	109	—	6.56
Surge Bin 15-SB-01	102.7	—	73.08
Tandem Rotary Dumper	103	—	21.25
Stg1 Conv Drv 01	100.2	—	11.97
Stg1 Conv Drv 03	100.2	—	11.97
Stg1 Conv Drv 05	100.2	—	11.97

Noise Source	Sound Power Level (dBA)[a]	Attenuation Applied	Height Above Ground (feet)[b]
Stg1 Conv Drv 09	100.2	—	11.97
Stg1 Conv Drv 10	100.2	—	11.97
Stg1 Conv Drv 06	100.2	—	11.97
Stg1 Conv Drv 13	100.2	—	11.97
Stg1 Conv Drv 15	100.2	—	11.97
Stg1 Conv Drv 17	100.2	—	11.97
Stg1 Trnsf Twr 1	98.8	—	41.26
Stg1 Trnsf Twr 2	98.8	—	36.08
Stg1 Trnsf Twr 3	98.8	—	40.97
Stg1 Trnsf Twr 5	98.8	—	31.75
Stg1 Trnsfr Twr 6	98.8	—	31.75
Stg1 Trnsfr Twr 7	98.8	—	31.75
Stg1 Trnsfr Twr 8	98.8	—	47.69
Stg2 Conv Drv A	100.2	—	11.97
Stg2 Conv Drv B	100.2	—	11.97
Stg2 Conv Drv C	100.2	—	11.97
Stg2 Conv Drv D	100.2	—	11.97
Stg2 Conv Drv E	100.2	—	11.97
Stg2 Trnsfr Twr 4	98.8	—	36.08
Stg2 Conv Drv F	100.2	—	11.97
Surge Bin 15-SB-02	102.7	—	73.08
Idling Train North1	109	—	6.56

Notes:
[a] Sound Power Level in dB re: 1 picoWatt
[b] Site ground elevation 10 feet
Source: URS 2014a
dBA = A-weighted decibels; FRP = fiberglass reinforced plastic

Table 6. Modeled Line-Type Sound Sources for Operations

Noise Source	Sound Power Level (dBA)[a]	Attenuation Applied	Height Above Ground (feet)[b]
Rail track	113.4	—	6.56
Tandem Rotary Dumper to TT01	88.5	FRP	87.53
Stage1 15-SB-02 to TT08	90.7	FRP	99.44
Stage1 Dock Conveyor	108.7	—	58.79
Stage1 Reclaim Conveyor to TT05	112.3	—	71.78
Stage1 Reclaim Conveyor to TT05	112.3	—	71.78
Stage1 Reclaim for 14-CV-09	106.5	—	114.83
Stage1 Reclaim for 14-CV-10	106.5	—	114.83
Stage1 Shiploader for Dock2	106.3	—	85.30
Stage1 Stacker for 13-CV-05	106.5	—	98.43
Stage1 Stacker for 13-CV-06	106.5	—	98.43

Noise Source	Sound Power Level (dBA)[a]	Attenuation Applied	Height Above Ground (feet)[b]
Stage1 Stacking Conveyor from TT03	112.3	—	71.78
Stage1 TT01 to TT02	83.8	FRP	80.54
Stage1 TT02 to Stacking	111.5	—	35.17
Stage1 TT02 to TT03	86.6	FRP	89.70
Stage1 TT05 to Surge Bin (15-SB-02)	92.4	FRP	149.28
Stage1 TT06 to TT09d	86.3	FRP	49.28
Stage1 TT09 to Surge Bind	87.3	FRP	149.28
Stage2 15-SB-02 to TT08	90.6	FRP	99.44
Stage2 Dock Conveyor	111.2	—	58.79
Stage2 Reclaim Conveyor to TT07	111.8	—	71.78
Stage2 Reclaim Conveyor to TT07	111.9	—	71.78
Stage2 Reclaim for 14-CV-11	106.5	—	114.83
Stage2 Reclaim for 14-CV-12	106.5	—	114.83
Stage2 Shiploader for Dock3	106.3	—	85.30
Stage2 Stacker for 13-CV-08	106.5	—	85.30
Stage2 Stacking Conveyor from TT04	111.7	—	35.17
Stage2 TT03 to TT04	86.9	FRP	89.70
Stage2 TT07 to 15-SB-02	90.9	FRP	149.28
Stage2 TT07 to TT09d	88.3	FRP	49.28
Stage2 TT09 to Surge Bind	87.2	FRP	149.28

Notes:
[a] Sound Power Level in dB re: 1 picoWatt
[b] Site ground elevation 10 feet
Source: URS 2014a
dBA = A-weighted decibels; FRP = fiberglass reinforced plastic

Parameters and Assumptions—Operations Equipment

The following notes and assumptions relate to the operations-related equipment of the project area.

- **Transfer towers.** The 98.8 dBA sound power level was derived from estimated octave band center frequency levels (Edison Electric Institute 1984: Table 4.34), adjusted downward by 17 decibels in each octave band so that the overall dBA was comparable to a transfer tower reference point (Heggies 2006). This adjustment reflects the addition of a cladded enclosure, so the FRP attenuation was not applied. The source height is approximately the top of the cladded structure (Edison Electric Institute 1984). While the transfer tower noise levels may include material falling and conveyor belts, they do not include the conveyor drives, which are considered separately.
- **Conveyor belts.** The stacking, reclaim, and dock conveyors are exposed to the outdoors and hence do not receive the benefit of cladding noise reduction as do the other conveyor segments. The 103 dBA sound power level (per 100 meters of length) was recommended for unenclosed low-noise conveyors based on an exchange of confidential information between URS and SLR Consulting (URS Corporation 2014b) regarding sound levels “generally being achieved in practice” at Kooragong Coal Terminal. For enclosed conveyor galleries, the FRP attenuation adjustment was applied.

- **Conveyor drives.** Conveyor drive locations were identified from available Worley-Parsons plan and elevation drawing sets. Consistent with these drawings, all conveyor drives would be located near grade and exposed to the outdoors. They would not be located inside the cladded transfer towers nor do they feature any substantial noise-reducing enclosure or other means of noise reduction. While project design information indicates that conveyor drives would have up to four 400-horsepower (HP) motors (URS Corporation 2014b), predictive model data (Heggies 2006) suggest that the low-noise specification sound power level is 100 dBA for either a 630-kilowatt motor (845 HP) or an 800-kilowatt motor (1,073 HP) and thus does not depend on the total drive power. Hence, all drives in the model for this technical report, ranging from 400 to 1,600 HP, had the same 100 dBA L_{eq} sound power.
- **Tandem rotary dumper.** The tandem rotary dumper sound level is assumed to include motor noise from indexers (positioners) fore and aft of the dumper building. The 103 dBA sound power level was derived from measured level octave band center frequency levels taken at the exteriors of the entry and exit openings of a similar rotary dumper facility (Pittsburgh Testing Laboratory 1982).
- **Startup rapid unloader.** For purposes of this analysis, the startup rapid unloader was assumed to be similar to the tandem rotary dumper with respect to noise emission.
- **Shiploader.** The shiploaders move bulk materials along the dock conveyors and are point sources of noise. The 106.3 dBA SPL was derived from a reference terminal (Whitt et al. 2007), adjusted so that the overall dBA was comparable to the value shown for the shiploader in a comparable noise impact assessment (Heggies 2006).
- **Stacker/reclaimer.** The stackers and reclaimers move bulk materials along assigned conveyors and are point sources of noise. The stackers and reclaimers do not emit noise from fixed positions but emit variable noise along a length (i.e., the underlying conveyor position). The model provides an average source position and depicts stacker and reclaimer movement or variable positions. The source heights correspond with the highest point of the boom (stacker) or the wheel axle (reclaimer). The 106.5 dBA SPL was derived from estimated octave band center frequency levels (Edison Electric Institute 1984: Table 4.34) so that the overall dBA was comparable to a stacker and reclaimer reference point (Heggies 2006).
- **Surge bin.** The 102.7 dBA sound power level was derived from octave band center frequency levels in a reference noise assessment (Heggies 2010), adjusted so that the overall dBA was comparable to the value shown for the buffer bin in a comparable noise impact assessment (Heggies 2006).
- **Train loops.** Trains undergoing active railcar unloading through the rotary car dumper would move slowly during the worst-case hour under consideration. Measurement data from a reference report (U.S. Environmental Protection Agency 1974) provides the basis for an assumed octave-band signature for a comparable sample train of four locomotives and 89 loaded cars. For this operations noise model, a value of 77 dBA per meter generates noise for the moving train (undergoing unloading) that is consistent with recommendations (URS Corporation 2014b) and sound power data from another noise impact assessment (Heggies 2006). Because other trains could be idling, the sound exposure level (SEL) was estimated (Federal Transit Administration 2006: Tables 5-5 and 5-6) and the octave-band profile was approximated data from the reference report (U.S. Environmental Protection Agency 1974). Idling trains were modeled as point sources of noise, with a pair of locomotives at the head of the train, and a single locomotive at the tail.

Parameters and Assumptions—Site Features

- **Structures.** The Cadna/A® 3-D model included path-occluding buildings and structures such as the tandem rotary dumper and the administration office and warehouse.
- **Coal storage.** The Cadna/A® model approximates the tall heaps of stored coal as sloped 15-meter-tall embankments having a size and geometry similar to what appears in available 3-D project layout rendering images.
- **Surface acoustical absorption.** On a recognized scale of zero to one, with zero representing a fully acoustically reflective surface and one representing a fully absorptive surface, the ground surface, on average, was considered 0.5. However, the Columbia River area was locally set to zero.
- **Foliage.** Consistent with what is shown on available aerial photography and observations from the ambient sound survey.
- **Temperature and relative humidity.** The Cadna/A® model assumes at least 70% relative humidity and 20 degrees Celsius—standard values in the model configuration. Available weather data for the project area indicates that seasonal average relative humidity ranges from 72 to 80% (Golden Gate Weather Services 2015), and high temperatures range from about 7 to 26 degrees Celsius (Western Regional Climate Center 2015). Hence, the selected relative humidity value is within the annual relative humidity range and would be considered representative; and, the selected temperature value is near the high value of the region's recorded range and would be considered both representative and conservative, because (all else being equal) sound travels farther in an atmosphere with higher temperatures. The relative humidity affects the degree to which sound is absorbed by the atmosphere over large distances and the effect is more pronounced at higher frequencies. At 20 degrees Celsius and at a fixed distance from a noise source, a change in humidity from 70 to 80%, would be expected to produce a reduction in noise level (from a continuous source) on the order of 1 decibel.
- **Cladding noise reduction.** Based on the Applicant's response to a data request, this analysis assumes that the three major types (roof, opaque wall, translucent window) of exterior surface material are corrugated FRP having a surface weight of 8 pounds per square foot. Because actual sound transmission loss data were not included in the material specifications and engineering data, and neither were such data found after a reasonable online search, an approximation was used for this analysis. Assuming its thickness and fluted structure was functionally similar to FRP material, the transmission loss data for a corrugated asbestos sheet of 2 pounds per square foot (Bies and Hansen 1996) was reduced by 12 decibel in each octave band to account for the mass law (a reduction of 6 decibel for each halving of material mass). Then, to account for expected differences between laboratory test and actual field conditions, another reduction of 3 decibels was conservatively applied. The resulting octave band center frequency transmission loss data are shown in Table 7.

Table 7. Estimated Transmission Loss for Fiberglass-Reinforced Plastic Cladding Material

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Transmission Loss (decibels)	5	10	15	18	18	23	24	27

Notes:
Hz = Hertz

Vibration

There would be no subtstantial sources of ground vibration on site during operations with the possible exception of trains moving on the rail loop. Using generalized ground surface vibration curves (Federal Transit Administration 2006) and correcting for speed, vibration from train operations is unlikely at distances greater than 40 feet from a railroad track for infrequent events (less than 30 passbys per day). The closest vibration-sensitive receptor is approximately 275 feet from the outer track of the rail loop. Therefore, no analysis was conducted to estimate vibration generated during project area operations.

2.1.2.3 Operations—Rail Traffic

The methods for analyzing noise and vibration impacts related to rail traffic to and from the project area are described in this subsection.

Noise

Operations-related rail traffic was estimated for four rail segments.

- BNSF Spur to the Reynolds Lead.
- Reynolds Lead from BNSF Spur to 3rd Avenue and California Way.
- Reynolds Lead from 3rd Avenue and California Way to midway between Industrial Way (State Route 432) and the Weyerhaueser entrance.
- Reynolds Lead from midway between Industrial Way and Weyerhaueser entrance to the project area.

The assumptions related to estimates of rail traffic are summarized in Tables 8 through 11.

Table 8. Average Freight Rail Traffic, Consists, and Speed—BNSF Spur to Reynolds Lead

	Number of Locomotives per Train	Number of Railcars per Train	Total Train Length (feet)[a]	Daily Average Train Traffic	Daily Total Train Passbys along BNSF Spur in Both Directions	Speed (mph)
Existing Traffic 2015	2.6	78	4,919	3.6	7.1	10
No-Action 2018	2.6	78	4,919	3.6	7.1	10
No-Action 2028[b]	2.6	78	4,919	3.6	7.1	10
Proposed Terminal Operation 2028[b]	3	125	6,844	8	16	10
Proposed Terminal Operation 2028[c]	3	125	6,844	8	16	20

Notes:

[a] Existing and No-Action Alternative locomotive length = 68.7 feet average; railcar length = 60.8 feet average; project locomotive length = 73 feet; project length = 53 feet

[b] Without track improvements

[c] With track improvements

mph = miles per hour

Table 9. Average Freight Schedule, Consists, and Speed—Reynolds Lead from BNSF Spur to 3rd Avenue and California Way

	Number of Locomotives per Train	Number of Railcars per Train	Total Train Length (feet)	Daily Average Trains	Daily Total Train Passbys along Reynolds Lead in Both Directions	Speed (mph)
Existing Traffic 2015	2	20.6	1,459	1.1	2.3	10
No-Action 2018	2	29.6	2,041	1.1	2.3	10
No-Action 2028[b]	2	29.8	2,052	2.0	4.0	10
No Action 2028[c]	2	29.8	2,052	2.0	4.0	20
Proposed Terminal Operation 2028[b]	3	125	6,844	8	16	10
Proposed Terminal Operation 2028[c]	3	125	6,844	8	16	20

Notes:

[a] Existing and No-Action Alternative locomotive length = 68.7 feet average; railcar length = 60.8 feet average; project locomotive length = 73 feet; project length = 53 feet

[b] Without track improvements

[c] With track improvements

mph = miles per hour

Table 10. Average Freight Schedule, Consists, and Speed—Reynolds Lead from Oregon Way and Industrial Way to Project Area

	Number of Locomotives per Train	Number of Railcars per Train	Total Train Length (feet)[a]	Daily Average Trains	Daily Total Train Passbys along Reynolds Lead in Both Directions	Speed (mph)
Existing Traffic 2015	2	20.6	1,441	1.1	2.3	10
No-Action 2018	2	29.6	2,024	1.1	2.3	10
No-Action 2028[e]	2	29.8	2,035	2.0	4.0	10
Proposed Terminal Operation 2028[b]	3	125	6,844	8	16	10
Proposed Terminal Operation 2028[c]	3	125	6,844	8	16	20

Notes:

[a] Existing and No-Action Alternative locomotive length = 68.7 feet average; railcar length = 60.8 feet average; project locomotive length = 73 feet; project length = 53 feet

[b] Without track improvements

[c] With track improvements

mph = miles per hour

Table 11. Freight Schedule, Consists, and Speed—Reynolds Lead from Midway between Industrial Way and Weyerhaueser Entrance to Project Area

	Number of Locomotives per Train	Number of Railcars per Train	Total Train Length (feet)[a]	Daily Average Trains	Daily Total Train Passbys along Reynolds Lead in Both Directions	Speed (mph)
Existing Traffic 2015	2	20.6	1,441	1.14	2.3	10
No-Action 2018	2	29.6	2,024	1.14	2.3	10
No-Action 2028[b]	2	29.8	2,035	1.995	4.0	10
Proposed Terminal Operation 2028[b]	3	125	6,844	8	16	10
Proposed Terminal Operation 2028[c]	3	125	6,844	8	16	10

Notes:

[a] Existing and No-Action Alternative locomotive length = 68.7 feet average; railcar length = 60.8 feet average; project locomotive length = 73 feet; project length = 53 feet

[b] Without track improvements

[c] With track improvements

mph = miles per hour

For the 2028 Proposed Action and No-Action Alternative analysis, proposed track improvements would include additional track around the yard and a new power switch. These improvements would allow an increase in train speed across some of the crossings from 10 to 20 miles per hour. The analysis also considered without track improvements. For this study, a conservative analysis incorporated the maximum allowable train speed into the noise model for the full length of each segment.

Reference SELs (Federal Railroad Administration 2012) for trains are 97 dBA SEL for freight locomotives (90 feet long) and 100 dBA SEL for freight cars (2,000 feet long). These reference SELs are normalized to 1 second duration at 50 feet for a train traveling 40 miles per hour. These reference SELs represent at-grade ballast and tie track with continuously welded rail conditions, similar to the Reynolds Lead track construction.

There are five public at-grade crossings along the Reynolds Lead and BNSF Spur from the main line to the project area.

- Dike Road
- 3rd Avenue
- California Way
- Oregon Way
- Industrial Way

At Industrial Way, the rail line crosses from the north side to the south side of Industrial Way, approximately 1000 feet west of the crossing at Oregon Way. The crossings at 3rd Avenue and California Way are within approximately 500 feet of each other. In addition to these public crossings, there are three private at-grade crossings.

- Weyerhaeuser entrance west of Douglas Street
- Weyerhaeuser entrance at Washington Way
- 38th Avenue entrance to the Applicant's existing bulk product terminal

The noise model included the FRA provision that horns be sounded not less than 15 seconds or more than 20 seconds before the locomotive reaches a crossing. To be conservative, the analysis assumes locomotive horn sounding would begin 20 seconds before the locomotive reaches a crossing (or 600 feet at 20 miles per hour) with a source reference level of 113 dBA SEL, per the FRA guidelines (2012) for assessing train horn noise impacts in the vicinity of grade crossings.

Day-night sound level (L_{dn}) is the A-weighted L_{eq} for a 24-hour period with a 10-decibel penalty applied to noise levels between 10 p.m. and 7 a.m. To calculate the L_{dn} metric, it is necessary to define the number of trains that pass during daytime hours (7 a.m. to 10 p.m.) and nighttime hours (10 p.m. to 7 a.m.). The proposed coal export terminal would operate 24 hours a day and 7 days a week. For the L_{dn} calculations, it was assumed rail traffic would be evenly distributed; therefore, 62.5% of the daily train traffic was assumed to pass in the day and the remaining 37.5% was assumed to pass in the night.

The Cadna/A® model was used to predict noise levels generated by rail traffic along the BNSF Spur and Reynolds Line for existing conditions (2015), the No-Action Alternative in 2018 (No Action 2018), the No-Action Alternative in 2028 (No Action 2028), and operation of the Proposed Action in 2028 (Operations 2028). A summary of the model input is provided in Tables 12 through 15. The noise levels were predicted for trains running without sounding horns at crossings and for trains running with horns sounding at crossings.

Table 12. Cadna/A® Freight Train Noise Model Input—BNSF Spur to Reynolds Lead

		Existing 2015	No Action 2018	No Action 2028[c]	No Action 2028[d]	Terminal Operation 2028[c]	Terminal Operation 2028[d]	Peak Hour, 1 Roundtrip Train
Locomotives	Reference SEL, dBA[a]	97	97	97	97	97	97	97
	Reference length, feet	90	90	90	90	90	90	90
	Reference speed, mph	40	40	40	40	40	40	40
	Speed coefficient, K	10	10	10	10	10	10	10
	Length per unit, feet	69	69	69	69	72	72	72
	Total number of daytime passbys[b]	12	12	12	12	30	30	6
	Total number of nighttime passbys[b]	7	7	7	7	18	18	n/a
Railcars	Reference SEL, dBA[a]	100	100	100	100	100	100	100
	Reference length, feet	2,000	2,000	2,000	2,000	2,000	2,000	2,000
	Reference speed, mph	40	40	40	40	40	40	40
	Speed coefficient, K	20	20	20	20	20	20	20
	Length per unit, feet	62	66	66	66	52	52	52
	Total number of daytime passbys[b]	347	347	347	347	1,250	1,250	250
	Total number of nighttime passbys[b]	208	208	208	208	750	750	n/a
Horns	Reference SEL, dBA1	113	113	113	113	113	113	113
	Number of daytime passbys[b]	4	4	4	4	10	10	2
	Number of nighttime passbys[b]	3	3	3	3	6	6	-
	Train speed, mph	10	10	10	20	10	20	20

Notes:

[a] Reference SEL at distance of 50 feet

[b] Daytime: 7 a.m. to 10 p.m., Nighttime: 10 p.m. to 7 a.m.

[c] Without track improvements

[d] With track improvements

SEL = sound exposure level; dBA = A-weighted decibel; mph = miles per hour; K = speed coefficient; n/a = not applicable

Table 13. Cadna/A® Freight Train Noise Model Input—Reynolds Lead from BNSF Spur to 3rd Avenue and California Way

		Existing 2015	No Action 2018	No Action 2028[c]	No Action 2028[d]	Terminal Operation 2028[c]	Terminal Operation 2028[d]	Peak Hour, 1 Roundtrip Train
Locomotives	Reference SEL, dBA[a]	97	97	97	97	97	97	97
	Reference length, feet	90	90	90	90	90	90	90
	Reference speed, mph	40	40	40	40	40	40	40
	Speed coefficient, K	10	10	10	10	10	10	10
	Length per unit, feet	59	59	59	59	72	72	72
	Total number of daytime passbys[b]	3	3	5	5	30	30	6
	Total number of nighttime passbys[b]	2	2	3	3	18	18	n/a
Railcars	Reference SEL, dBA[a]	100	100	100	100	100	100	100
	Reference length, feet	2,000	2,000	2,000	2,000	2,000	2,000	2,000
	Reference speed, mph	40	40	40	40	40	40	40
	Speed coefficient, K	20	20	20	20	20	20	20
	Length per unit, feet	66	66	66	66	52	52	52
	Total number of daytime passbys[b]	29	42	74	74	1,250	1,250	250
	Total number of nighttime passbys[b]	18	25	45	45	750	750	n/a
Horns	Reference SEL, dBA1	113	113	113	113	113	113	113
	Number of daytime passbys[b]	1	1	2	2	10	10	2
	Number of nighttime passbys[b]	1	1	1	1	6	6	-
	Train speed, mph	10	10	10	20	10	20	20

Notes:

a Reference SEL at distance of 50 feet

b Daytime: 7 a.m. to 10 p.m., Nighttime: 10 p.m. to 7 a.m.

c Without track improvements

d With track improvements

SEL = sound exposure level; dBA = A-weighted decibel; mph = miles per hour; K = speed coefficient; n/a = not applicable

Table 14. Cadna/A® Freight Train Noise Model Input—Reynolds Lead from Oregon Way and Industrial to the Project Area

		Existing 2015	No Action 2018	No Action 2028[c]	No Action 2028[d]	Terminal Operation 2028[c]	Terminal Operation 2028[d]	Peak Hour, 1 Roundtrip Train
Locomotives	Reference SEL, dBA[a]	97	97	97	97	97	97	97
	Reference length, feet	90	90	90	90	90	90	90
	Reference speed, mph	40	40	40	40	40	40	40
	Speed coefficient, K	10	10	10	10	10	10	10
	Length per unit, feet	49	49	49	49	72	72	72
	Total number of daytime passbys[b]	3	3	5	5	30	30	6
	Total number of nighttime passbys[b]	2	2	3	3	18	18	n/a
Railcars	Reference SEL, dBA[a]	100	100	100	100	100	100	100
	Reference length, feet	2,000	2,000	2,000	2,000	2,000	2,000	2,000
	Reference speed, mph	40	40	40	40	40	40	40
	Speed coefficient, K	20	20	20	20	20	20	20
	Length per unit, feet	66	66	66	66	52	52	52
	Total number of daytime passbys[b]	29	42	74	74	1,250	1,250	250
	Total number of nighttime passbys[b]	18	25	45	45	750	750	n/a
Horns	Reference SEL, dBA1	113	113	113	113	113	113	113
	Number of daytime passbys[b]	1	1	2	2	10	10	2
	Number of nighttime passbys[b]	1	1	1	1	6	6	-
	Train speed, mph	10	10	10	20	10	20	20

Notes:
[a] Reference SEL at distance of 50 feet
[b] Daytime: 7 a.m. to 10 p.m., Nighttime: 10 p.m. to 7 a.m.
[c] Without track improvements
[d] With track improvements
SEL = sound exposure level; dBA = A-weighted decibel; mph = miles per hour; K = speed coefficient; n/a = not applicable

Table 15. Cadna/A® Freight Train Noise Model Input—Reynolds Lead from Midway between Industrial Way and Weyerhaeuser Entrance to Project Area

		Existing / Baseline	No Action 2018	No Action 2028[c]	No Action 2028[d]	Terminal Operation 2028[c]	Terminal Operation 2028[d]	Peak Hour, 1 Roundtrip Train
Locomotives	Reference SEL, dBA[a]	97	97	97	97	97	97	97
	Reference length, feet	90	90	90	90	90	90	90
	Reference speed, mph	40	40	40	40	40	40	40
	Speed coefficient, K	10	10	10	10	10	10	10
	Length per unit, feet	49	49	49	49	72	72	72
	Total number of daytime passbys[b]	3	3	5	5	30	30	6
	Total number of nighttime passbys[b]	2	2	3	3	18	18	n/a
Railcars	Reference SEL, dBA[a]	100	100	100	100	100	100	100
	Reference length, feet	2,000	2,000	2,000	2,000	2,000	2,000	2,000
	Reference speed, mph	40	40	40	40	40	40	40
	Speed coefficient, K	20	20	20	20	20	20	20
	Length per unit, feet	66	66	66	66	52	52	52
	Total number of daytime passbys[b]	29	42	74	74	1,250	1,250	250
	Total number of nighttime passbys[b]	18	25	45	45	750	750	n/a
Horns	Reference SEL, dBA1	113	113	113	113	113	113	113
	Number of daytime passbys[b]	1	1	2	2	10	10	2
	Number of nighttime passbys[b]	1	1	1	1	6	6	-
	Train speed, mph	10	10	10	10	10	10	10

Notes:

a Reference SEL at distance of 50 feet

b Daytime: 7 a.m. to 10 p.m., Nighttime: 10 p.m. to 7 a.m.

c Without track improvements

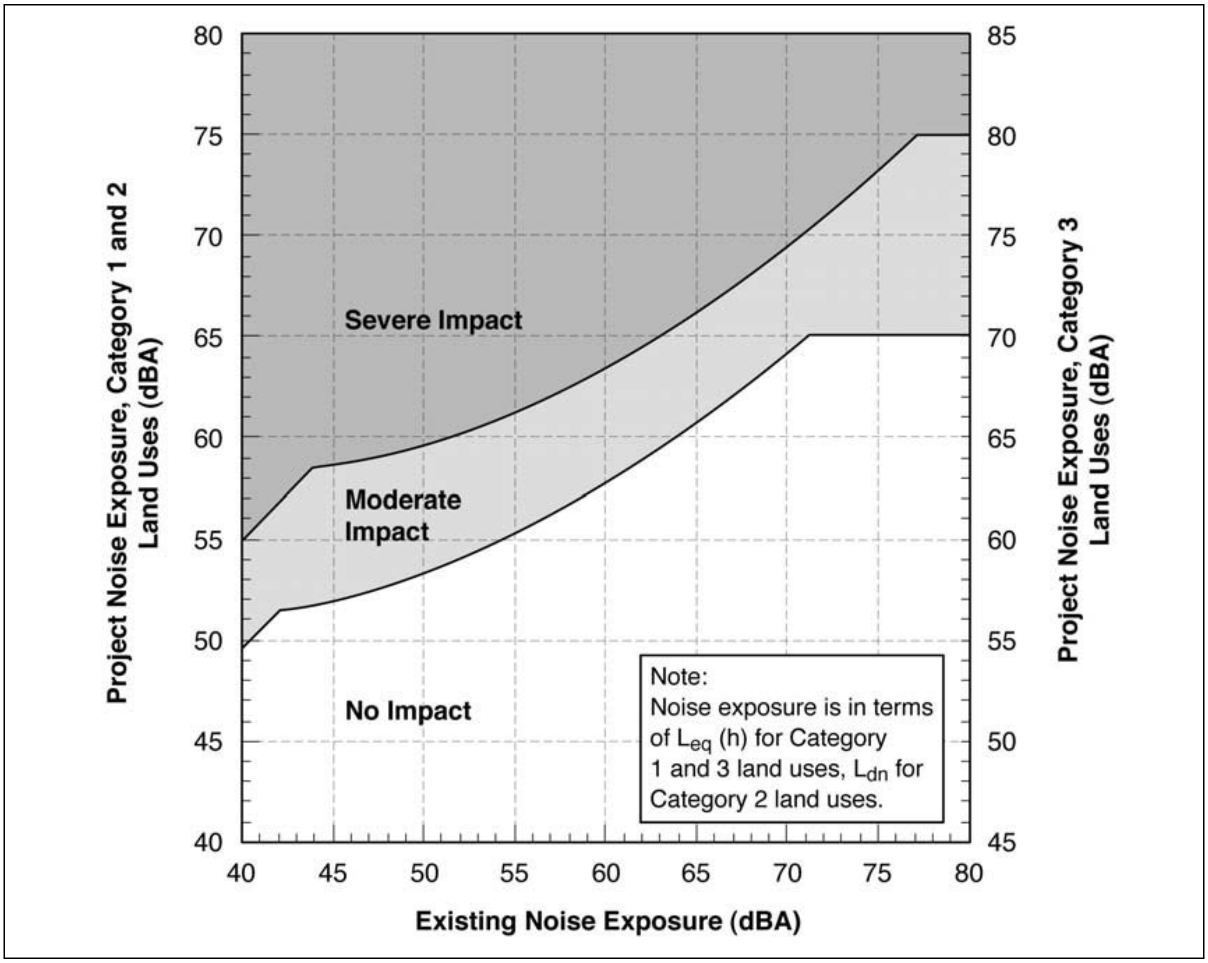
d With track improvements

SEL = sound exposure level; dBA = A-weighted decibel; mph = miles per hour; K = speed coefficient; n/a not applicable

Railroad noise is exempt from Washington State noise limits. There are no criteria or guidelines for assessing noise impacts specifically from freight trains. However, the guidelines provided for assessing noise impacts from high-speed rail projects (Federal Railroad Administration 2012) and from transit projects (Federal Transit Administration 2006) are appropriate for assessing potential noise impacts from rail traffic for the Proposed Action. Per these guidelines, noise impacts are determined by the increase in ambient noise level (L_{dn} or peak hour L_{eq}, depending on the type of receptor) after the project is completed. The amount of increase that is acceptable depends on the existing ambient noise level.

The FTA/FRA guidance defines two levels of potential impact, *moderate impact* or *severe impact*. The level of impact is determined by the existing level of noise exposure and the change in noise exposure that would result from the Proposed Action using a sliding scale according to the land uses affected. Noise impacts are assessed by comparing the existing outdoor noise exposure with Proposed Action-Related outdoor noise levels, as illustrated in Figure 6. The criterion for each degree of impact is based on a sliding scale that is dependent on the existing noise exposure and noise exposure with project-related trains. As the existing level of noise exposure increases, the additional noise exposure causing a moderate or severe impact decreases.

Figure 6. Noise Impact Criteria



Source: Federal Transit Administration 2006.

FTA/FRA guidance noise impact criteria are based on the land-use category of the receiving properties. The FTA/FRA guidance identifies three land-use categories for assessing potential noise impacts.[4]

- **Category 1.** Tracts of land where quiet is an essential element of their intended purpose, such as outdoor amphitheaters, concert pavilions, and national historic landmarks with significant outdoor use.
- **Category 2.** Residences and buildings where people normally sleep, including homes, hospitals, and hotels.

[4] Noise exposure values are reported as hourly equivalent sound level ($L_{eq[h]}$) for Category 1 and 3 land uses, and L_{dn} for residential land uses (Category 2).

- **Category 3.** Institutional land uses (schools, places of worship, libraries) that are typically available during daytime and evening hours. Other uses in this category can include medical offices, conference rooms, recording studios, concert halls, cemeteries, monuments, museums, historical sites, parks, and recreational facilities.

The analysis considered two types of rail noise.

- *Wayside* noise refers to the combined effect of locomotive noise and car/wheel noise.
- *Horn* noise refers to the sound of locomotive warning horns, which are sounded at public at-grade road/rail crossings. Because horn sounding is intentionally loud to warn motorists of oncoming trains, the horn noise footprint is often larger than the wayside noise footprint.

To determine noise impact for the No-Action Alternative, the L_{dn} predicted for existing trains was decibel subtracted from the measured L_{dn} at each ambient survey location. This provided L_{dn} levels representative of sources other than trains. The L_{dn} predicted for the No-Action Alternative was then added to the result to provide the No-Action Alternative L_{dn} including all sources of noise. Any increases between the No-Action Alternative L_{dn} and the measured L_{dn} (which included noise from the existing trains) were compared to the FTA/FRA guidance to determine impact.

To determine noise impacts for the operation of the Proposed Action in 2028, the calculated L_{dn} for associated train traffic was added to the No Action 2028 L_{dn} calculated at each ambient survey location as described above. Any relative increases between the above summation and the No Action 2028 levels were compared to the FTA/FRA guidance. The above approach accounted for increases, if any, in rail traffic noise not associated with the Proposed Action by 2028.

At locations where potential noise impacts were indicated, additional nearby calculation points were added to the Cadna/A® model to determine the potential extent of the impacts. The model results and online satellite photography were then used to determine the number of potentially affected properties.

For noise-sensitive receptors that have predominantly daytime use only (e.g., churches, schools), noise impacts are determined from the peak hour L_{eq} per the FTA/FRA guidance. The existing L_{eq} was determined at each ambient survey location from the long-term survey data. The ambient survey data and the calculated L_{eq} were used to determine impacts in a similar fashion as for the L_{dn} at residences described above.

Statewide Analysis of Train Noise

Assessment of the potential noise impact from increased train traffic on BNSF and UP routes in Washington State to and from the project area was based on a potential increase in L_{dn}, which was calculated using the following equation.

$$L_{dn}\text{ increase} = 10\log\left(\frac{V_{total}}{V_{non\text{-}project}}\right)$$

Where:

- V_{total} is the total volume of train traffic, i.e., the average total number of trains per day, including Proposed Action-Related trains and all other trains.
- $V_{non\text{-}project}$ is the number of trains per day that are not related to the Proposed Action.

The above equation is similar to the method used to calculate noise exposure based on train traffic volume per the FTA guidance manual for detailed noise analysis (Federal Transit Administration 2006). The above assumes that the distribution of the number of trains between daytime and nighttime does not change.

Vibration

Using generalized ground surface vibration curves (Federal Transit Administration 2006) and correcting for speed, vibration from train operations is unlikely at distances greater than 40 feet from a railroad track for infrequent events (less than 30 passbys per day). The closest vibration-sensitive receptor is approximately 150 feet away from the Reynolds Lead. There are no vibration sensitive receptors along the BNSF Spur. Therefore, no analysis was conducted to estimate vibration generated during rail operations.

2.1.2.4 Operations—Vessel Traffic

The methods for analyzing noise and vibration impacts related to vessel traffic to and from the project area are described in this subsection.

Noise

There are numerous sources of noise from stationary and moving vessels, summarized as follows.

- **Stationary vessels.** Vessels may be considered stationary noise sources while moored at the docks for loading or unloading. The primary sources of airborne noise from large commercial cargo vessels are the ventilation systems for the engine room and cargo hold. Localized noise may also emit from exhaust stacks or ventilation ducts on the sides of a ship. Noise levels produced by a large moored bulk container ship have been measured at about 65 dBA at a distance of 19 meters (62 feet) at both the engine room ventilation fans and the cargo hold fans (Badino et al. 2014). Using the above information as a reference, the L_{eq} at any distance from a stationary vessel was calculated using the following equation.

$$L_{eq_{(stationary\ vessel)}} = 65 - 20\log\left(\frac{d}{62}\right)$$

Where d is the distance in feet between the receiver and the vessel. The above equation is based on the basic concept of spherical spreading from a point source of noise (i.e., 6 dB reduction per doubling of distance). A similar term is used in the FTA guidance manual for projecting noise during construction (Federal Transit Administration 2006).

- **Vessels under way.** Vessels may be considered slow moving, single sources of noise while under way in the river. For these vessels, the dominant noise source is engine noise transmitted through intake air vents and exhaust stacks. An analysis of noise from vessels under way estimated the L_{dn} from a moving ship, assuming existing self-propelled vessel traffic on the Columbia River with an average of 6.46 ships per day (U.S. Army Corps of Engineers 2011), half during daytime hours and half at night, passing the Port of Longview, Washington. At a perpendicular distance of 400 feet from the moving ship, the L_{dn} was estimated to be 45 dBA, well under the European Union Directive noise limit of 75 dBA at 25 meters for vessels under way (URS Corporation Corporation 2014a). Using the above information as a reference, the L_{dn} at any perpendicular distance from the shipping lane with a specific volume of ship traffic was calculated using the following equation.

$$L_{dn_{(\text{vessels under way})}} = 45 - 20\log\left(\frac{d}{400}\right) + 10\log\left(\frac{V}{6.46}\right)$$

Where:

- d is the perpendicular distance between the lane of ship traffic and the noise sensitive receiver.
- V is the volume of ship traffic, i.e., average total number of vessels per day.

The second term on the right-hand side of the above equation accounts for spherical spreading from a point source of noise as described for stationary vehicles above. The third term is similar to the method used to calculate noise exposure based on train traffic volume per FTA guidance for detailed noise analysis (Federal Transit Administration 2006).

- **Foghorns.** Vessels may sound their foghorns while under way in heavy fog. One such horn was heard and monitored during a site visit. The foghorn reached a maximum noise level of 60 dBA at the ship's point of closest approach to the measurement location (approximately 1,800 feet). This represents the highest foghorn sound level to which noise-sensitive receptors would be exposed. The L_{max} from foghorns at any perpendicular distance from the shipping lane was calculated using the following equation.

$$L_{max_{(\text{foghorn})}} = 60 - 20\log\left(\frac{d}{1800}\right)$$

Where d is the perpendicular distance in feet between the receiver and the shipping lane. The above equation accounts for spherical spreading from a point source of noise as described for stationary vehicles above.

Vibration

The vessels that would be used are similar to those which are already traveling on the Columbia River. There have been no documented cases of perceptible vibration on shore generated by ship traffic on the river. Therefore, no analysis was conducted to estimate vibration generated during vessel operations.

2.2 Existing Conditions

This section describes the existing noise conditions in the study area.

Figure 3 in Section 1.3, *Study Area*, illustrates the land uses in the study area. Figure 4 in Section 2.1, *Methods*, illustrates the sensitive receptors in the study area, including residential land uses. As shown in Figure 4, the closest sensitive receptors to the project area and Reynolds Lead and BNSF Spur are residential land uses. These land uses are located north of the Reynolds Lead and Industrial Way (SR 432) between Oregon Way and Washington Way (a distance of approximately 1.5 miles along the Reynolds Lead). Residential land uses are also located across Mt. Solo Road (SR 432) from the project area. Figures 7 through 10 are plots of the equal L_{dn} estimated for existing rail traffic along the Reynolds Lead and BNSF Spur based on the existing rail traffic provided in the SEPA Rail Transportation Technical Report (ICF International and Hellerworx 2016). The following subsections describe existing noise conditions for the Proposed Action, including primary noise sources in the study area and noise-measurement data.

Figure 7. Existing Rail Noise Contours, BNSF Spur to Reynolds Lead, Including Train Horns

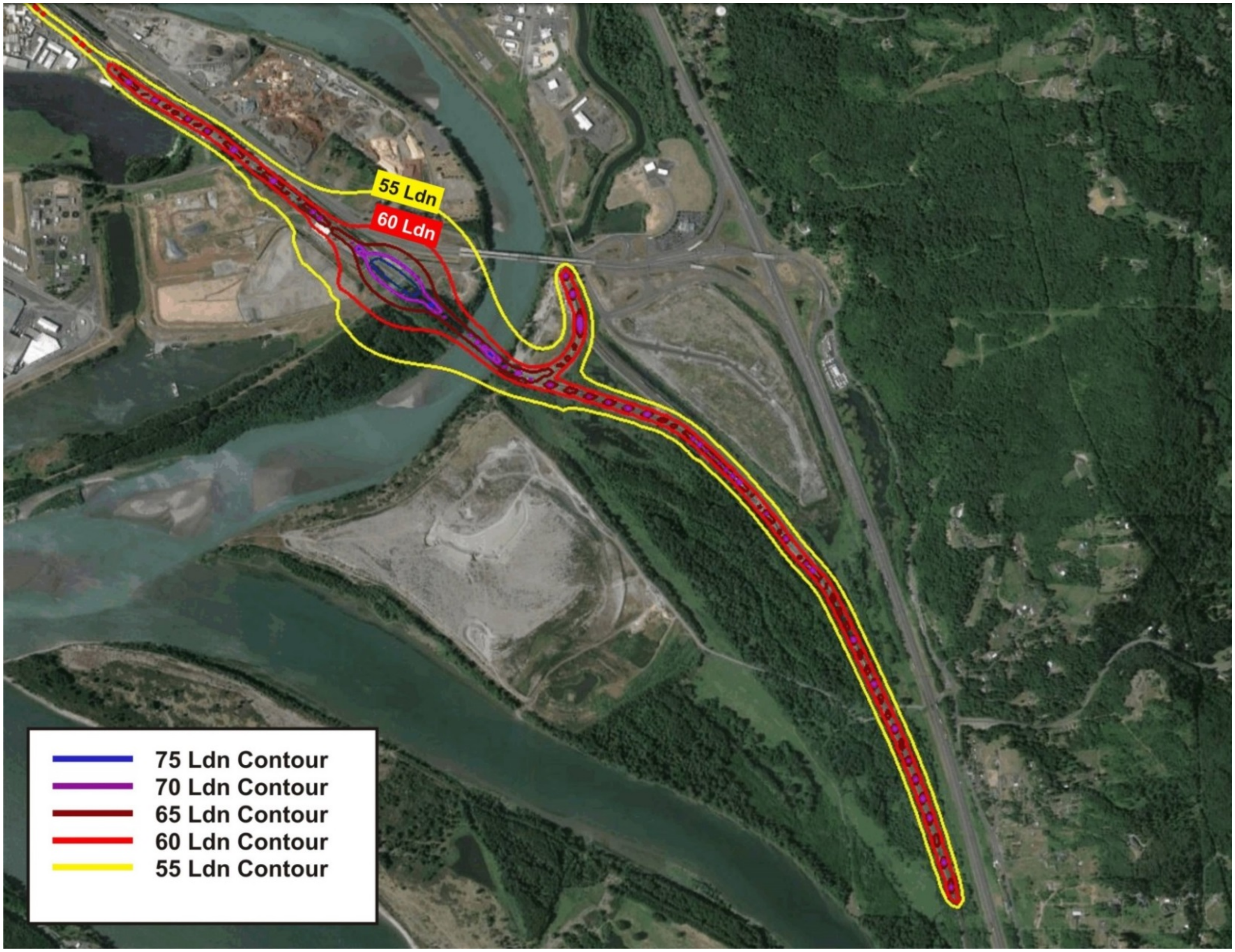


Figure 8. Existing Rail Noise Contours, Beginning of Reynolds Lead, Including Train Horns

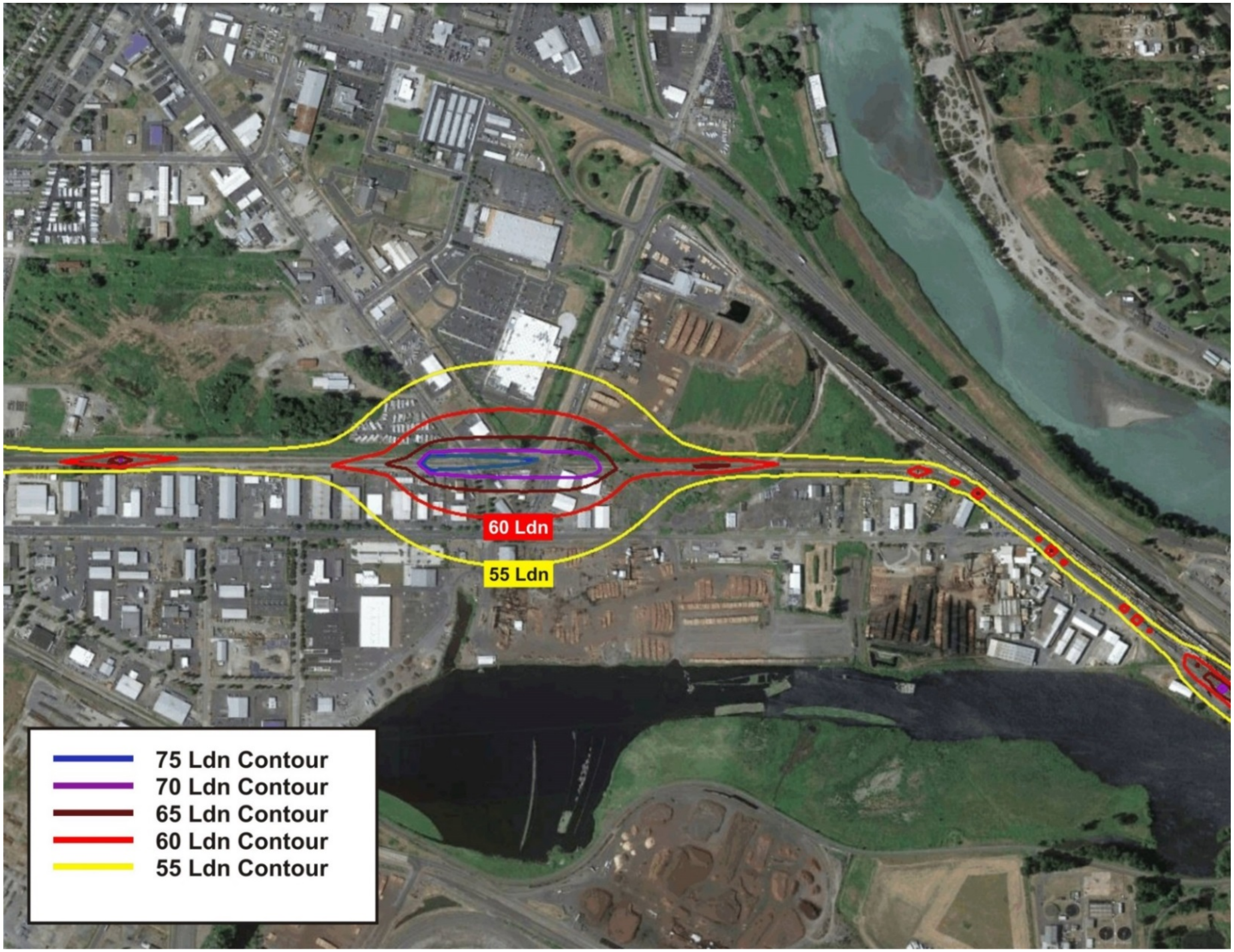
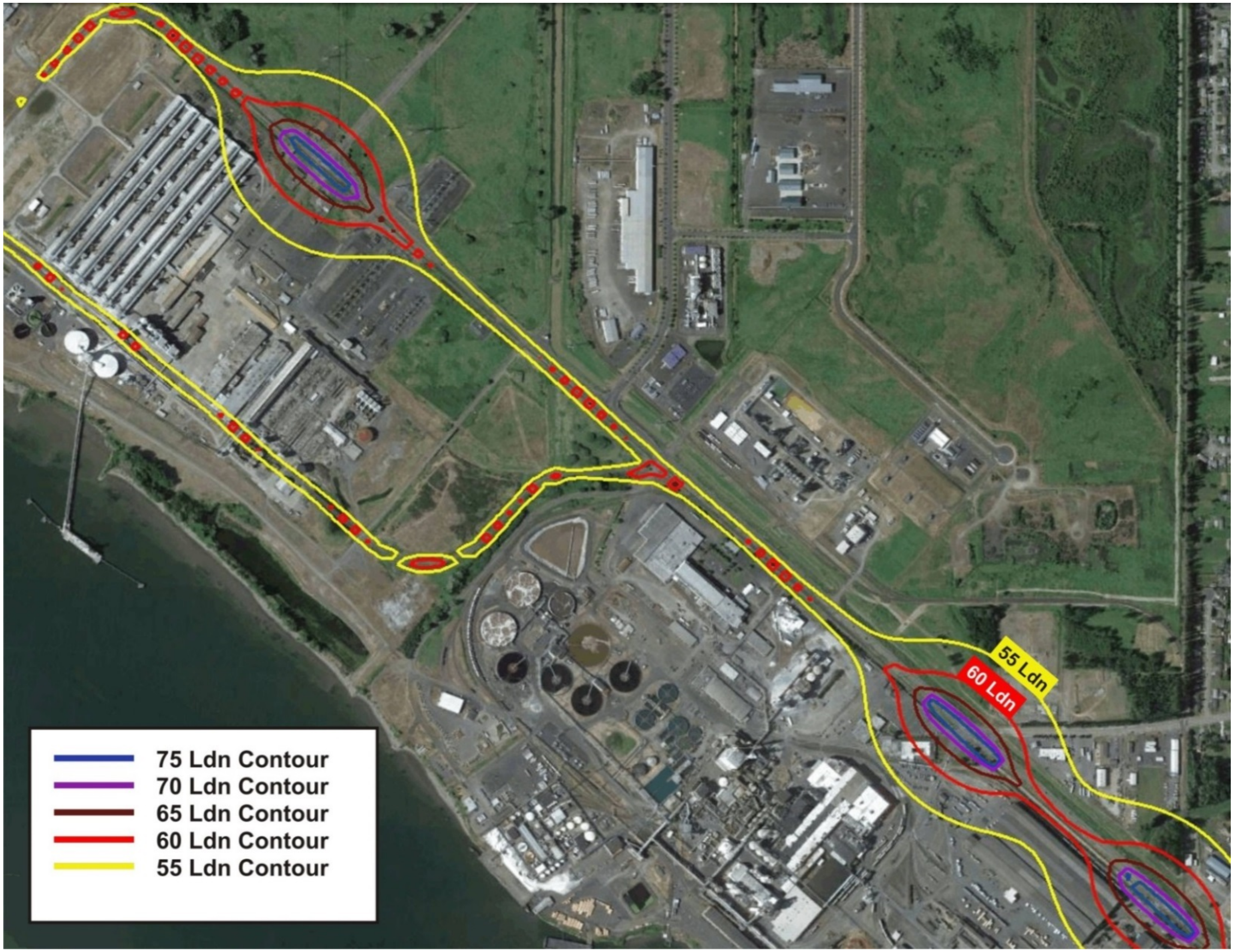


Figure 9. Existing Rail Noise Contours, Mid-Reynolds Lead, Including Train Horns

Figure 10. Existing Rail Noise Contours, End of Reynolds Lead, Including Train Horns



2.2.1 Proposed Action

A summary of primary noise sources at each long-term survey location is included in Table 16.

Table 16. Existing Environmental Noise Sources near the Project Area[a]

Location	Noise Sources
N1: 602 California Way	California Way and Industrial Way traffic Trains on Reynolds Lead Horizon Metals recycling center on California Way
N2: 111 15th Avenue	Industrial Way cars and trucks Trains on Reynolds Lead
N3: 221 Beech Street	Local traffic Industrial Way traffic Weyerhaeuser mill Trains on Reynolds Lead
N4: 875 34th Avenue	Local traffic and residential activity PNW Metal Recycling at Mint Farm
N5: 3600 Memorial Park	Local traffic PNW Metal Recycling at Mint Farm
N6: 420 Rutherglen Drive	Distant industrial at Mint Farm, Weyerhaeuser mill Port of Longview
N7: 4723 Mt. Solo Road	Traffic on Mt. Solo Road (mostly cars)
N8: 1719 Dorothy Avenue	Local traffic and residential activity PMW Metal Recycling at Mint Farm

Notes:
[a] As observed at long-term ambient noise survey locations.

A summary of daily noise descriptors (L_{dn}, community noise equivalent [CNEL], daytime L_{eq} and nighttime L_{eq}) for each day of measurements at all long-term locations is included in Table 17. The data in Table 17 indicate that the L_{dn} and CNEL values are generally within 1 decibel of each other, which is typical of environmental noise dominated by daytime human activity. The hourly L_{eq} for 6 or 7 days of measurement at locations N1 through N8 are plotted in Appendix A, *Existing Ambient Sound Pressure Level Survey Data*. The hourly statistical SPL for each 24-hour period of measurement and at all eight locations are also plotted in Appendix A.

Table 17. Daily Noise Measurements at Sources near the Project Area

Location	Date	L_{dn} (dBA)	CNEL (dBA)	Daytime L_{eq} (dBA)	Nighttime L_{eq} (dBA)
N1 602 California Way	Tue, Oct 28, 2014	75	75	72	68
	Wed, Oct 29, 2014	76	76	67	70
	Thu, Oct 30, 2014	78	78	68	71
	Fri, Oct 31, 2014	77	77	70	70
	Sat, Nov 1, 2014	72	72	64	66
	Sun, Nov 2, 2014	69	73	67	56
N2 111 15th Avenue	Tue, Nov 4, 2014	77	77	63	71
	Wed, Nov 5, 2014	72	72	60	66
	Thu, Nov 6, 2014	72	73	64	66
	Fri, Nov 7, 2014	67	67	60	61
	Sat, Nov 8, 2014	60	60	60	51
	Sun, Nov 9, 2014	63	63	64	53
	Mon, Nov 10, 2014	74	74	61	68
N3 221 Beech Street at Alder St.	Tue, Nov 4, 2014	72	72	68	65
	Wed, Nov 5, 2014	71	71	68	64
	Thu, Nov 6, 2014	71	71	68	64
	Fri, Nov 7, 2014	70	70	67	63
	Sat, Nov 8, 2014	67	67	64	59
	Sun, Nov 9, 2014	67	67	66	59
	Mon, Nov 10, 2014	70	71	67	63
N4 875 34th Avenue	Tue, Nov 4, 2014	67	67	56	61
	Wed, Nov 5, 2014	60	60	51	54
	Thu, Nov 6, 2014	63	63	58	57
	Fri, Nov 7, 2014	58	58	49	52
	Sat, Nov 8, 2014	60	60	60	51
	Sun, Nov 9, 2014	61	61	60	53
	Mon, Nov 10, 2014	58	58	49	52
N5 3600 Memorial Park Drive	Tue, Oct 28, 2014	71	71	66	64
	Wed, Oct 29, 2014	62	62	59	55
	Thu, Oct 30, 2014	66	66	61	59
	Fri, Oct 31, 2014	70	70	63	64
	Sat, Nov 1, 2014	59	60	57	52
	Sun, Nov 2, 2014	61	62	61	51
N6 420 Rutherglen Drive	Tue, Oct 28, 2014	65	65	55	59
	Wed, Oct 29, 2014	62	62	63	52
	Thu, Oct 30, 2014	62	62	56	55
	Fri, Oct 31, 2014	65	65	56	59
	Sat, Nov 1, 2014	52	52	49	44
	Sun, Nov 2, 2014	56	57	55	48

Location	Date	L_{dn} (dBA)	CNEL (dBA)	Daytime L_{eq} (dBA)	Nighttime L_{eq} (dBA)
N7 4723 Mt. Solo Road	Tue, Oct 28, 2014	69	69	65	62
	Wed, Oct 29, 2014	68	68	65	60
	Thu, Oct 30, 2014	68	68	65	60
	Fri, Oct 31, 2014	69	69	65	62
	Sat, Nov 1, 2014	65	65	63	56
	Sun, Nov 2, 2014	63	64	62	55
N8 1719 Dorothy Avenue	Tue, Nov 4, 2014	64	64	56	57
	Wed, Nov 5, 2014	58	58	52	51
	Thu, Nov 6, 2014	63	64	64	53
	Fri, Nov 7, 2014	90[a]	90[a]	93[a]	49
	Sat, Nov 8, 2014	57	57	55	50
	Sun, Nov 9, 2014	88[a]	89[a]	60	81[a]
	Mon, Nov 10, 2014	86[a]	86[a]	53	81[a]

Notes:
[a] Includes anomalous high level events, likely due to residential activity near microphone or heavy rainfall.
Ldn = day-night sound level; dBA = A-weighted decibels; CNEL = community noise equivalent; L_{eq} = equivalent sound level

A summary of the short-term ambient survey results (10-minute L_{eq}) is provided in Table 18. For the purpose of assessing potential noise impacts due to increased rail traffic associated with the Proposed Action along the Reynolds Lead, L_{dn} levels were estimated at each of the above short-term locations by comparing the 10-minute L_{eq} to the hourly L_{eq} detected at the nearest long-term measurement during the same time of day as the short-term measurement (the hourly L_{eq}s were averaged over the days included in the long-term measurements). The L_{dn} estimated at each short-term location is included in Table 18.

Table 18. Short-Term Noise Measurements at Sources near the Project Area

Location	Address (Longview, WA)	Date	Time	10-minute L_{eq} (dBA)	L_{dn}[a] (dBA)
N1s	605 California	10/27/14	4:28–4:38 p.m.	66	76
N2s-a	111 15th Avenue	11/3/14	3:06–3:16 p.m.	62	76
N2s-b	End of Sidewalk at 15th Ave at Pole	11/3/14	4:18–4:24 p.m.	59	73
N2s-c	125 feet north of N2s-b	11/3/14	4:27–4:34 p.m.	57	71
N2s-d	250 feet north of N2s-b	11/3/14	4:37–4:43 p.m.	56	70
N2s-e	375 feet north of N2s-b	11/3/14	4:46–4:53 p.m.	56	70
N3s-a	Beech Street & Alder Street	11/3/14	5:55–6:05 p.m.	65	71
N3s-b	100 feet north up Beech from N3s-a	11/3/14	7:15–7:24 p.m.	62	68
N3s-c	200 feet north up Beech from N3s-a	11/3/14	7:25–7:31 p.m.	57	63
N4s	875 34th Avenue	12/8/14	11:10–11:20 a.m.	51	63
N5s	3534 Memorial Park Drive	10/27/14	3:25–3:35 p.m.	55	66
N6s	420 Rutherglen Drive	11/3/14	1:40–1:50 p.m.	50	62
N7s	4723 Mt. Solo Road	10/27/14	5:11–5:21 p.m.	62	68
N8s	1719 Dorothy Avenue	12/8/14	10:37–10:47 a.m.	52	61

Location	Address (Longview, WA)	Date	Time	10-minute L_{eq} (dBA)	L_{dn}[a] (dBA)
S1	3128 Louisiana Street	12/8/14	10:52–11:02 a.m.	51	71
S2	3011 Hemlock Street	12/8/14	11:35–11:45 a.m.	59	71
S3	2642 Field Street	12/8/14	11:54 a.m.–12:04 p.m.	56	68
S4	30th Ave median & Colorado Street	12/8/14	12:25–12:35 p.m.	61	73
S5	St Rose	12/8/14	3:32–3:42 p.m.	58	70
S6	540 23rd Avenue	12/8/14	12:58–1:08 p.m.	49	55
S7	645 15th Avenue	12/8/14	2:59–3:09 p.m.	63	77
S8	214 23rd Avenue	12/8/14	1:43–1:53 p.m.	61	67
S9	410 15th Avenue	12/8/14	1:19–1:29 p.m.	57	91
S10	Alder Street & Douglas Street	12/8/14	2:05–2:15 p.m.	63	69
S11	427 28th Avenue	12/8/14	12:40–12:50 p.m.	55	61
S12	Olive Way & Ocean Beach Hwy	12/8/14	2:32–2:42 p.m.	68	77

Notes:

[a] Estimated from the data collected at the nearest long-term survey location

L_{eq} = equivalent sound level; L_{dn} = day-night sound level; dBA = A-weighted decibel

Chapter 3
Impacts and Mitigation

This chapter describes the impacts on noise and vibration that would result from construction and operation of the Proposed Action and the noise and vibration impacts under the No-Action Alternative.

3.1 Impacts

This section describes the impacts on noise and vibration that could result from the Proposed Action and No-Action Alternative.

3.1.1 Proposed Action

Potential impacts on noise and vibration from the Proposed Action are described below.

3.1.1.1 Construction: Direct Impacts

Construction of the Proposed Action would result in the following direct impacts. These impacts would occur during the construction period in 2018.

Exceed Federal Railroad Administration Construction Noise Criteria

Washington State maximum permissible noise level regulations (WAC 173-60-040) do not apply to construction noise during daytime hours (between 7 a.m. and 10 p.m.). Construction of the Proposed Action would result in noise levels exceeding FRA criteria at one residence (104 Bradford Place). This residence is the noise-sensitive receptor that is closest to the project area. The noise impact is predicted to occur only during pile driving when the maximum noise level is predicted to reach 83 dBA, exceeding the FRA criteria of 80 dBA for construction noise. No noise impact is predicted for all other times during construction when there is no pile driving or when pile driving is taking place further than 1,500 feet from the residence. Projected noise levels during construction are summarized in Appendix B, *Construction Noise Impact Analysis*, Table B-1.

Emit Pile-Driving Vibration

The maximum predicted vibration levels would occur during pile driving. The maximum predicted vibration velocity level at the closest vibration-sensitive receptor would be 72 VdB at 104 Bradford Place during pile driving. This level is the highest estimated value and would not exceed the FTA/FRA guidance criteria for maximum allowable vibration due to construction at residences. Therefore, no construction vibration impacts at the closest vibration-sensitive receivers are expected with the Proposed Action.

3.1.1.2 Construction: Indirect Impacts

Construction of the Proposed Action would result in the following indirect impacts.

Emit Noise from Construction-Related Road Traffic

A potential source of noise impacts related to construction would be automobile and truck traffic traveling to and from the project area, mainly on Industrial Way. As discussed in the SEPA Vehicle Transportation Technical Report (ICF International and DKS Associates 2016), the average daily traffic (ADT) on Industrial Way approaches 10,000 trucks for all vehicles, of which approximately 7% (or 700 trucks) are heavy trucks with three or more axles per day. In general, changes in a noise level of less than 3 dBA are not typically noticed by the human ear. A doubling of traffic volume (i.e., a 100% increase) would be required to increase the L_{dn} from road traffic by 3 dBA at the noise sensitive receptors. It is expected that approximately 330 truck trips per day would be required for a 6-month period during the first year to support construction. The increase in truck traffic represents an increase of 3.3% in ADT for all vehicles on Industrial Way. The potential for noise impact would be less if truck traffic distributed off Industrial Way to other roadways in the study area. This increase in vehicular traffic would not result in a substantial change to the existing noise levels, would be temporary (during the peak year of construction), and would occur only during daytime hours. Therefore, no noise or vibration impact related to construction traffic would be anticipated.

Emit Noise from Construction-Related Rail Traffic

The Proposed Action would add approximately 1.3 train trips during the peak construction year if construction materials are delivered by rail. This level of rail activitiy would not cause noise levels to increase more than 3 L_{dn} (dBA). Proposed Action-Related rail traffic would not result in noise impacts that would meet FTA/FRA criteria for a noise impact.

3.1.1.3 Operations: Direct Impacts

Noise

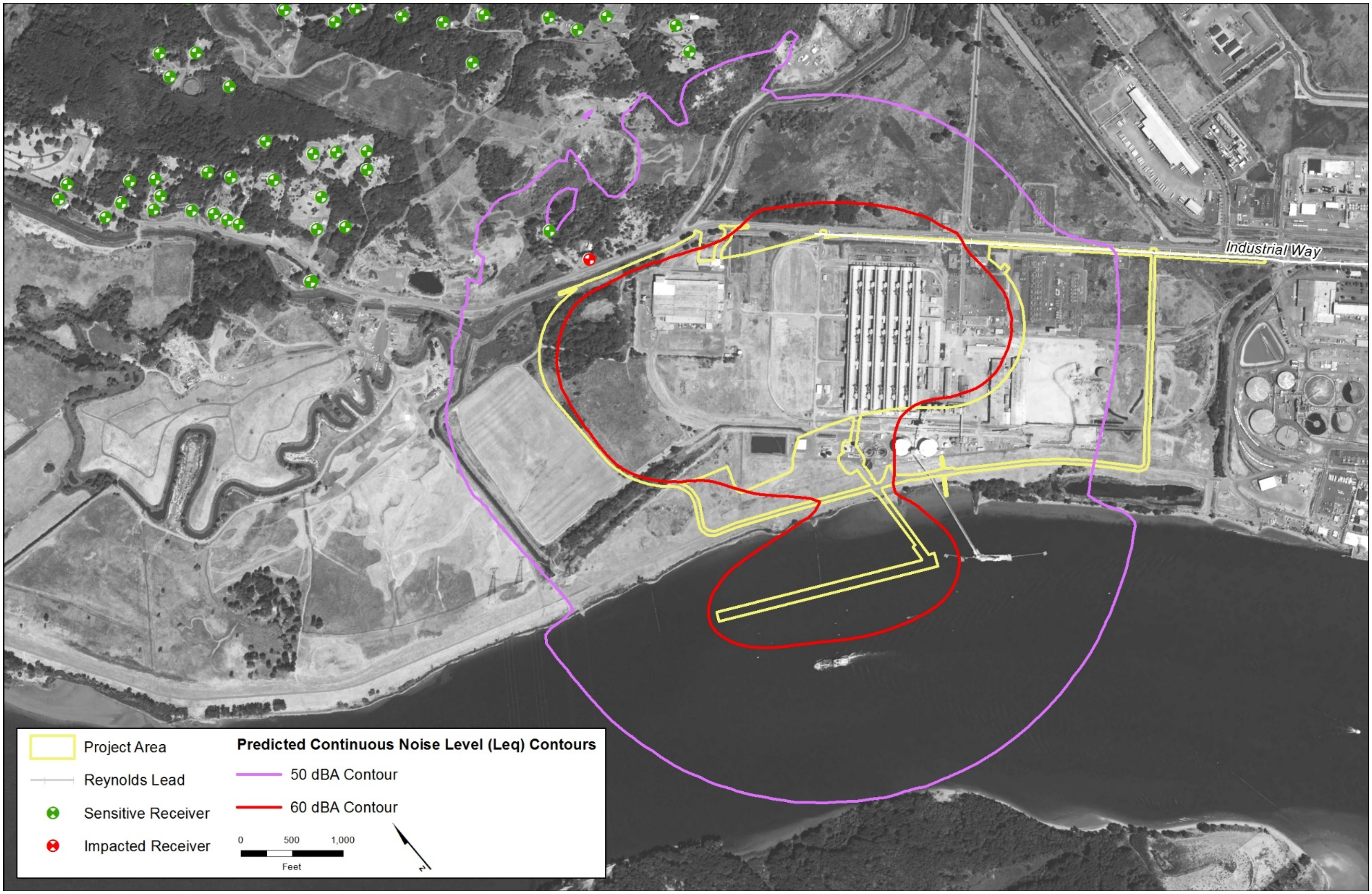
Operation of the Proposed Action would result in the following direct impacts. These impacts are estimated for full-scale operations in 2028.

Exceed Washington Administrative Code Maximum Environmental Noise Levels

Figure 11 indicates the predicted noise contours (L_{eq} of 50 dBA and 60 dBA) for operations at the Proposed Action. The analysis indicates noise from operation of the Proposed Action in 2028 would exceed the Washington State noise standard at a single residence (104 Bradford Place). As indicated in Figure 11, this residence is within the 50 dBA L_{eq} contour, which is the applicable Washington State limit for nighttime noise levels in a residential area when the noise is from an industrial source. The predicted L_{eq} at the residence is 55 dBA. This predicted noise level is likely comparable to the current nighttime noise level because the residence has a similar exposure to the Mt. Solo Road traffic noise as the N7 noise monitor location. At N7, the nighttime noise levels ranged from 55 dBA on a Sunday night to 62 dBA on week nights.

Another residence, just north of the above residence, would be shielded by the topography of the land (Figure 11). The predicted L_{eq} at the second residence is 50 dBA and would not exceed the Washington State maximum environmental noise level at this location.

Figure 11. Predicted Continuous Noise Level (L_{eq}) Contours during Operations



Vibration

No significant sources of ground vibration would occur at the project area during operations and the closest vibration receptor is too far away to be affected by vibration from trains on the rail loop. Therefore, no vibration impacts associated with operations at the project area would be anticipated.

3.1.1.4 Operations: Indirect Impacts

Figures 12 through 15 are plots of the equal L_{dn} noise levels in 2028 with the Proposed Action. All contours include the contribution of noise from train horns. Operation of the Proposed Action would result in the following indirect impacts. These impacts are estimated for full-scale operations in 2028.

Exceed FTA/FRA Guidelines for No Noise Impact

Operation of the Proposed Action would increase rail traffic-related noise along the Reynolds Lead and BNSF Spur. Train engineers are required by FRA rules to begin to sound locomotive horns at least 15 seconds and not more than 20 seconds in advance of public grade crossings.[5] In addition, LVSW operating rules require train engineers to sound locomotive horns at private grade crossings. These noise impacts would occur with or without the incorporation of proposed track improvements that would allow higher train speed through the grade crossings. In either case, train horns sounded near grade crossings would still be required and would be the dominant noise impact.

Noise from surface carriers engaged in interstate commerce by railroad is exempt from Washington state maximum permissible noise level regulations (WAC 173-60-040). As discussed above in Section 2.1.2.3, *Operations—Rail Traffic*, FTA and FRA have defined two levels of potential impact, *moderate impact* or *severe impact*. The level of impact is determined by the existing level of noise exposure and the change in noise exposure that would result from the Proposed Action. As the existing level of noise exposure increases, the additional noise exposure needed to cause a moderate or severe impact decreases. For this analysis, the existing level of noise exposure was determined by the ambient noise study results and the projected No-Action Alternative 2028 noise levels described in Section 2.1.2.3 *Operations—Rail Traffic*.

[5] The FRA horn noise regulations that require locomotive horn sounding at public at-grade crossings also include provisions for establishing quiet zones where horn sounding would not be required if adequate alternative safety measures are provided.

Figure 12. Noise Contours for Proposed Action 2028 Rail Traffic, BNSF Spur to Reynolds Lead, Including Train Horns

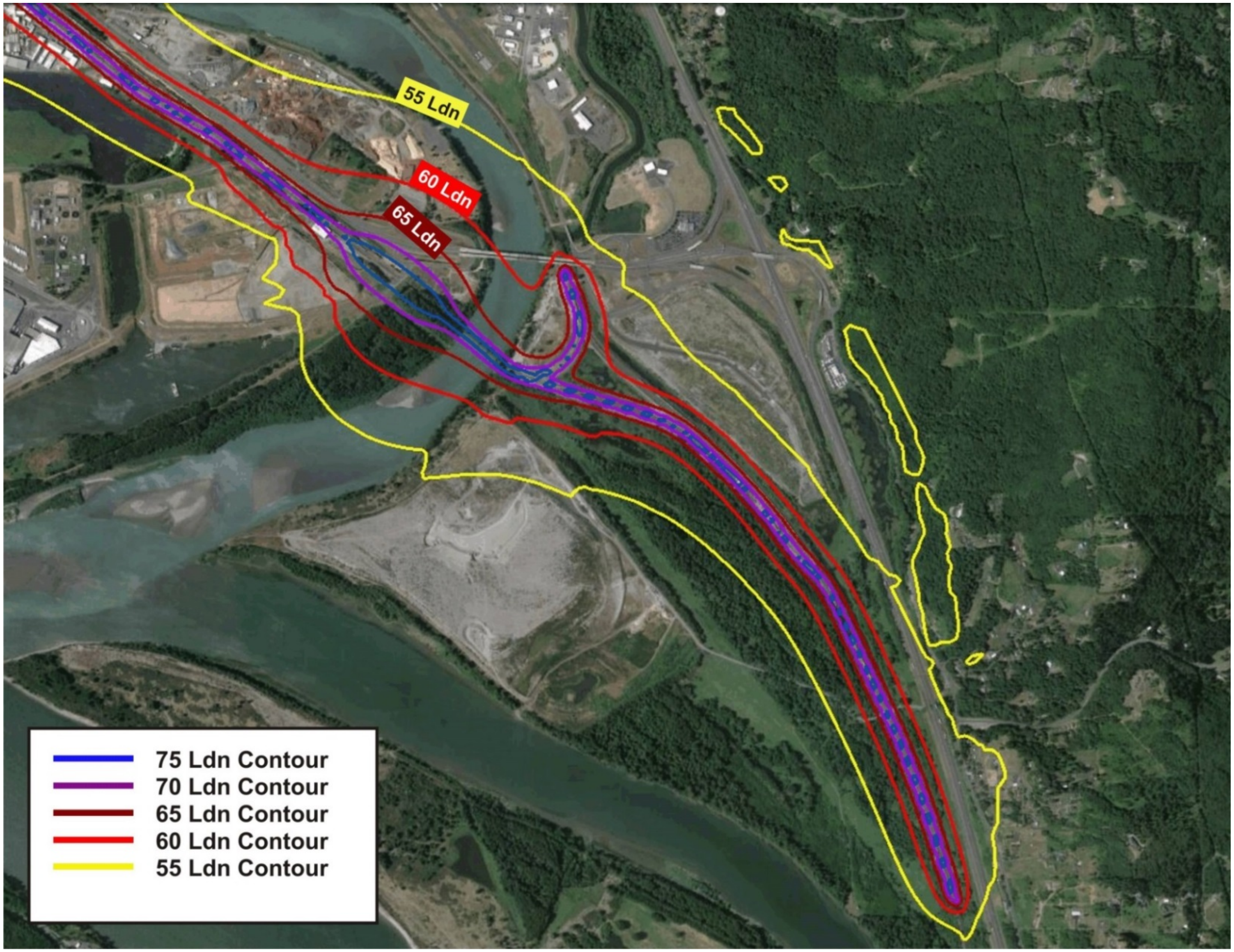


Figure 13. Noise Contours for Proposed Action 2028 Rail Traffic, Beginning of Reynolds Lead, Including Train Horns

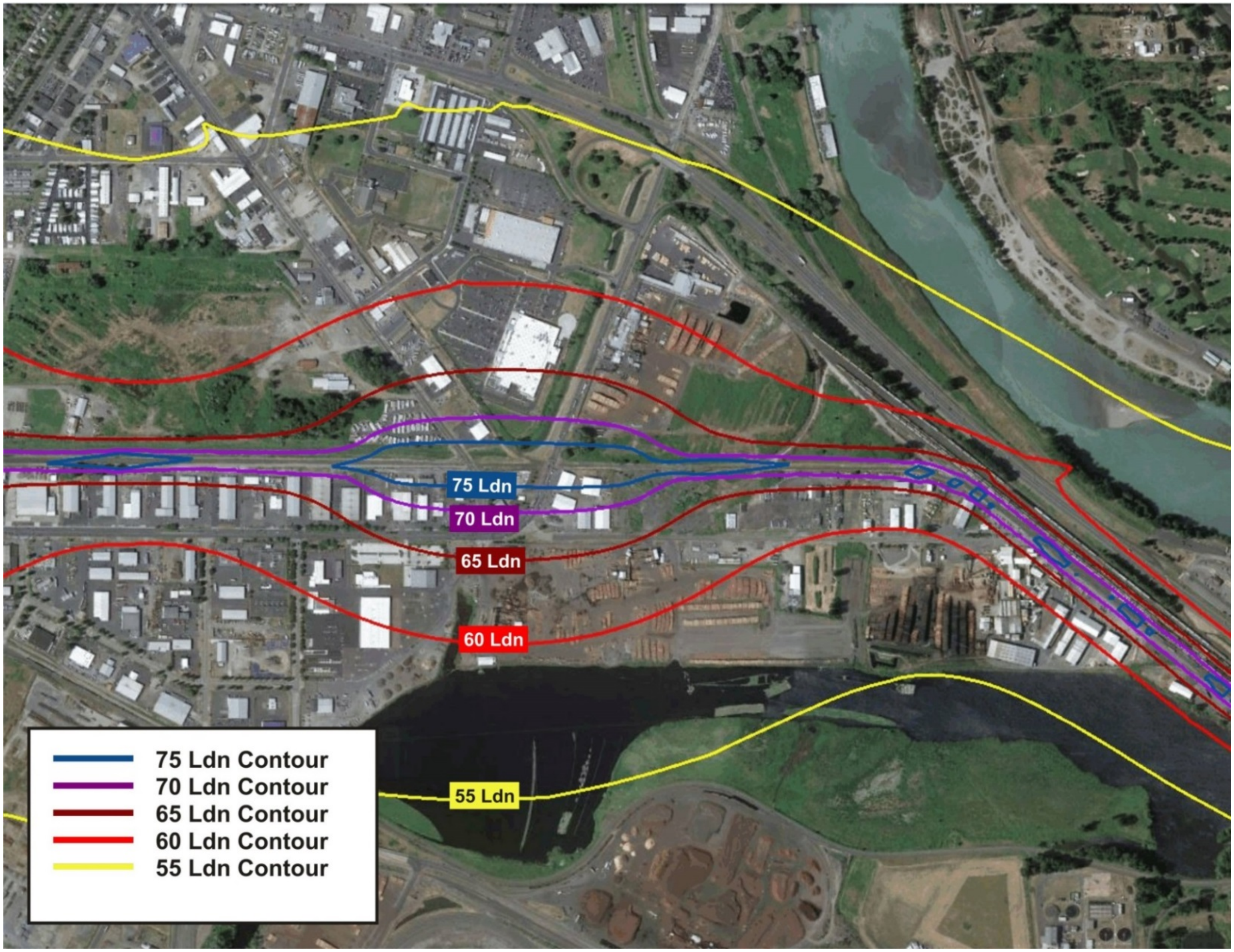


Figure 14. Noise Contours for Proposed Action 2028 Rail Traffic, Mid-Reynolds Lead, Including Train Horns

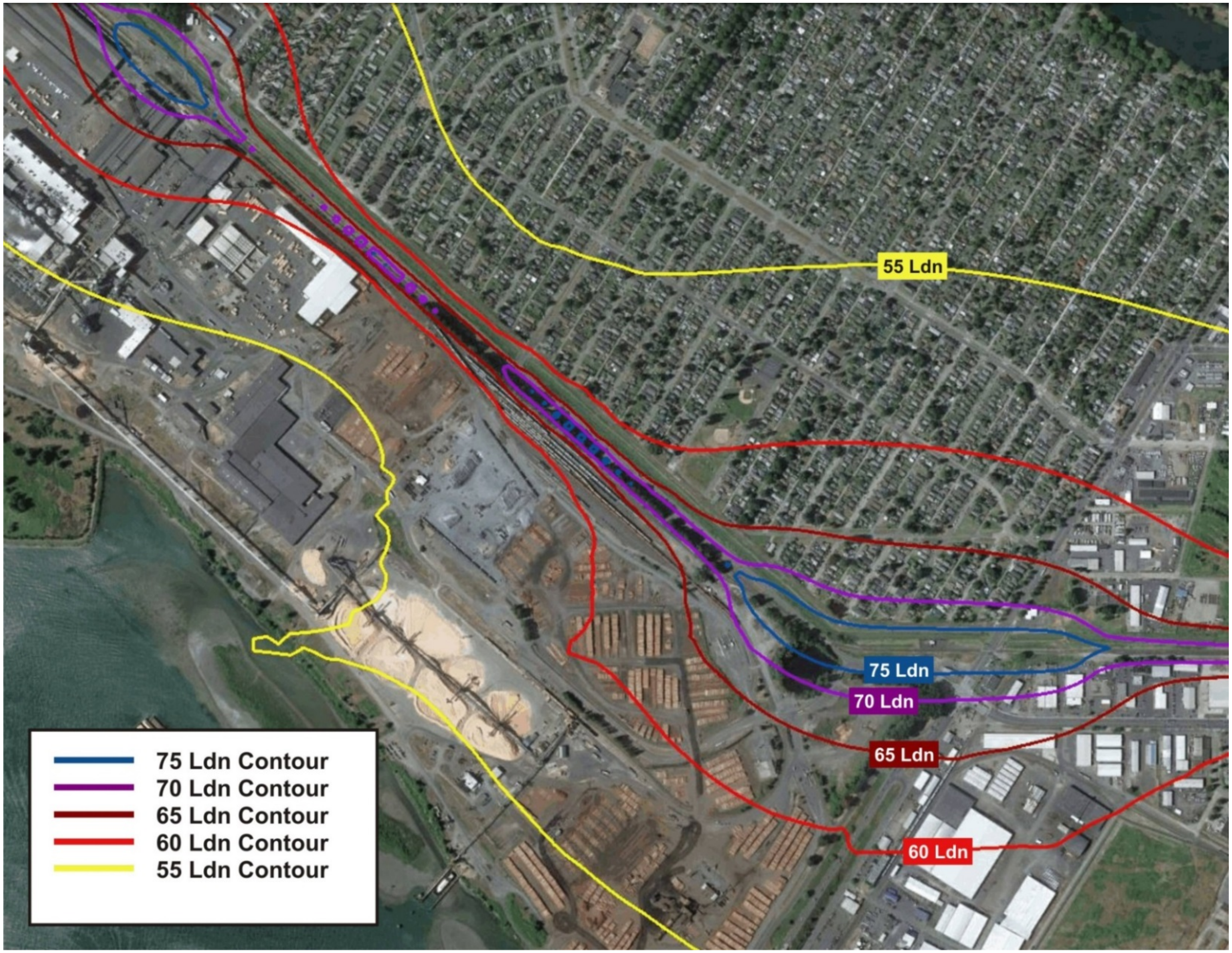


Figure 15. Noise Contours for Proposed Action 2028 Rail Traffic, End of Reynolds Lead, Including Train Horns

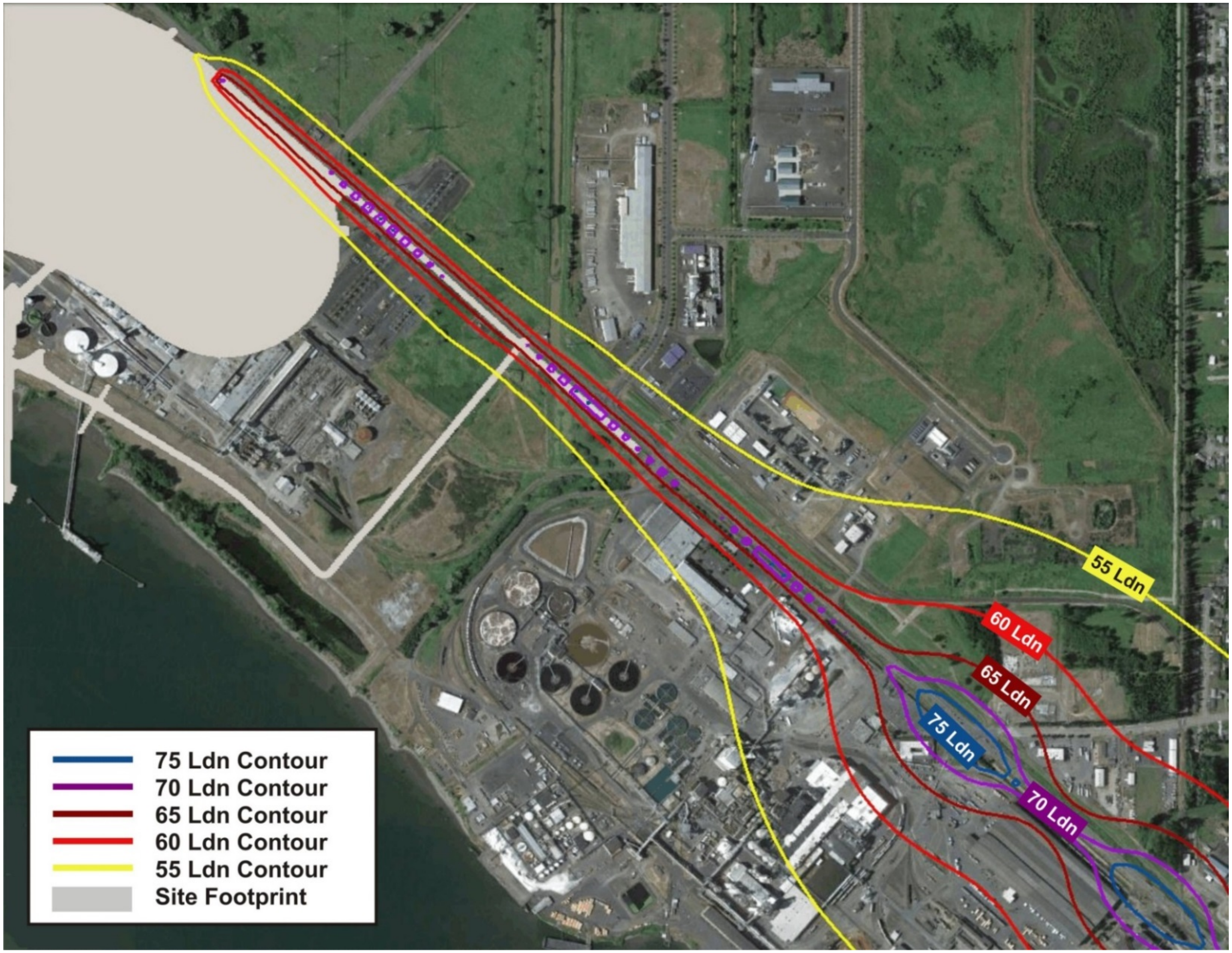


Table 19 lists the results of the noise impact assessment per the guidelines established by the FTA/FRA guidance at each ambient survey location for trains traveling to and from the project area. The table lists the following.

- L_{dn} existing noise exposure (based on the ambient noise study results presented in Chapter 2)
- L_{dn} predicted existing noise exposure
- L_{dn} levels representative of all other sources of noise not related to trains (decibel subtracted)
- L_{dn} predicted for the No-Action Alternative trains alone
- L_{dn} for total noise exposure (Proposed Action-Related trains, plus No-Action Alternative trains, plus all other sources of noise not related to trains)
- Net increase in noise exposure
- The thresholds of moderate and severe impact

Impact determination at each survey location per the moderate and severe thresholds established according to FTA/FRA guidance. The net increase is determined relative to the estimated future ambient level (2028 No-Action Alternative trains plus all other sources of noise not related to trains).

Table 19. 2028 Noise Impact Assessment with Proposed Action-Related Rail Traffic

Location	Distance to Track (feet)	Measured Existing Level, L_{dn} (dBA)	Existing Trains, L_{dn} (dBA)	Ambient All Other Sources, L_{dn} (dBA)	No Action Trains, L_{dn} (dBA)	Project Trains, L_{dn} (dBA)	Total Noise, L_{dn} (dBA)	Increase (dBA)	MI Threshold	SI Threshold	Impact Type
N1, 602 California Way	171	76	66	76	66	75	79	2.5	0.3	2.1	**SI**
N1s, 605 California Way	146	76	64	76	65	74	78	2.1	0.3	2.1	**MI**
N2, 111 15th Avenue	212	74	57	74	58	70	75	1.5	0.5	2.3	**MI**
N2s-a, 111 15th Avenue	189	73	56	73	57	69	74	1.4	0.6	2.4	**MI**
N2s-b, 111 15th Avenue	212	71	56	71	56	68	73	1.6	1.0	2.6	**MI**
N2s-c, 139 15th Avenue	313	76	65	76	66	74	78	2.0	0.3	2.1	**MI**
N2s-d, 151 15th Avenue	416	73	65	72	65	73	76	2.9	0.6	2.4	**SI**
N2s-e, 163 15th Avenue	522	73	65	72	65	73	76	2.9	0.6	2.4	**SI**
N3, 221 Beech St at Alder	252	71	62	70	62	70	74	2.7	1.0	2.6	**SI**
N3s-a, 221-227 Beech St	256	70	60	70	60	69	72	2.3	1.0	2.8	**MI**
N3s-b, 221-227 Beech St	363	70	58	70	58	67	72	1.7	1.0	2.8	**MI**
N3s-c, 255 Beech Street	458	71	48	71	50	59	71	0.3	1.0	2.6	NI
N4, 875 34th Avenue	1,838	71	49	71	50	59	71	0.3	1.0	2.6	NI
N4s, 875 34th Avenue	1,838	68	48	68	49	58	68	0.4	1.2	3.1	NI
N5, 3600 Memorial Park Dr	4,018	63	48	63	49	57	64	1.0	1.6	4.1	NI
N5s, 3600 Memorial Park Dr	3,936	63	46	63	46	54	64	0.5	1.6	4.1	NI

Location	Distance to Track (feet)	Measured Existing Level, L_{dn} (dBA)	Existing Trains, L_{dn} (dBA)	Ambient All Other Sources, L_{dn} (dBA)	No Action Trains, L_{dn} (dBA)	Project Trains, L_{dn} (dBA)	Total Noise, L_{dn} (dBA)	Increase (dBA)	MI Threshold	SI Threshold	Impact Type
N6, 420 Rutherglen Dr	3,021	63	46	63	46	54	64	0.5	1.6	4.1	NI
N6s, 420 Rutherglen Dr	3,071	66	38	66	39	47	66	0.1	1.3	3.4	NI
N7, 4723 Mount Solo Road	5,459	66	38	66	39	47	66	0.1	1.3	3.4	NI
N7s, 4723 Mt. Solo Road	5,459	62	45	62	46	53	63	0.6	1.7	4.4	NI
N8, 1719 Dorothy Avenue	4,511	62	45	62	46	53	63	0.6	1.7	4.4	NI
N8s, 1715 Dorothy Avenue	4,457	68	24	68	25	42	68	0.0	1.2	3.1	NI
S1, 3128 Louisiana Street	5,443	68	24	68	25	42	68	0.0	1.2	3.1	NI
S2, 3007 Hemlock Street	4,306	61	39	61	39	48	61	0.2	1.9	4.7	NI
S3, 2642 Field Street	4,824	61	39	61	39	48	61	0.2	1.9	4.7	NI
S4, 30th Avenue	2,595	71	38	71	38	47	71	0.0	1.0	2.6	NI
S5, St Rose de Viterbo	4,426	71	40	71	40	49	71	0.0	1.0	2.6	NI
S6, 540 23rd Road	3,207	68	40	68	40	49	68	0.1	1.2	3.1	NI
S7, 645 15th Avenue	3,281	73	43	73	43	52	73	0.0	0.6	2.4	NI
S8, 23rd Ave/Industrial Way	252	70	40	70	41	50	70	0.0	1.0	2.8	NI
S9, 410 15th Avenue	1,669	55	43	55	43	52	57	1.8	3.1	7.1	NI
S10, Alder Street	261	77	43	77	44	53	77	0.0	0.3	2.1	NI
S11, 427 28th Avenue	1,970	67	50	67	51	60	68	0.9	1.2	3.2	NI
S12, 3297 Ocean Bch Hwy	5,988	71	48	71	49	58	71	0.2	1.0	2.6	NI

Notes:

[a] Impact determinations of moderate or severe are established per Federal Transit Administration (2006) and Federal Railroad Administration (2012) guidelines

L_{dn} = day-night equivalent; dBA = A-weighted decibel; NI = No Impact; MI = Moderate Impact; SI = Severe Impact

Figure 16 indicates the properties that would be expected to have moderate to severe noise impacts from Proposed Action-Related rail traffic. The impacts would be the same with or without the track improvements because the train noise would be dominated by the locomotive horn sounding at the grade crossings. Increased noise from locomotive or car traffic alone (without horn sounding) would not result in noise impacts based on the FTA/FRA guidance. This applies for train speeds of 10 or 20 miles per hour.

Figure 16. Noise Impacts from Proposed Action-Related Rail Traffic

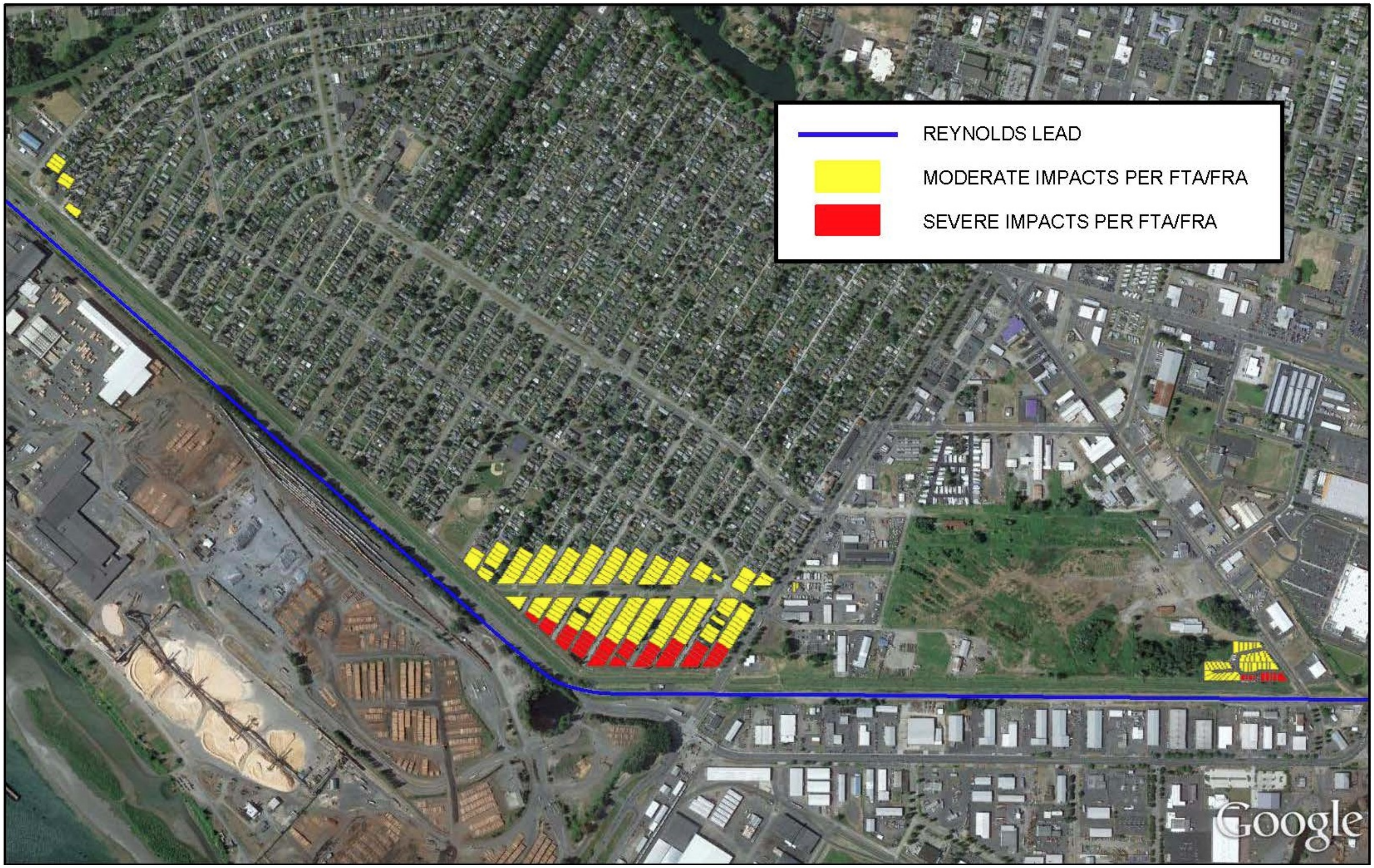


Table 20 summarizes the number of affected noise-sensitive receptors predicted near each grade crossing. Some of the properties that may be affected are multifamily residences. The number of single residential units that could be affected at each multifamily residence was estimated using online satellite and street photography.

Table 20. Indirect Noise Impacts from Proposed Action-Related Trains

	Estimated Number of Receptors	
Grade Crossing	**Moderate Impact**	**Severe Impact**
3rd Avenue & California Way	34 mobile homes	10 mobile homes
Oregon Way & Industrial Way	2 mobile homes 133 single-family 18 multifamily[a]	34 single family 5 multifamily[c]
Driveway near Douglas Street & Washington Way	4 single family 2 multifamily[b]	0
Total Properties	**193**	**49**

Notes:
[a] Estimated 52 individual residences affected
[b] Estimated 4 individual residences affected
[c] Estimated 16 individual residences affected

Emit Noise and Vibration from Operations-Related Road Traffic

A potential source of noise impacts related to operations would be automobile and truck traffic traveling to and from the project area, mainly on Industrial Way. As discussed in the SEPA Vehicle Transportation Technical Report (ICF International and DKS Associates 2016), the annual ADT on Industrial Way is projected be approximately 11,450 without the Proposed Action, and 12,100 with the Proposed Action, representing 5.7% increase in ADT for all vehicles. In general, changes in a noise level of less than 3 dBA are not typically noticed by the human ear. A doubling of traffic volume (i.e., a 100% increase) would be required to increase the L_{dn} from road traffic by 3 dBA at the noise sensitive receptors. The increase in vehicle traffic represents an increase of 5.6% in ADT for all vehicles on Industrial Way. This increase in vehicular traffic would not result in a material significant change in noise levels. Therefore, no noise or vibration impact related to operations traffic would be anticipated.

Emit Noise from Vessel Operations

For ships moored at the project area docks, the noise associated with stationary vessels is estimated to be 29 dBA at the closest noise-sensitive receptors on Mt. Solo Road, approximately 3,800 feet away. This accounts only for sound attenuation with distance from the source. The estimated Proposed Action-Related ship noise would be comparable to or less than ambient noise levels at this noise-sensitive receptor. Therefore, noise from river vessels associated with the Proposed Action would not cause a noise impact at noise-sensitive receptors.

For vessels under way, ship traffic is expected to be 70 ships per month during full operation in 2028. This corresponds to daily traffic of 4.66 ships per day. The noise-sensitive receptors on Barlow Point Road are all more than 400 feet from the edge of the Columbia River. Online satellite imagery indicates that a typical minimum distance between these receptors and vessels navigating the Columbia River would be about 1,600 feet. The corresponding L_{dn}, corrected to the 1,600-foot distance, would be 32 $L_{dn.}$ Other receptors are at substantially greater distances. The estimated noise exposure from Proposed Action-Related ship traffic would be comparable or less than ambient noise levels at the noise sensitive receivers and would, therefore, not result in any noise impacts at the receivers. Table 21 summarizes the potential L_{dn} from Proposed Action 2028 vessel traffic at various perpendicular distances from the Columbia River navigational channel. The estimated noise exposure from Proposed Action-Related ship traffic would be comparable to or less than ambient noise levels at noise sensitive receivers and is unlikely to cause noise impacts along the Columbia River.

Table 21. Potential Noise Exposure Levels from Vessel Traffic at Various Perpendicular Distances from the Columbia River Navigational Channel

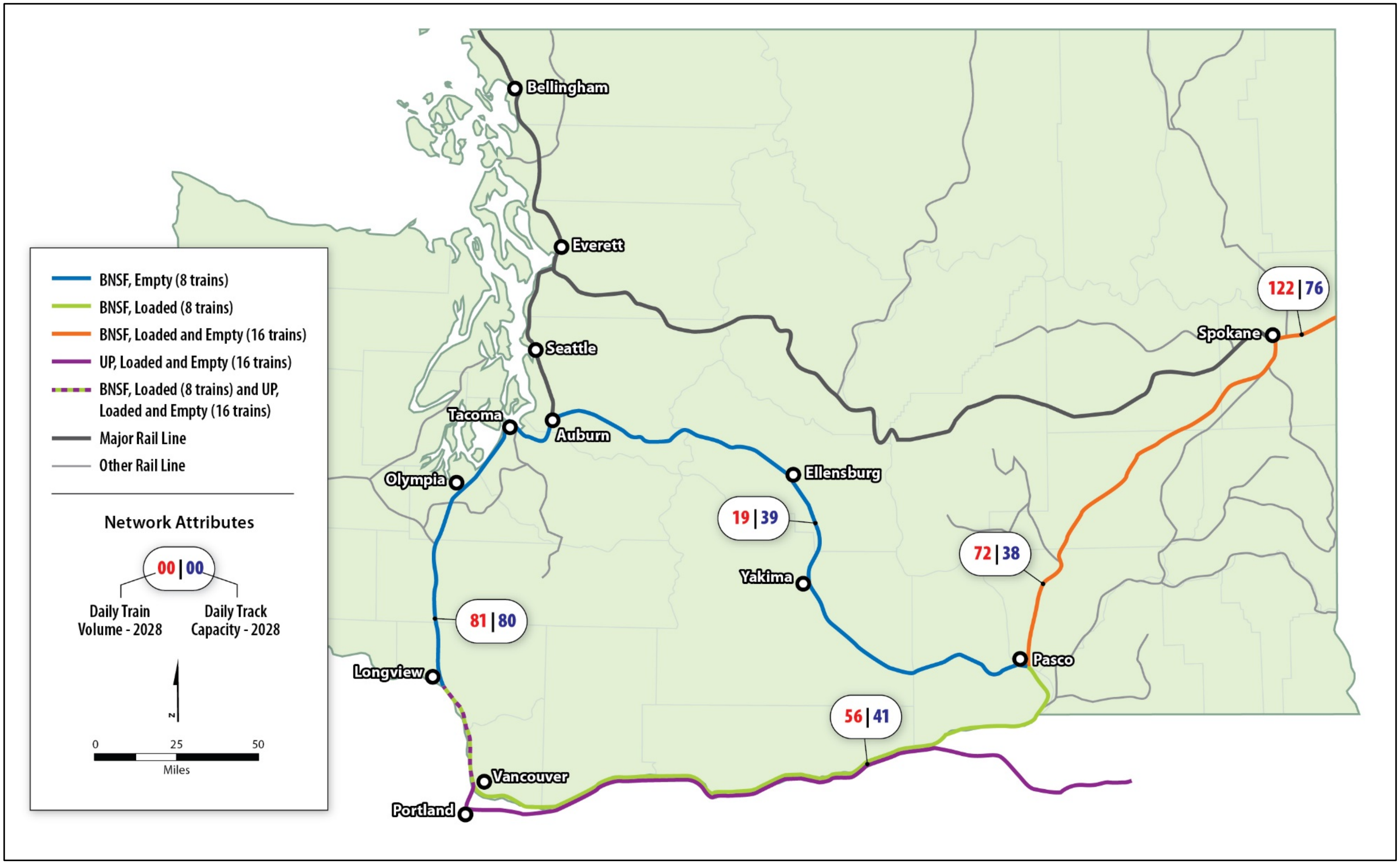
Distance (feet)	L_{dn}
400	44
600	40
800	38
1000	36
1200	34
1400	33
1600	32

With respect to foghorn noise, a foghorn was recorded from Barlow Road. It sounded for approximately 4 seconds every 2 minutes and achieved a maximum noise level of 60 dBA at its point of closest approach to the measurement location (approximately 1,800 feet). These noise levels represent the highest foghorn sound levels to which noise-sensitive receptors on Barlow Point Road are exposed. The levee that runs between the Columbia River and Barlow Point Road interrupts the line of sight between the receptors and vessels under way in the river, and therefore, serves to some extent as a sound barrier. The exception is the noise-sensitive receptor at 274 Barlow Point Road, which sits on top of the dike and has a clear view of the river. The next-closest receptors along Mt. Solo Road are at a distance of 4,000 feet or more from the middle of the river. Noise from foghorns is infrequent and is not expected to cause any noise impacts at the noise-sensitive receivers.

Emit Noise from Rail Traffic beyond Longview Junction

At full operation, the coal export terminal would add 8 loaded and 8 empty trains per day (16 total trains per day) to the rail network in Washington State beyond Longview Junction. As described in the SEPA Rail Transportation Technical Report (ICF International and Hellerworx 2016), the rail routes to the Longview area would are assumed to be the same as current BNSF and UP routes. Loaded trains would be expected to travel through Spokane and Pasco along BNSF's Fallbridge Subdivision to Vancouver, Washington. From there, loaded trains would likely move north on BNSF's Seattle Division main line north to Longview Junction. Empty trains would likely move from Longview Junction north on BNSF's Seattle Division main line to Auburn, Washington. From Auburn, trains would likely move east over BNSF's Stampede and Yakima Valley Subdivisions to Pasco, Washington. From Pasco, empty trains would move over the same route as the loaded trains. Figure 17 illustrates the route of loaded and empty coal trains with estimated 2028 daily track volume, including Proposed Action-Related trains, and 2028 daily track capacity.

Figure 17. Washington Rail Network Daily Track Utilization, 2028 with Proposed Action-Related Train Traffic



Trains associated with the Proposed Action would travel at similar speeds as existing trains, and locomotives would sound horns consistent with existing practices. Therefore, the wayside and horn noise levels associated with any individual train trips would not change substantially compared to existing conditions. However, because the Proposed Action would result in more rail traffic, average noise levels would increase. Generally, in areas where existing noise levels are low (particularly at night), there is a greater likelihood that increased train traffic would result in more noticeable noise, particularly near grade crossings where trains are required to sound horns.

Table 22 provides a summary of existing train volumes, 2028 baseline train volumes, and 2028 train volumes with the Proposed Action. The table also provides a summary of the potential increase in train-related L_{dn} levels from the addition of Proposed Action-Related trains relative to baseline conditions.

In general, changes in a noise level of less than 3 dBA are not typically noticed by the human ear. As indicated in Table 22, the potential increase from Proposed Action-Related trains is less than 3 dBA on all routes to and from the project area. In most cases, the potential increase is less than 1 dBA, which is within the level of precision for acoustical measurements. Therefore, noise impacts from Proposed Action-Related trains on the routes to and from Longview would not be expected.

Table 22. 2028 Rail Traffic Volumes on BNSF and UP Routes to and from Longview, WA and Potential Increase in Noise Exposure from Proposed Action-Related Trains

	Trains per Day			
Route	**Existing**	**Projected Baseline 2028**	**Projected Baseline 2028 with Proposed Action**[a]	**L_{dn} Increase**
Idaho/Washington State Line-Spokane	70	106	122	0.6
Spokane-Pasco	39	56	72	1.1
Pasco-Vancouver	34	48	56	0.7
Vancouver-Longview Junction	50	73	81	0.5
Longview Junction-Auburn	50	73	81	0.5
Auburn-Pasco	7	11	19	2.4

Notes:
[a] Includes No Action volume plus Operations 2028 volume.

There is the potential that all Proposed Action-Related trains could travel through the Columbia River Gorge (16 trains per day). The analysis indicated that the increase in noise that would occur between Pasco and Longview Junction would range between 0.9 and 1.2 L_{dn}. Therefore, no adverse noise impacts from Proposed Action-Related trains would be expected if all trains traveled via the Columbia River Gorge and Vancouver.

3.1.2 No-Action Alternative

Under the No Action Alternative, the Applicant would not construct the coal export terminal and noise and vibration impacts related to construction and operation of the coal export terminal would not occur. The Applicant would continue with current and future increased operations in the project area. The project area could be developed for other industrial uses including an expanded bulk product terminal or other industrial uses. The Applicant has indicated that, over the long term, it would expand the existing bulk product terminal and develop new facilities to handle more products such as calcine petroleum coke, coal tar pitch, and cement, as described in the SEPA Alternatives Technical Report (ICF International 2016). The Applicant's planned growth would require approximately two additional trains per day on the Reynolds Lead.

The potential for changes in noise levels unrelated to the Proposed Action on the BNSF Spur and Reynolds Lead were analyzed for 2028. The analysis indicated that noise levels under the No-Action Alternative would be expected to be higher than under existing conditions but would not result in additional noise impacts based on FRA/FTA criteria. There would also be no vibration impacts as the closest receptors are too far away to experience significant vibration generated by the trains.

Figures 18 through 21 are plots of the equal L_{dn} noise levels from rail traffic related to the No-Action Alternative in 2028.

Figure 18. Noise Contours for No-Action Alternative 2028 Rail Traffic, BNSF Spur to Reynolds Lead, Including Train Horns

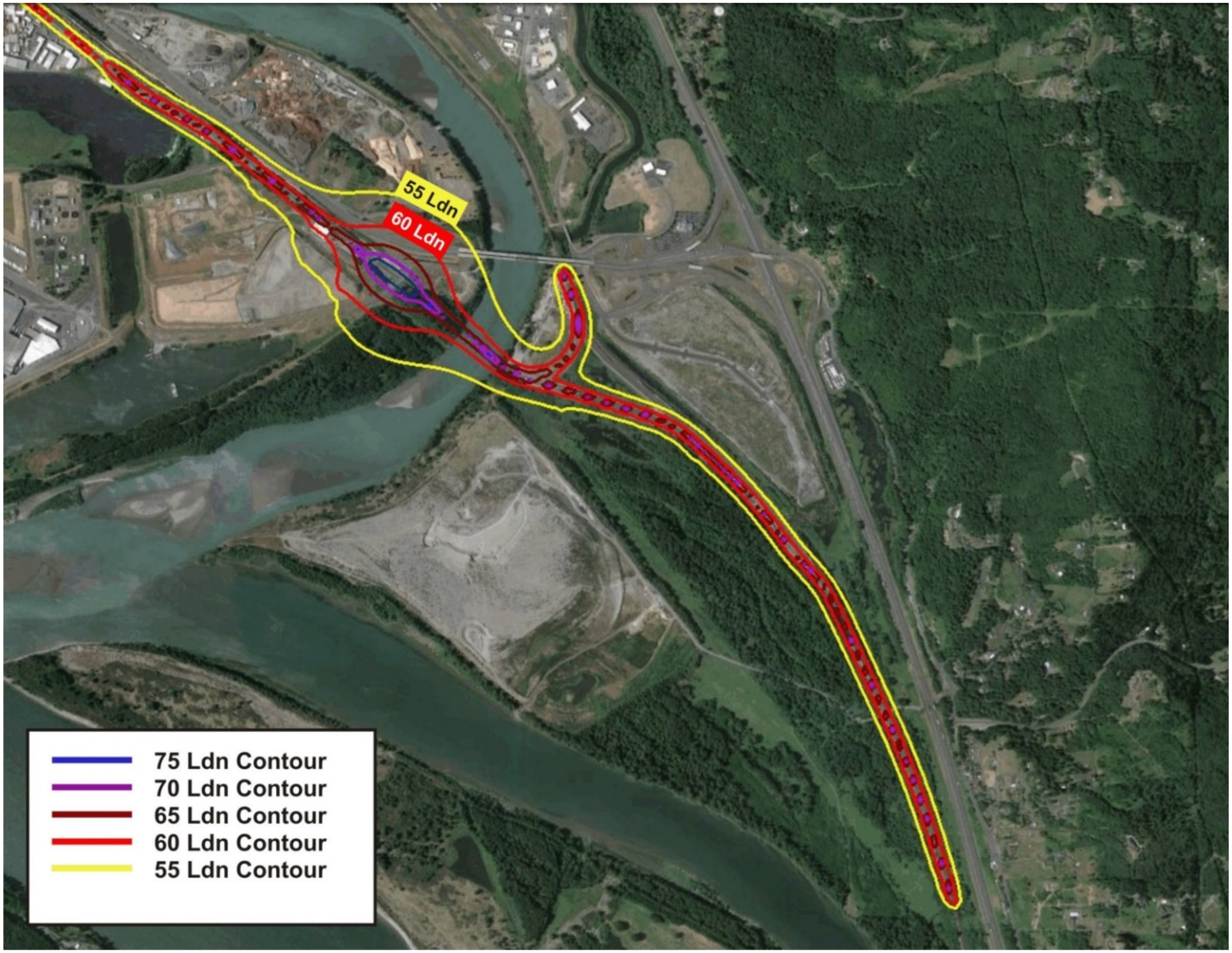


Figure 19. Noise Contours for No-Action Alternative 2028 Rail Traffic, Beginning of Reynolds Lead, Including Train Horns

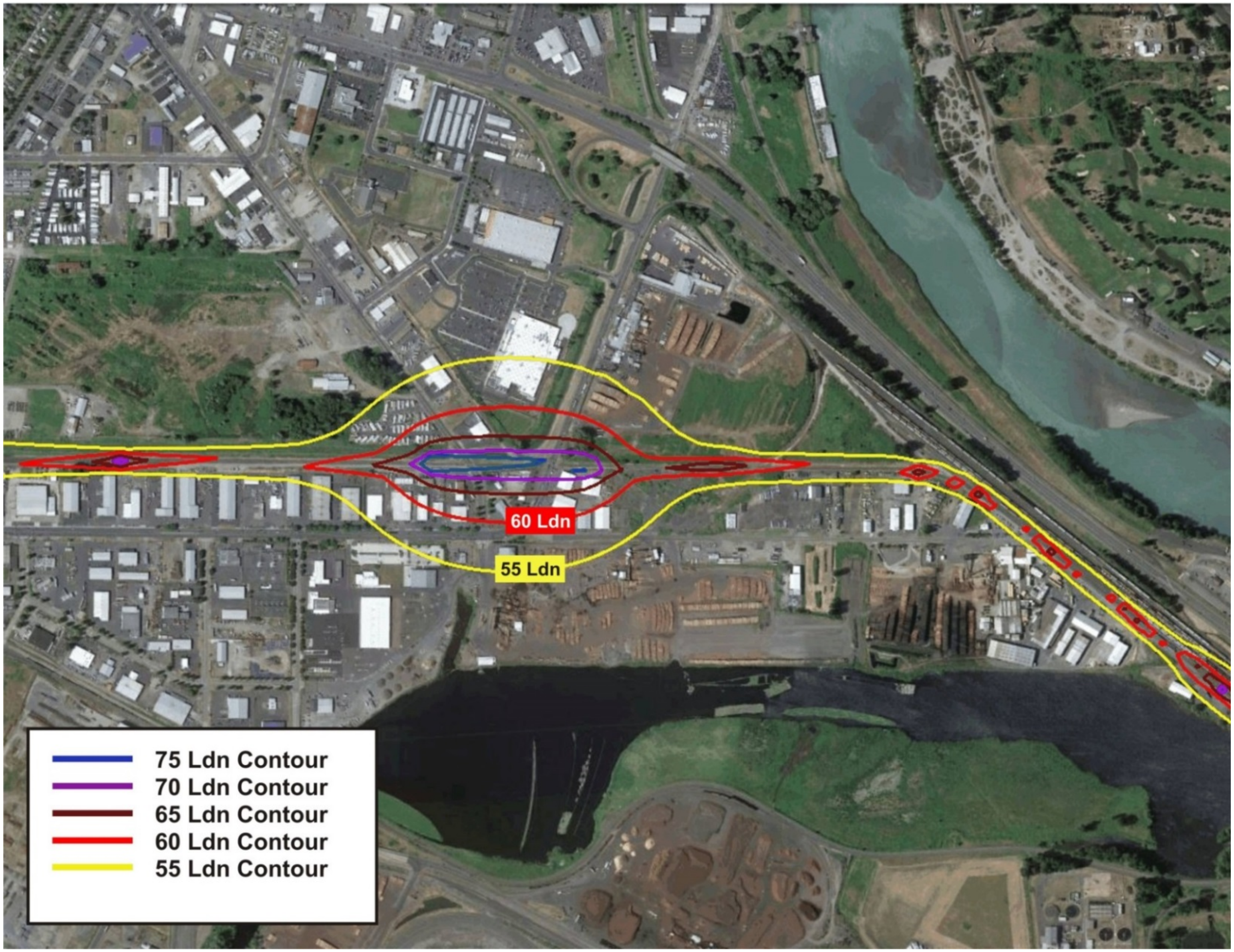


Figure 20. Noise Contours for No-Action Alternative 2028 Rail Traffic, Mid-Reynolds Lead, Including Train Horns

Figure 21. Noise Contours for No-Action Alternative 2028 Rail Traffic, End of Reynolds Lead, Including Train Horns

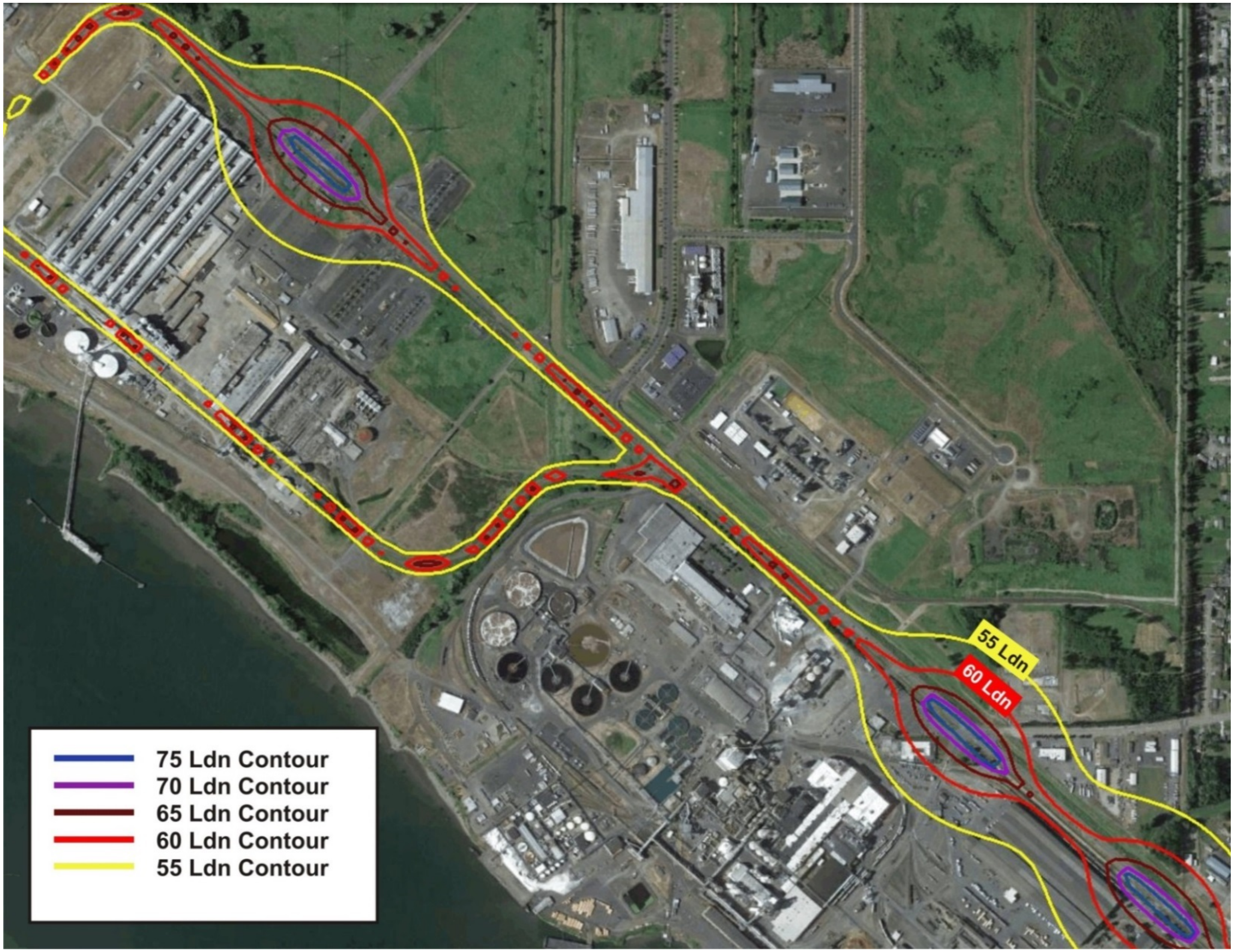


Table 23 lists the results of the noise impact assessment per the guidelines established by the FTA/FRA guidance at each ambient survey location. The table illustrates the net increase relative to the existing noise exposure based on the ambient noise study results.

Table 23. Noise Impact Assessment for No-Action Alternative, 2028 Rail Traffic

Location	Distance to Track (feet)	Measured Existing Level, L_{dn} (dBA)	Existing Trains, L_{dn} (dBA)	Ambient All Other Sources, L_{dn} (dBA)	No Action Trains, L_{dn} (dBA)	Project Trains, L_{dn} (dBA)	Total Noise, L_{dn} (dBA)	Increase (dBA)	MI Threshold[a]	SI Threshold[a]	Impact Type
N1, 602 California Way	171	76	66	76	66	n/a	76	0.0	0.3	2.1	NI
N1s, 605 California Way	146	76	64	76	65	n/a	76	0.0	0.3	2.1	NI
N2, 111 15th Avenue	212	74	57	74	58	n/a	74	0.0	0.5	2.3	NI
N2s-a, 111 15th Avenue	189	73	56	73	57	n/a	73	0.0	0.6	2.4	NI
N2s-b, 111 15th Avenue	212	71	56	71	56	n/a	71	0.0	1.0	2.6	NI
N2s-c, 139 15th Avenue	313	76	65	76	66	n/a	76	0.0	0.3	2.1	NI
N2s-d, 151 15th Avenue	416	73	65	72	65	n/a	73	0.1	0.6	2.4	NI
N2s-e, 163 15th Avenue	522	73	65	72	65	n/a	73	0.1	0.6	2.4	NI
N3, 221 Beech St at Alder	252	71	62	70	62	n/a	71	0.1	1.0	2.6	NI
N3s-a, 221-227 Beech St	256	70	60	70	60	n/a	70	0.0	1.0	2.8	NI
N3s-b, 221-227 Beech St	363	70	58	70	58	n/a	70	0.0	1.0	2.8	NI
N3s-c, 255 Beech Street	458	71	48	71	50	n/a	71	0.0	1.0	2.6	NI
N4, 875 34th Avenue	1,838	71	49	71	50	n/a	71	0.0	1.0	2.6	NI
N4s, 875 34th Avenue	1,838	68	48	68	49	n/a	68	0.0	1.2	3.1	NI
N5, 3600 Memorial Park Dr	4,018	63	48	63	49	n/a	63	0.0	1.6	4.1	NI
N5s, 3600 Memorial Park Dr	3,936	63	46	63	46	n/a	63	0.0	1.6	4.1	NI
N6, 420 Rutherglen Dr	3,021	63	46	63	46	n/a	63	0.0	1.6	4.1	NI
N6s, 420 Rutherglen Dr	3,071	66	38	66	39	n/a	66	0.0	1.3	3.4	NI
N7, 4723 Mount Solo Road	5,459	66	38	66	39	n/a	66	0.0	1.3	3.4	NI
N7s, 4723 Mt. Solo Road	5,459	62	45	62	46	n/a	62	0.0	1.7	4.4	NI
N8, 1719 Dorothy Avenue	4,511	62	45	62	46	n/a	62	0.0	1.7	4.4	NI
N8s, 1715 Dorothy Avenue	4,457	68	24	68	25	n/a	68	0.0	1.2	3.1	NI
S1, 3128 Louisiana Street	5,443	68	24	68	25	n/a	68	0.0	1.2	3.1	NI
S2, 3007 Hemlock Street	4,306	61	39	61	39	n/a	61	0.0	1.9	4.7	NI
S3, 2642 Field Street	4,824	61	39	61	39	n/a	61	0.0	1.9	4.7	NI
S4, 30th Avenue	2,595	71	38	71	38	n/a	71	0.0	1.0	2.6	NI
S5, St Rose de Viterbo	4,426	71	40	71	40	n/a	71	0.0	1.0	2.6	NI
S6, 540 23rd Road	3,207	68	40	68	40	n/a	68	0.0	1.2	3.1	NI
S7, 645 15th Avenue	3,281	73	43	73	43	n/a	73	0.0	0.6	2.4	NI

Location	Distance to Track (feet)	Measured Existing Level, L_{dn} (dBA)	Existing Trains, L_{dn} (dBA)	Ambient All Other Sources, L_{dn} (dBA)	No Action Trains, L_{dn} (dBA)	Project Trains, L_{dn} (dBA)	Total Noise, L_{dn} (dBA)	Increase (dBA)	MI Threshold[a]	SI Threshold[a]	Impact Type
S8, 23rd Ave/Industrial Way	252	70	40	70	41	n/a	70	0.0	1.0	2.8	NI
S9, 410 15th Avenue	1,669	55	43	55	43	n/a	55	0.0	3.2	7.1	NI
S10, Alder Street	261	77	43	77	44	n/a	77	0.0	0.3	2.0	NI
S11, 427 28th Avenue	1,970	67	50	67	51	n/a	67	0.0	1.2	3.2	NI
S12, 3297 Ocean Bch Hwy	5,988	71	48	71	49	n/a	71	0.0	1.0	2.6	NI

Notes:

[a] Impact determinations of moderate or severe are established per Federal Transit Administration (2006) and Federal Railroad Administration (2012) guidelines

L_{dn} = day-night equivalent; dBA = A-weighted decibel; NI = No Impact; MI = Moderate Impact; SI = Severe Impact

3.2 Mitigation

Based on the findings in this technical report, the co-lead agencies (Cowlitz County and the Washington State Department of Ecology) developed potential Applicant mitigation measures. In addition, the Applicant has committed to voluntary measures to mitigate potential impacts. The SEPA Draft Environmental Impact Statement presents these mitigation measures.

Chapter 4
Required Permits

No permits specific to noise or vibration would be required for construction and operation of the Proposed Action.

Chapter 5
References

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Appendix A

Existing Ambient Sound Pressure Level Survey Data

Appendix A
Existing Ambient Sound Pressure Level Survey Data

Figures A-1 through Figure A-8 provide plots of the hourly equivalent sound level (L_{eq}) for each full day of measurements at eight long-term ambient survey locations (N1 through N8). Figures A-9 through Figure A-60 provide plots of the hourly Statistical sound pressure levels (SPL) for each 24-hour period of measurement at all eight locations (N1 through N8).

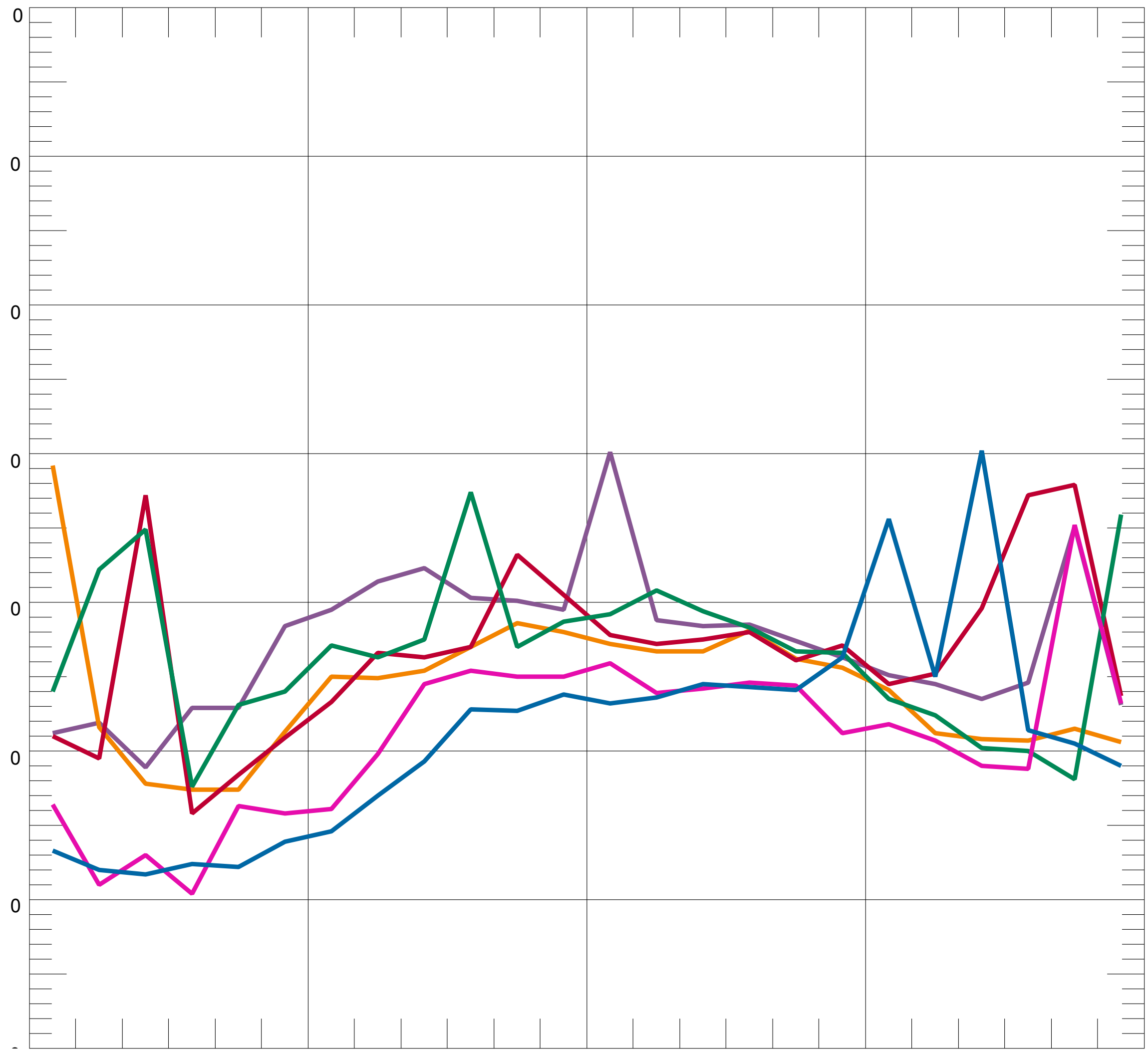

Figure A-1. Location N1, 602 California Way, Longview, WA, hourly L_{eq}

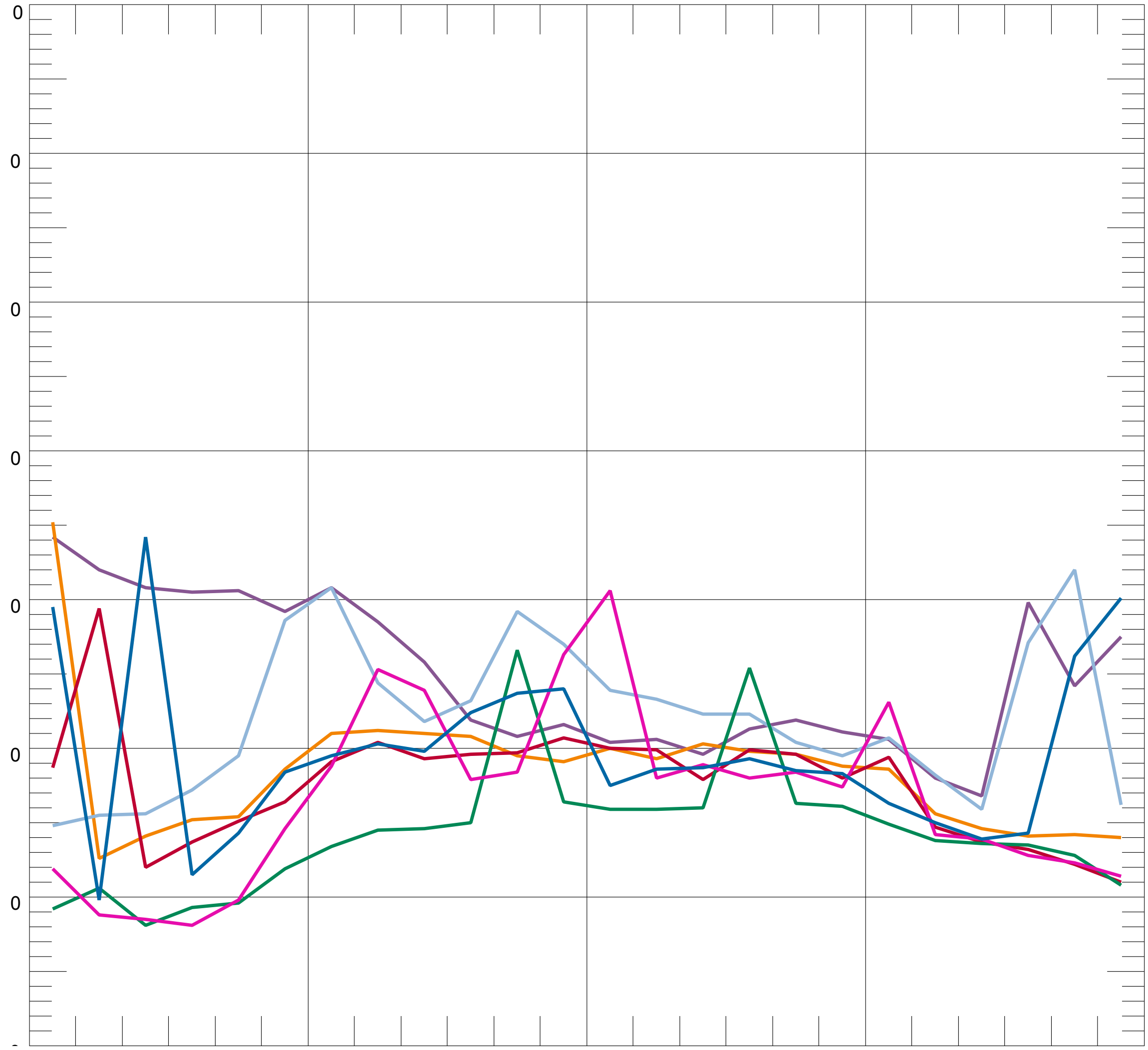

Figure A-2. Location N2, 111-15th Avenue, Longview, WA, hourly L_{eq}

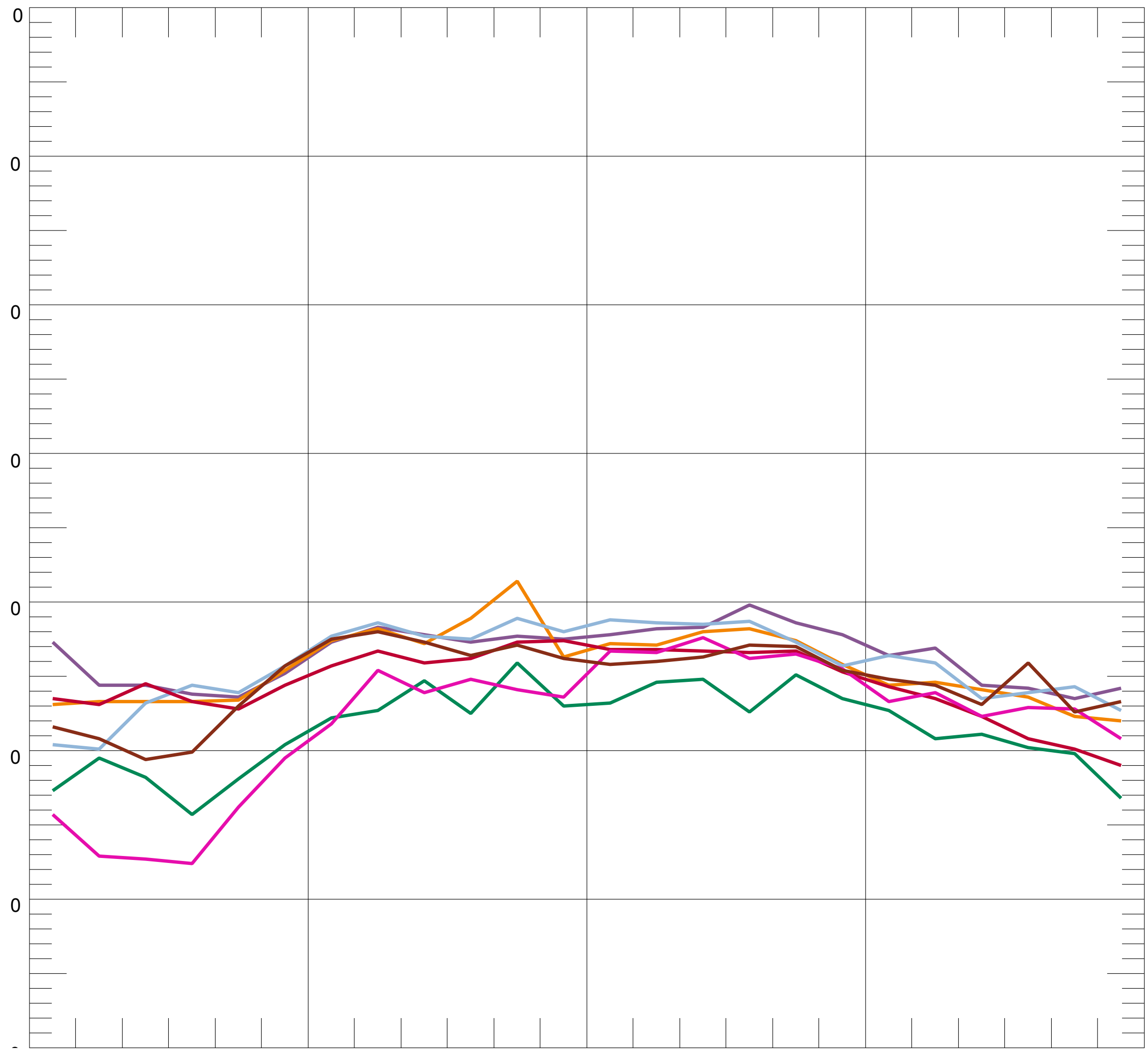

Figure A-3. Location N3, 221 Beech Street, Longview, WA, hourly L_{eq}

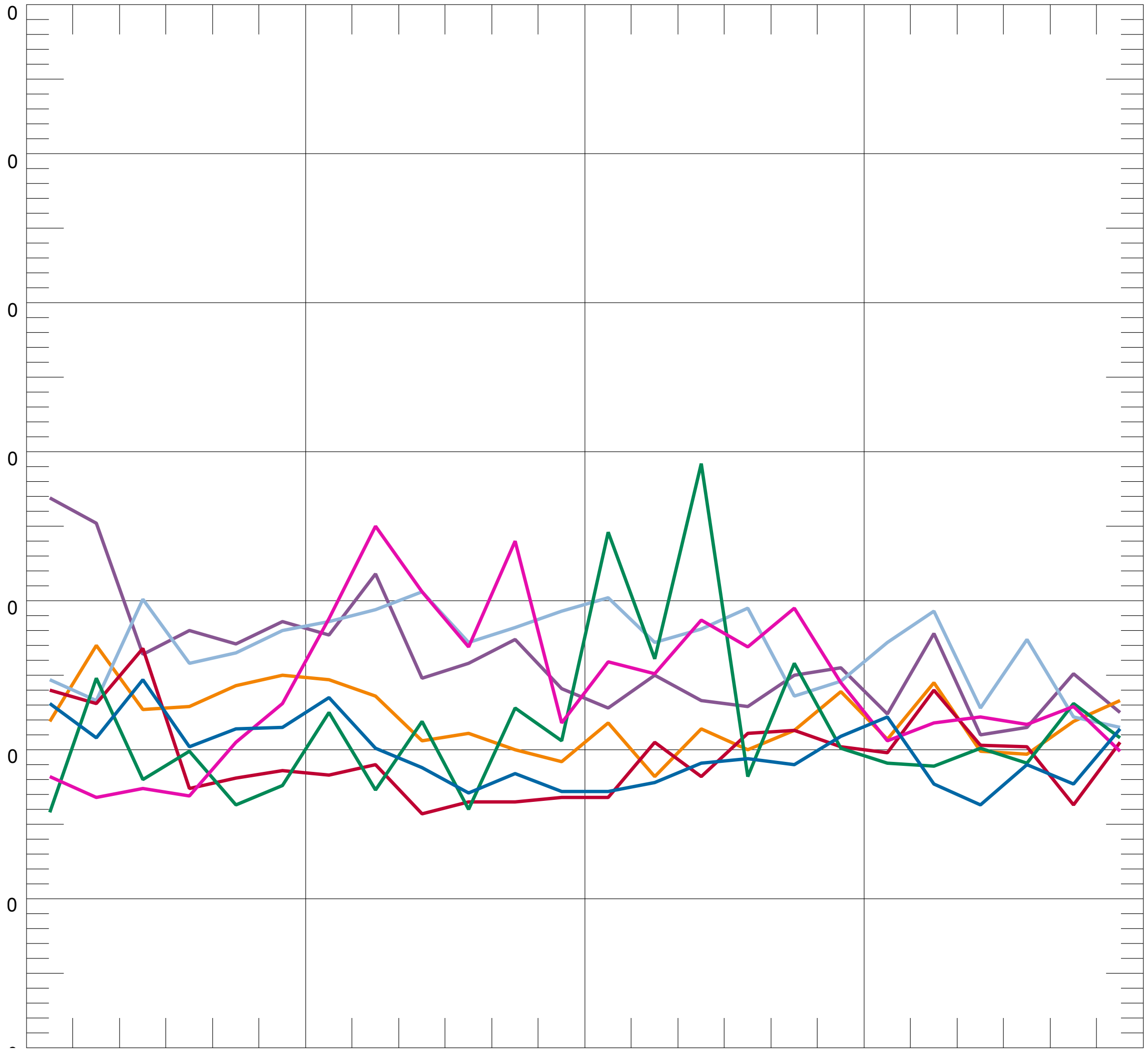

Figure A-4. Location N4, 875-34th Avenue, Longview, WA, hourly L_{eq}

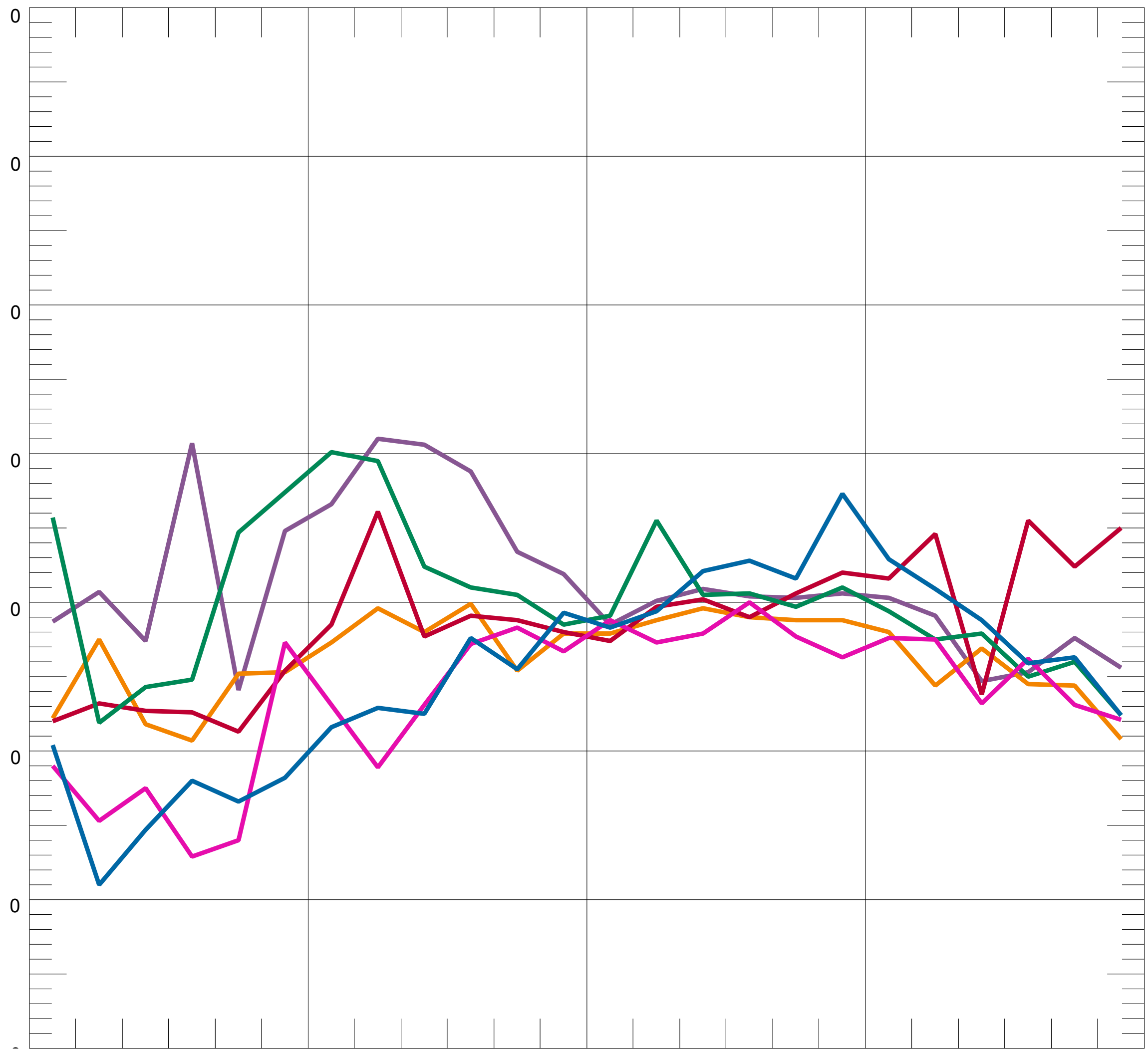

Figure A-5. Location N5, 3600 Memorial Park Drive, Longview, WA, hourly L_{eq}

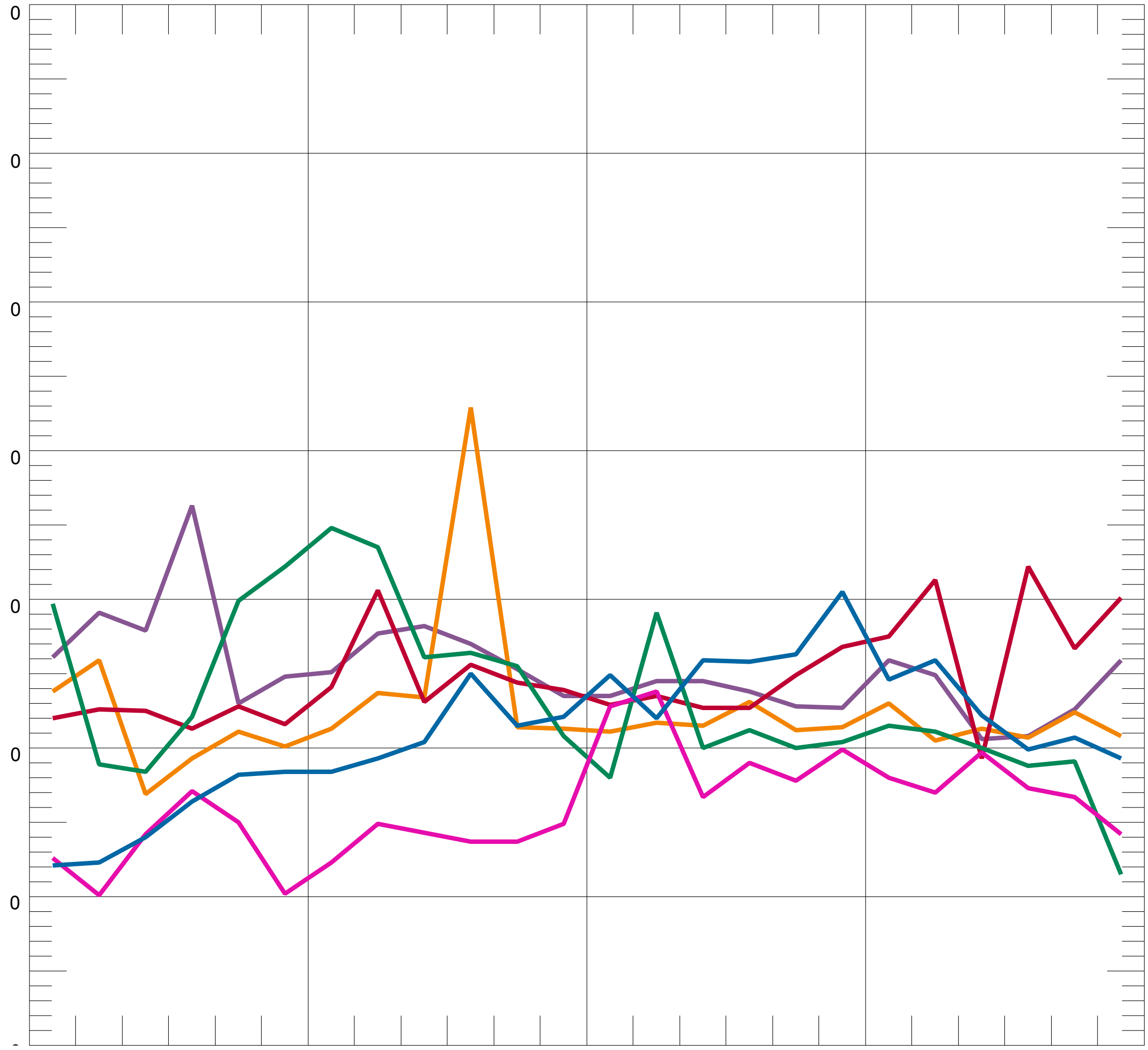

Figure A-6. Location N6, 420 Rutherglen Drive, Longview, WA, hourly L_{eq}

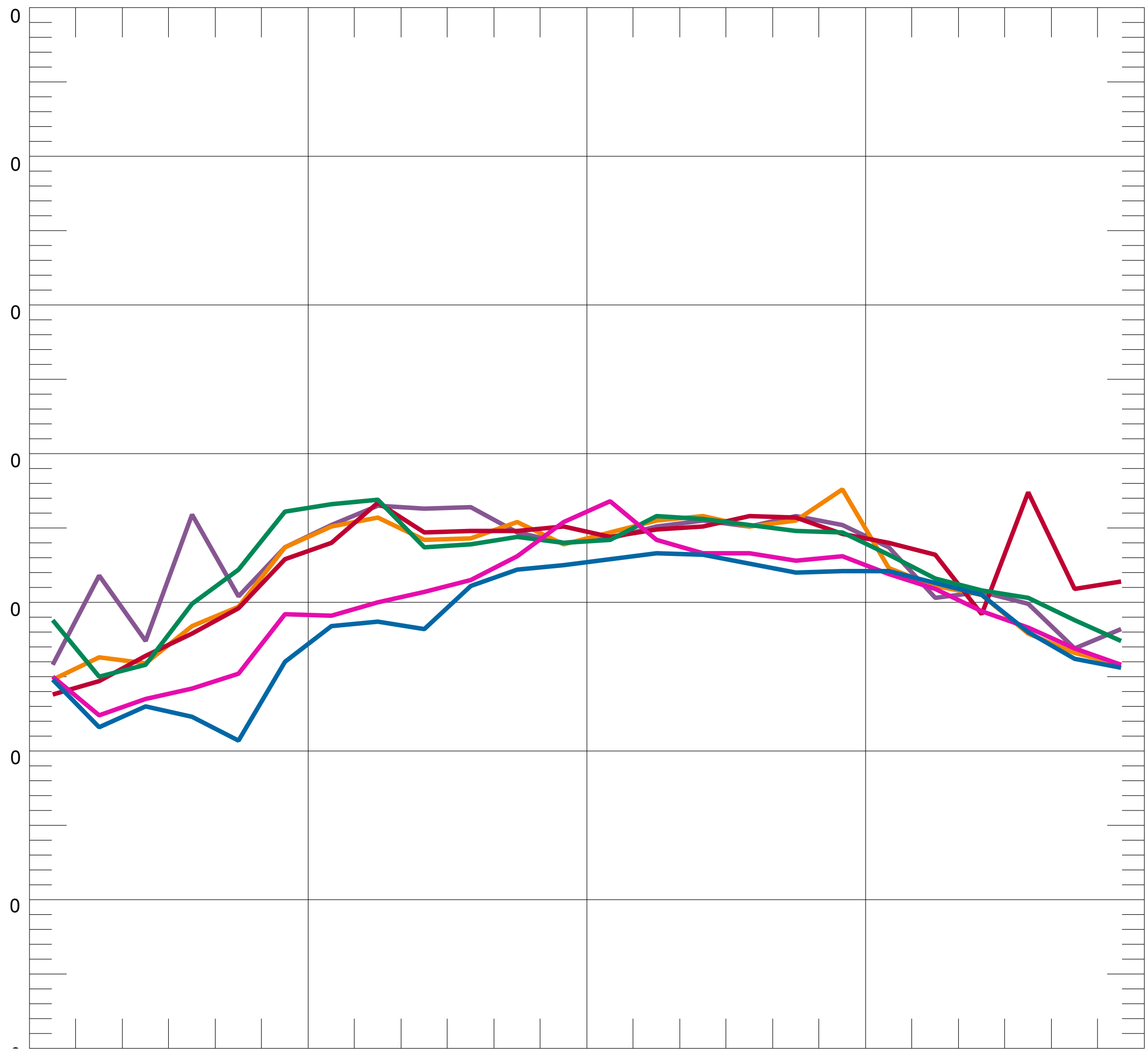

Figure A-7. Location N7, 4723 Mount Solo Road, Longview, WA, hourly L_{eq}

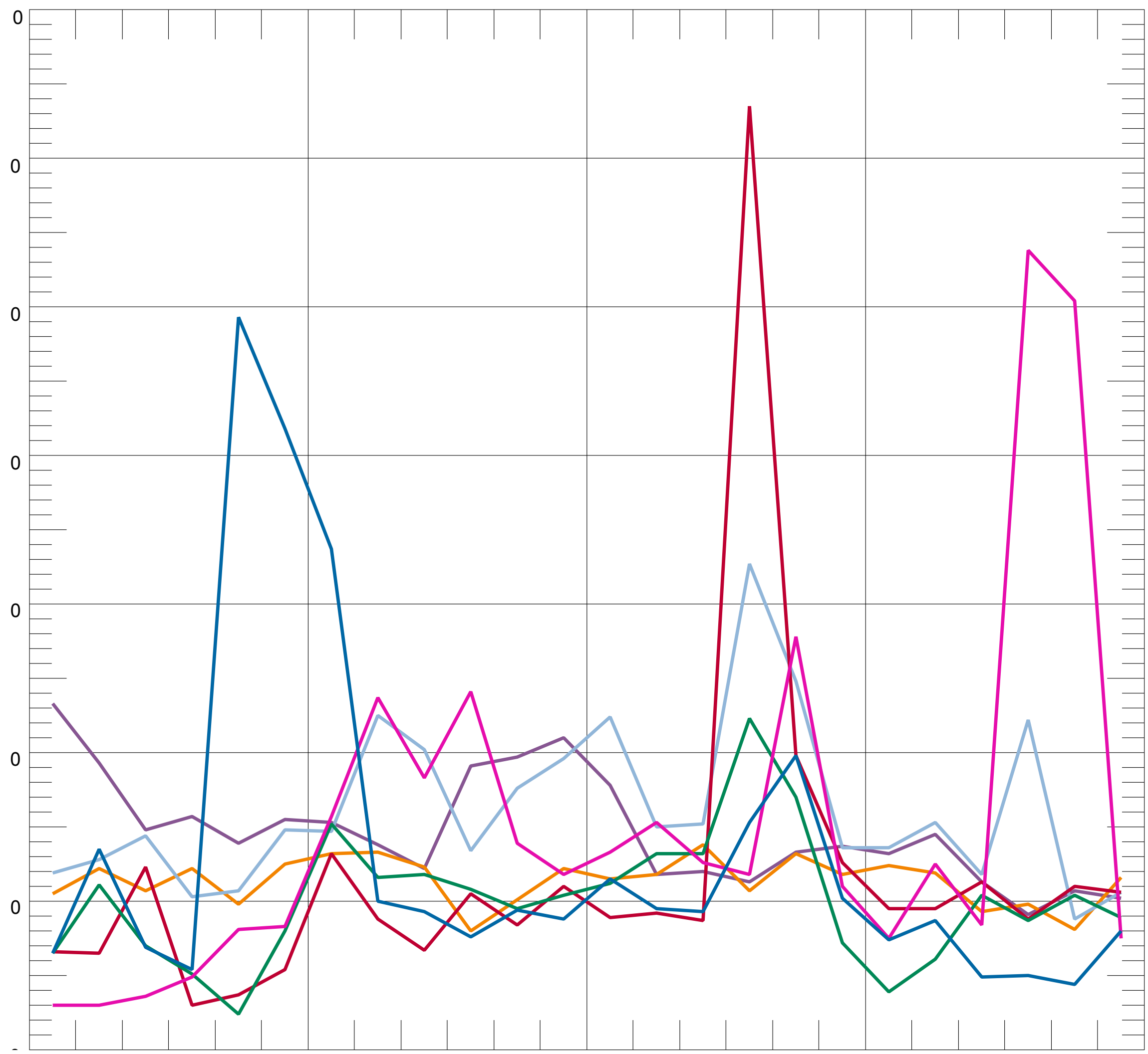

Figure A-8. Location N8, 1719 Dorothy Avenue, Longview, WA, hourly L_{eq}

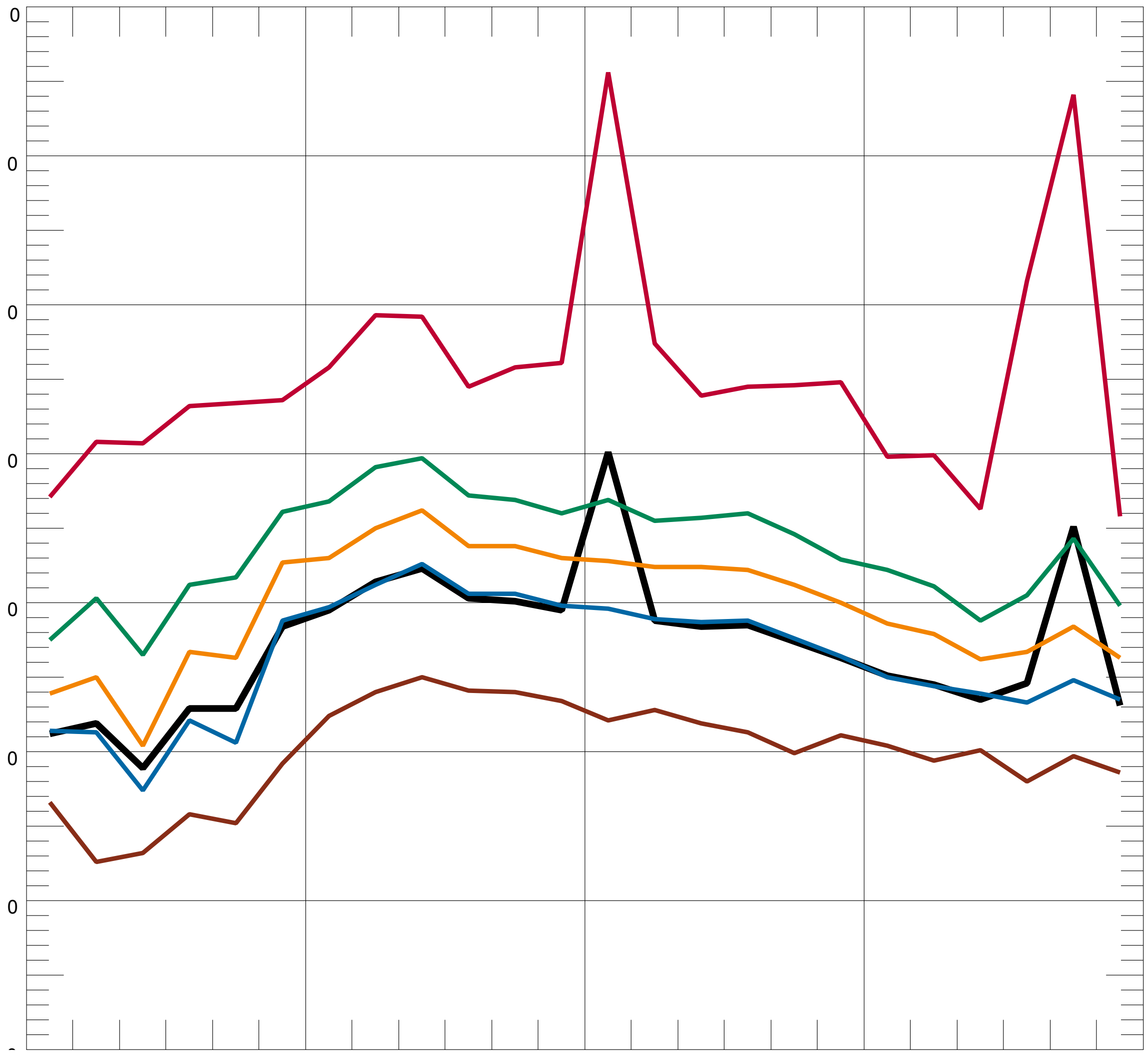

Figure A-9. Hourly Statistical Summary of Noise Levels on Oct 28, 2014 Location N1, 602 California Way, Longview, WA

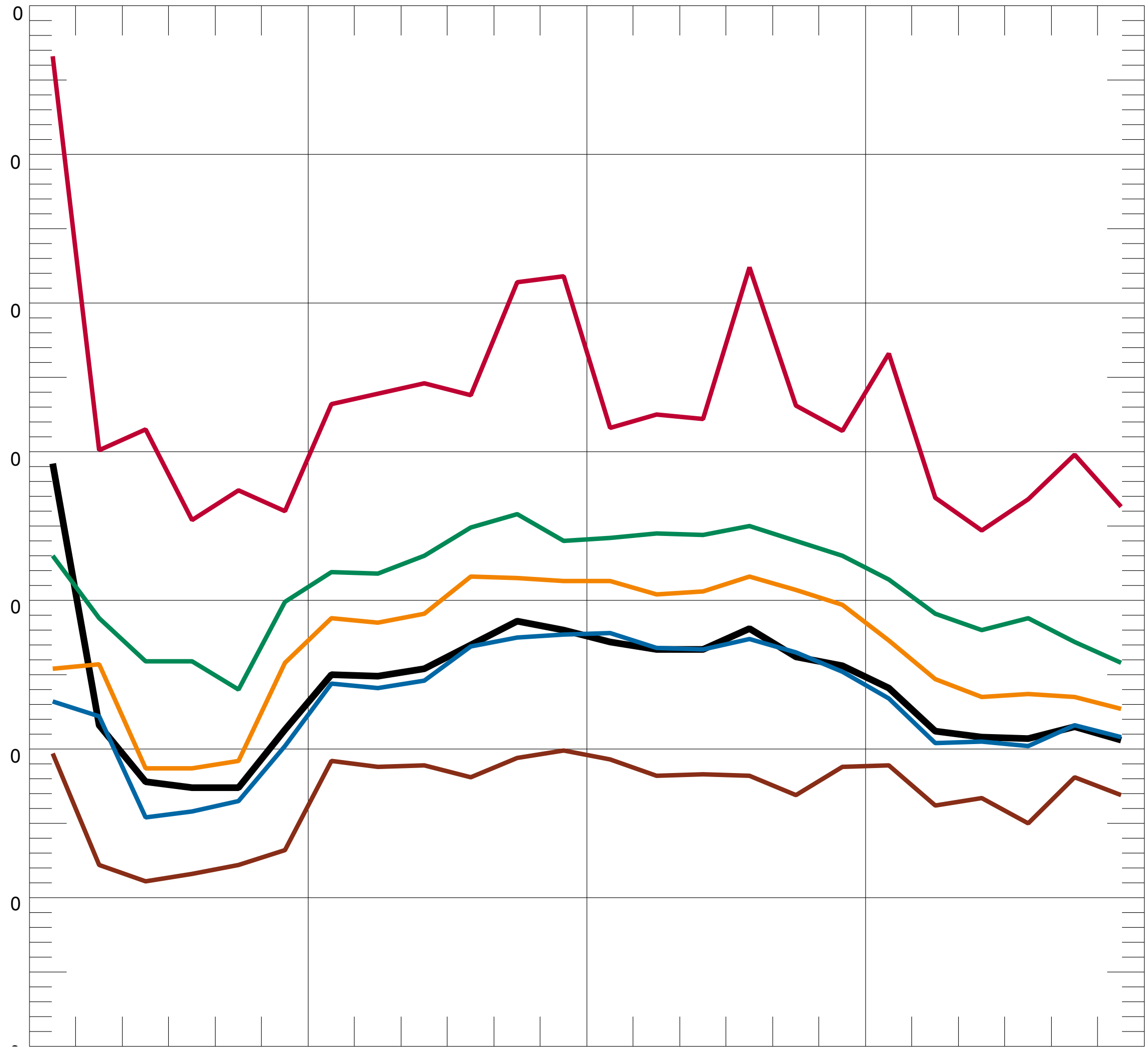

Figure A-10. Hourly Statistical Summary of Noise Levels on Oct 29, 2014 Location N1, 602 California Way, Longview, WA

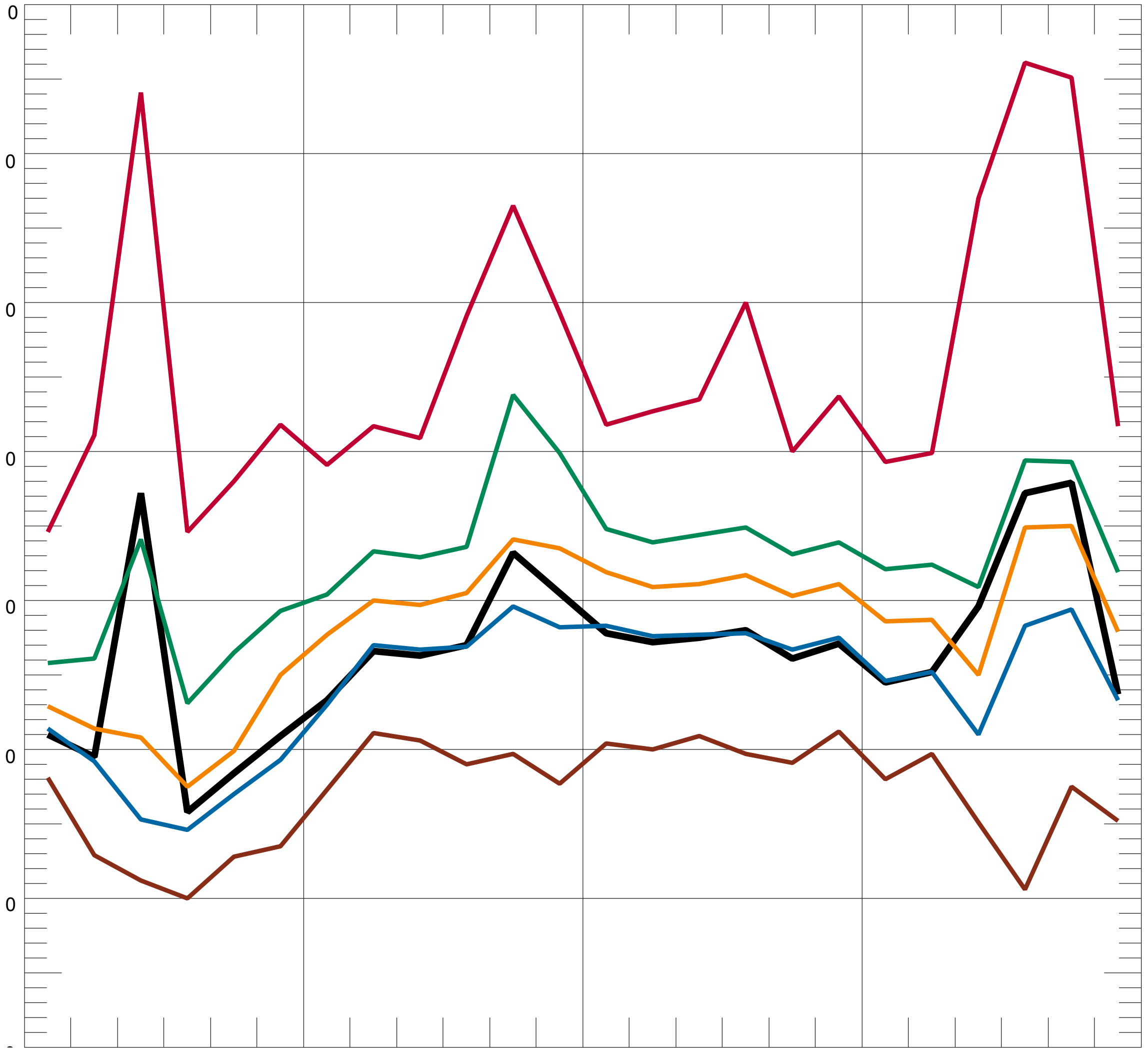

Figure A-11. Hourly Statistical Summary of Noise Levels on Oct 30, 2014 Location N1, 602 California Way, Longview, WA

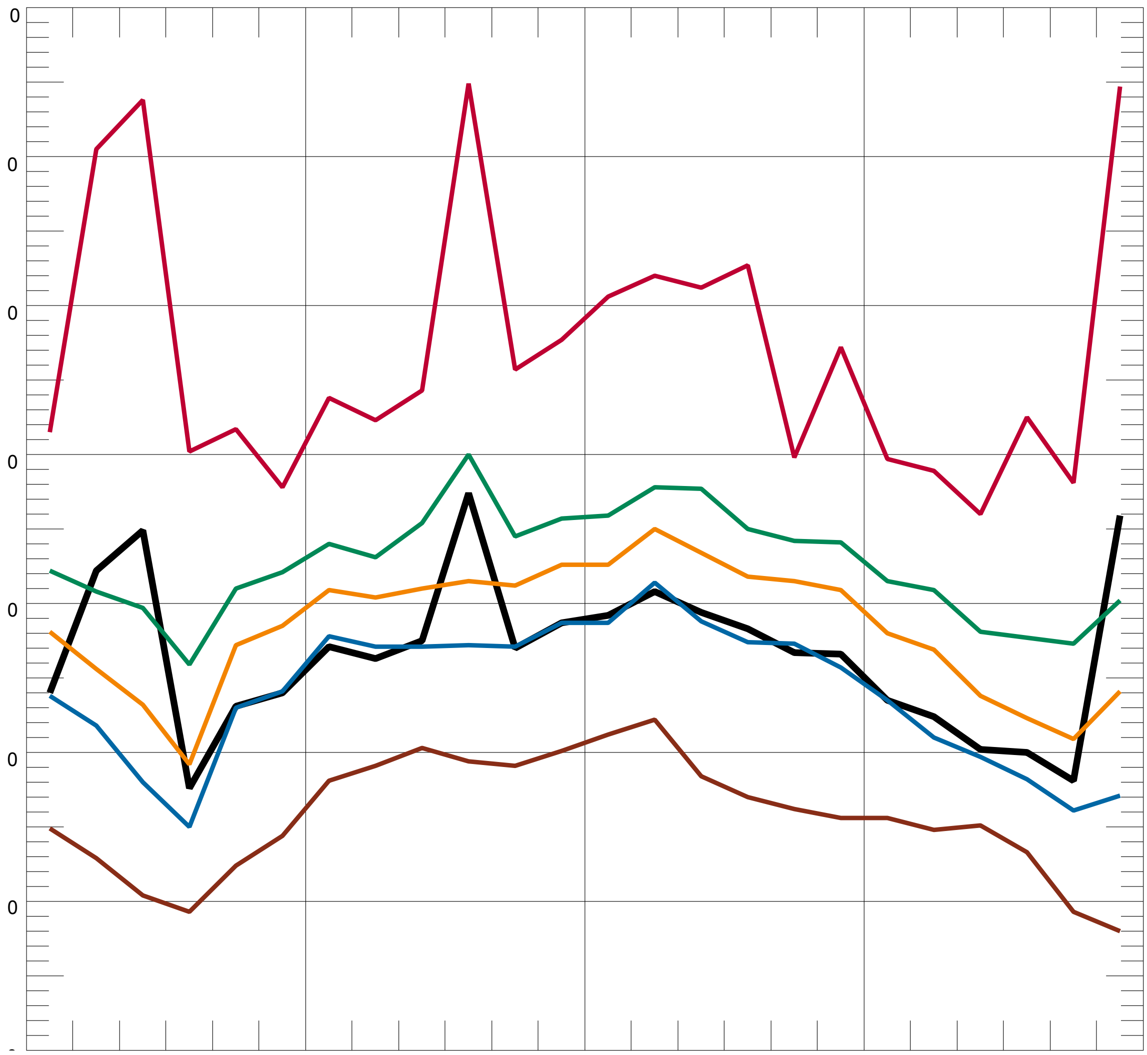

Figure A-12. Hourly Statistical Summary of Noise Levels on Oct 31, 2014 Location N1, 602 California Way, Longview, WA

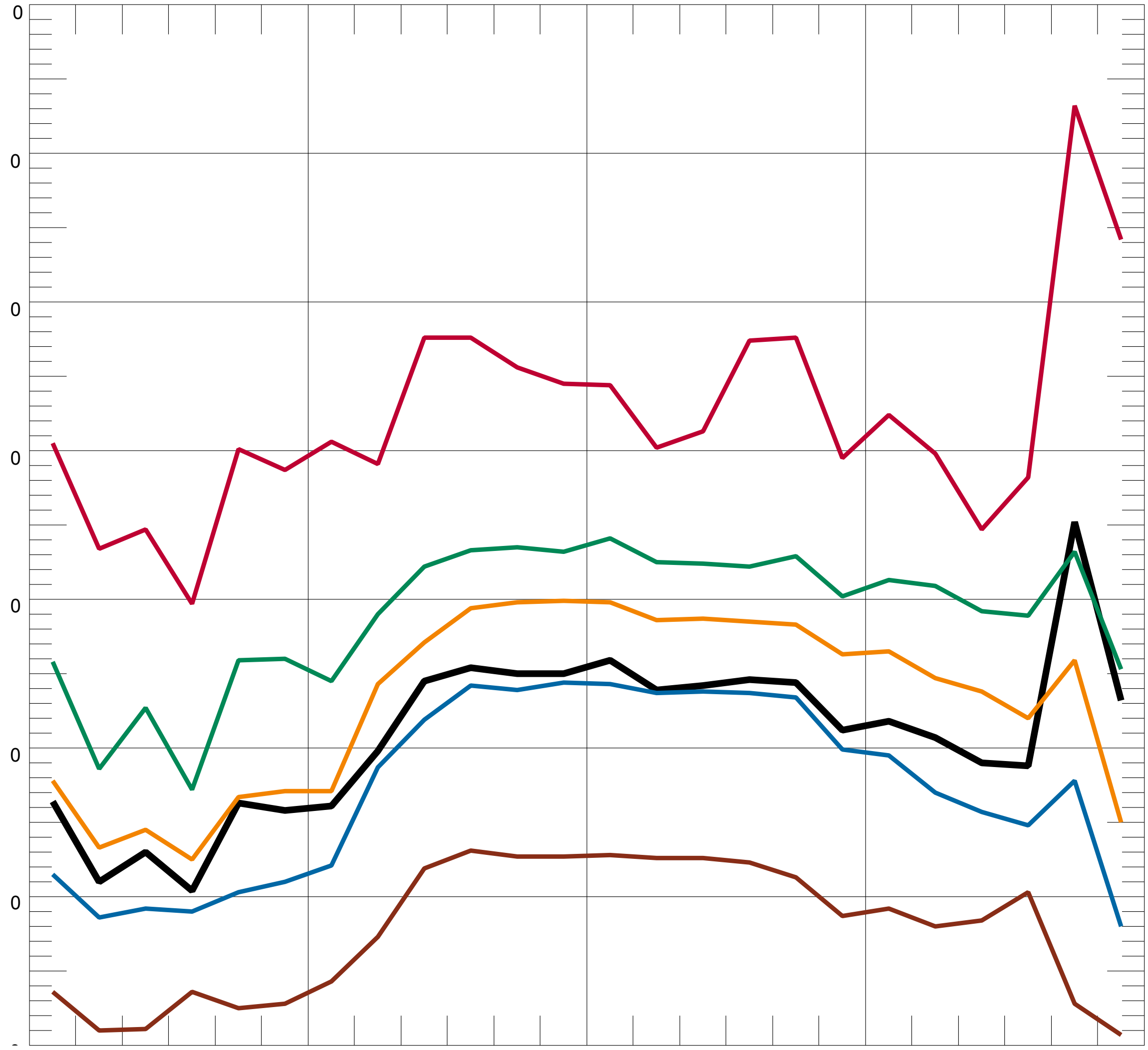

Figure A-13. Hourly Statistical Summary of Noise Levels on Nov 1, 2014 Location N1, 602 California Way, Longview, WA

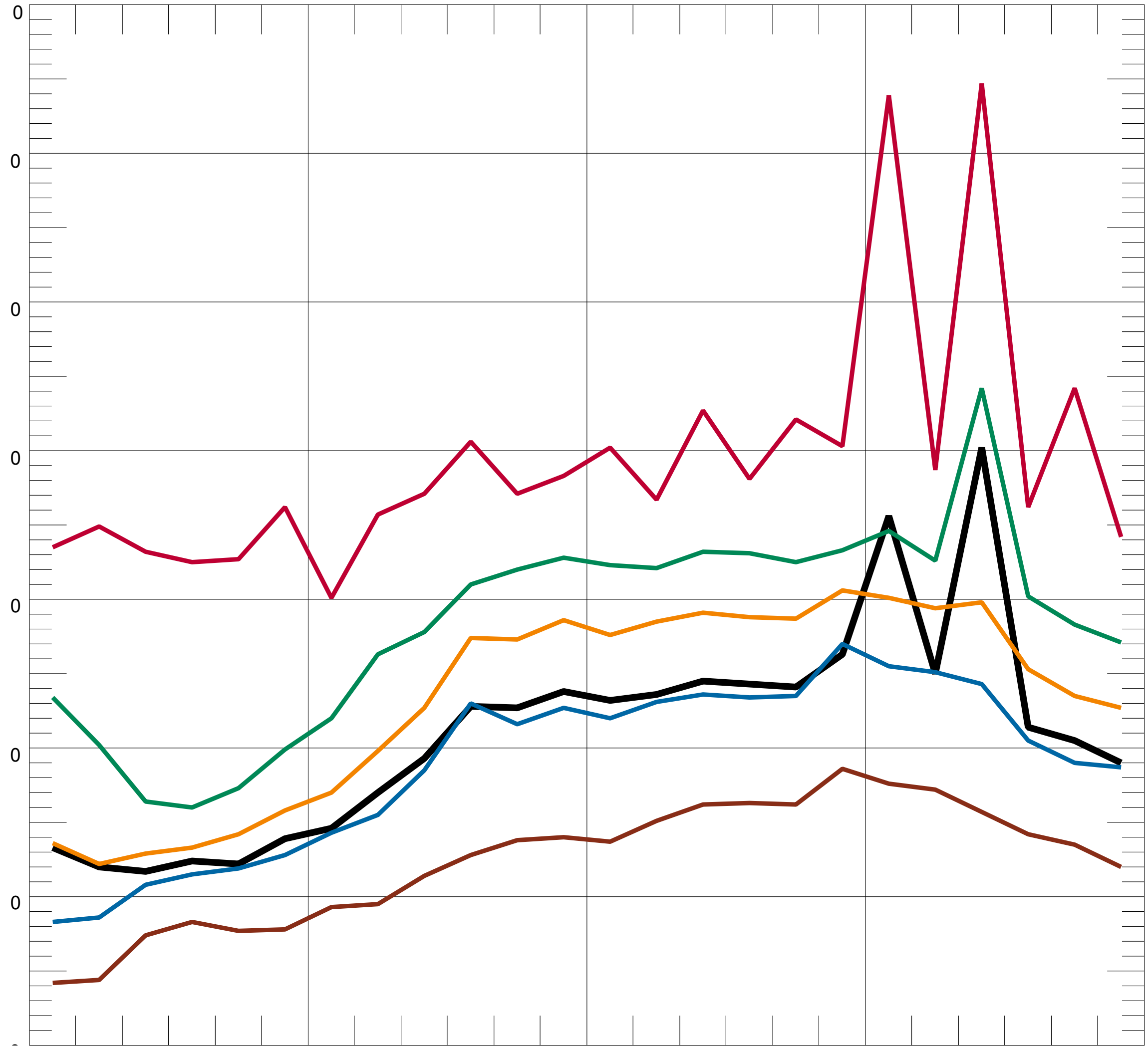

Figure A-14. Hourly Statistical Summary of Noise Levels on Nov 2, 2014 Location N1, 602 California Way, Longview, WA

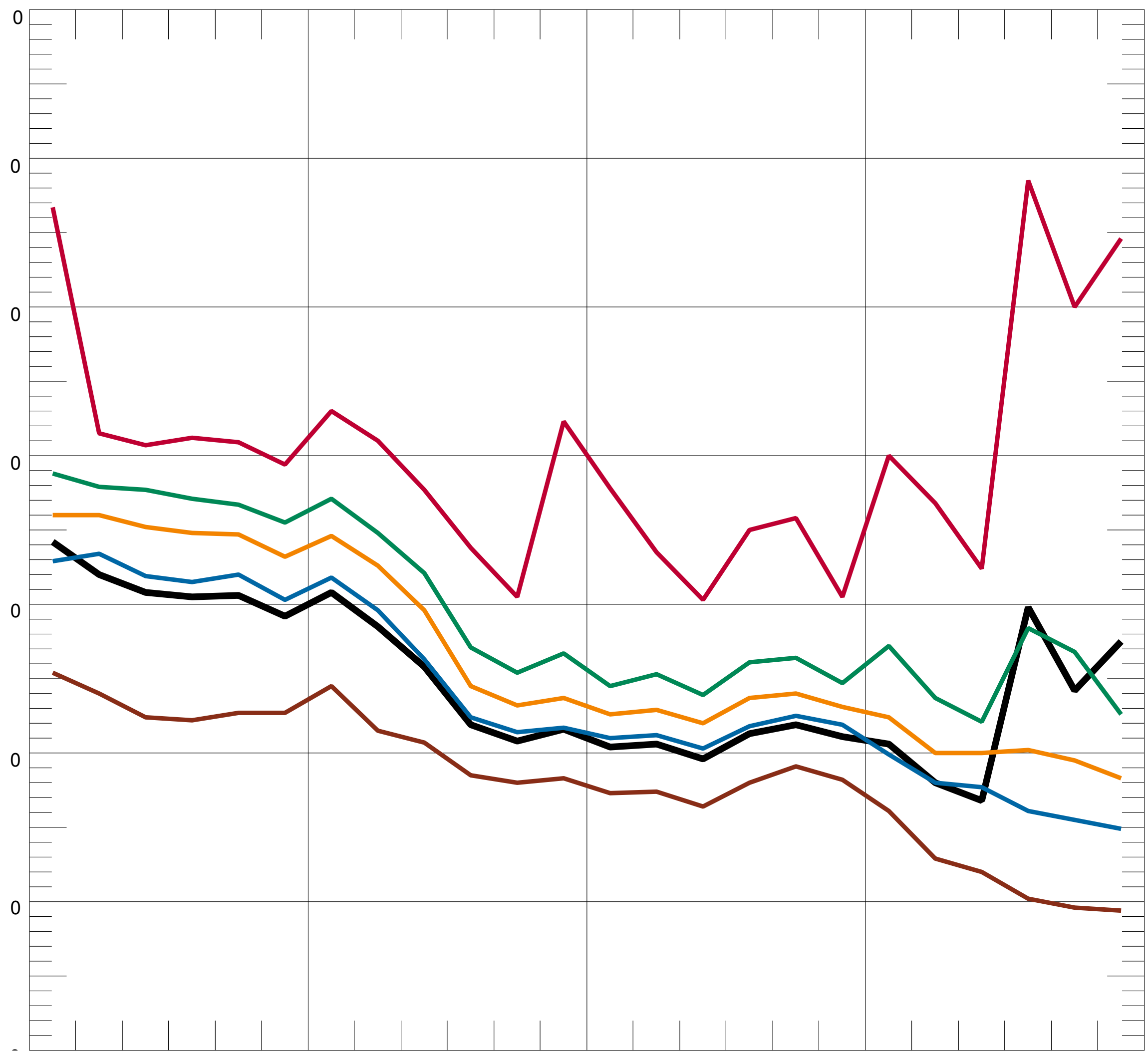

Figure A-15. Hourly Statistical Summary of Noise Levels on Nov 4, 2014 Location N2, 111-15th Avenue, Longview, WA

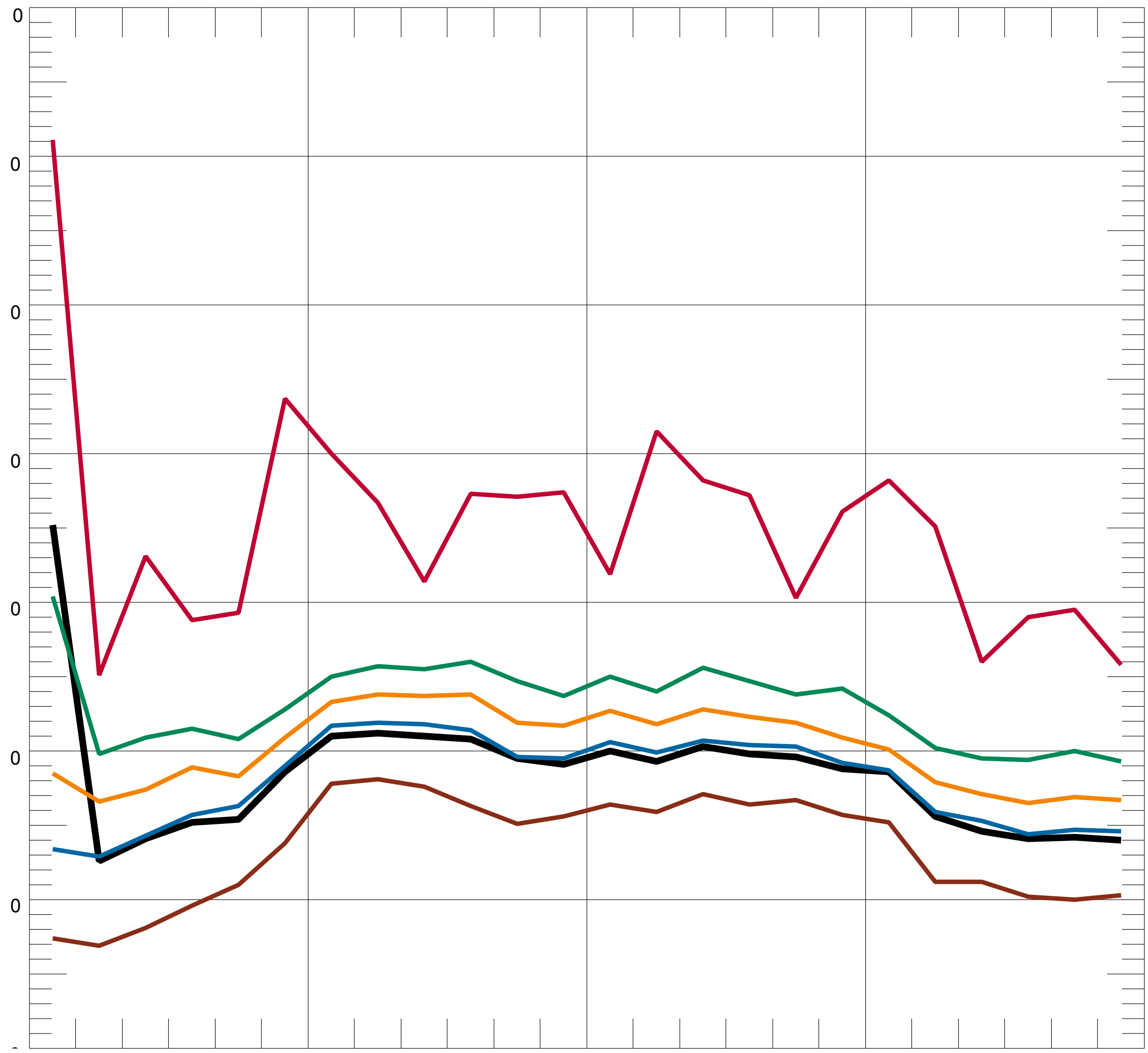

Figure A-16. Hourly Statistical Summary of Noise Levels on Nov 5, 2014 Location N2, 111-15th Avenue, Longview, WA

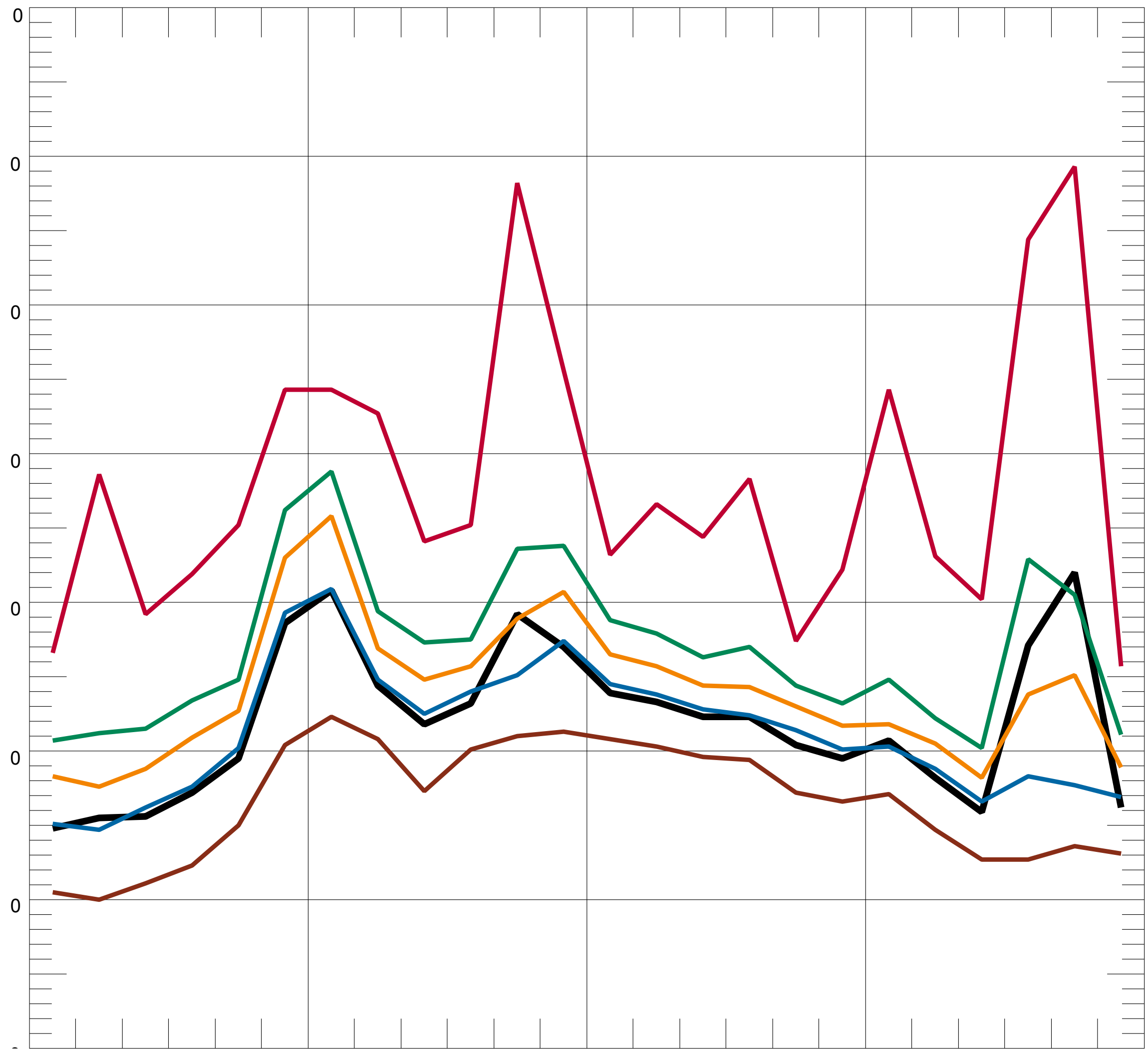

Figure A-17. Hourly Statistical Summary of Noise Levels on Nov 6, 2014 Location N2, 111-15th Avenue, Longview, WA

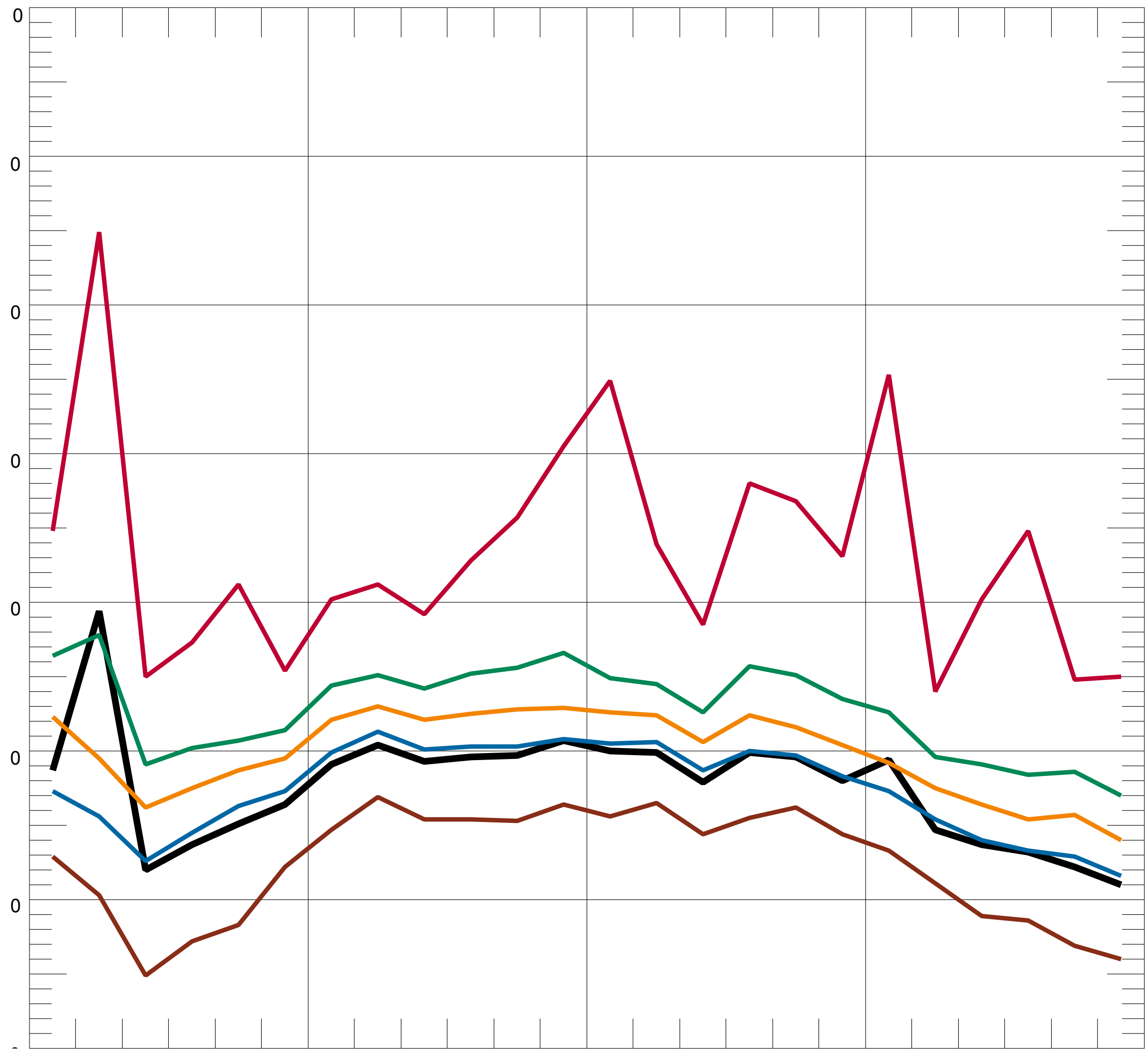

Figure A-18. Hourly Statistical Summary of Noise Levels on Nov 7, 2014 Location N2, 111-15th Avenue, Longview, WA

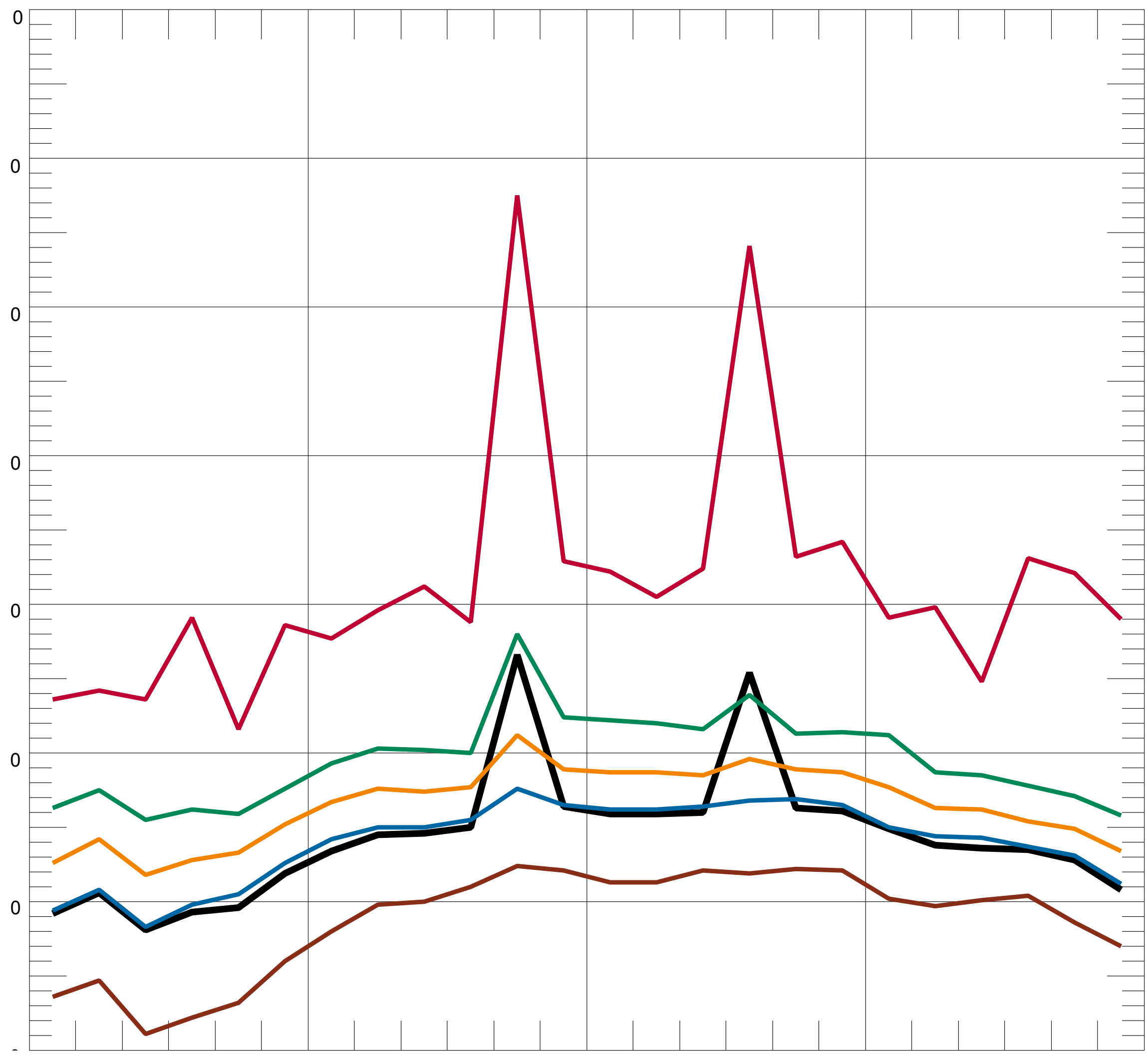

Figure A-19. Hourly Statistical Summary of Noise Levels on Nov 8, 2014 Location N2, 111-15th Avenue, Longview, WA

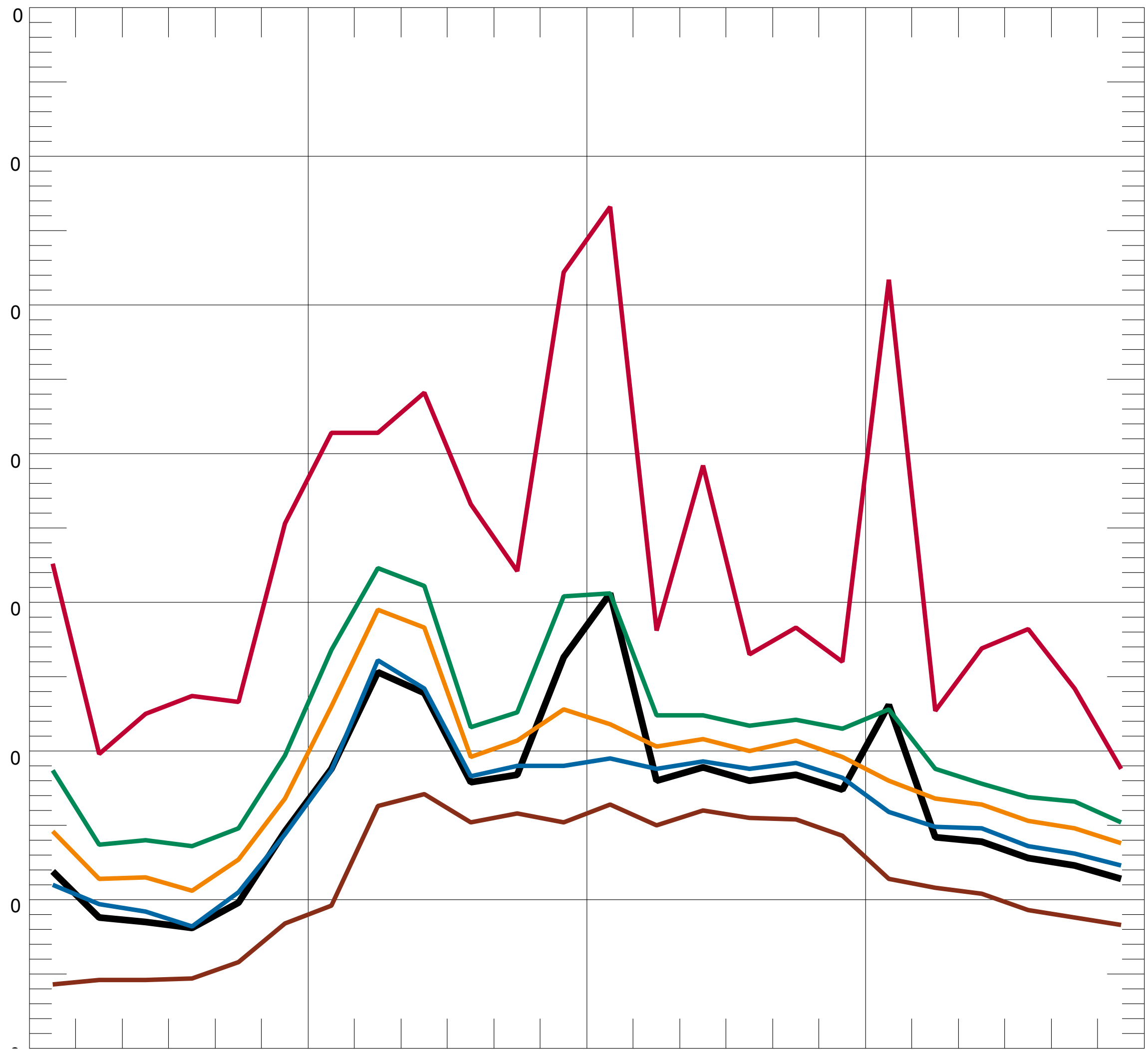

Figure A-20. Hourly Statistical Summary of Noise Levels on Nov 9, 2014 Location N2, 111-15th Avenue, Longview, WA

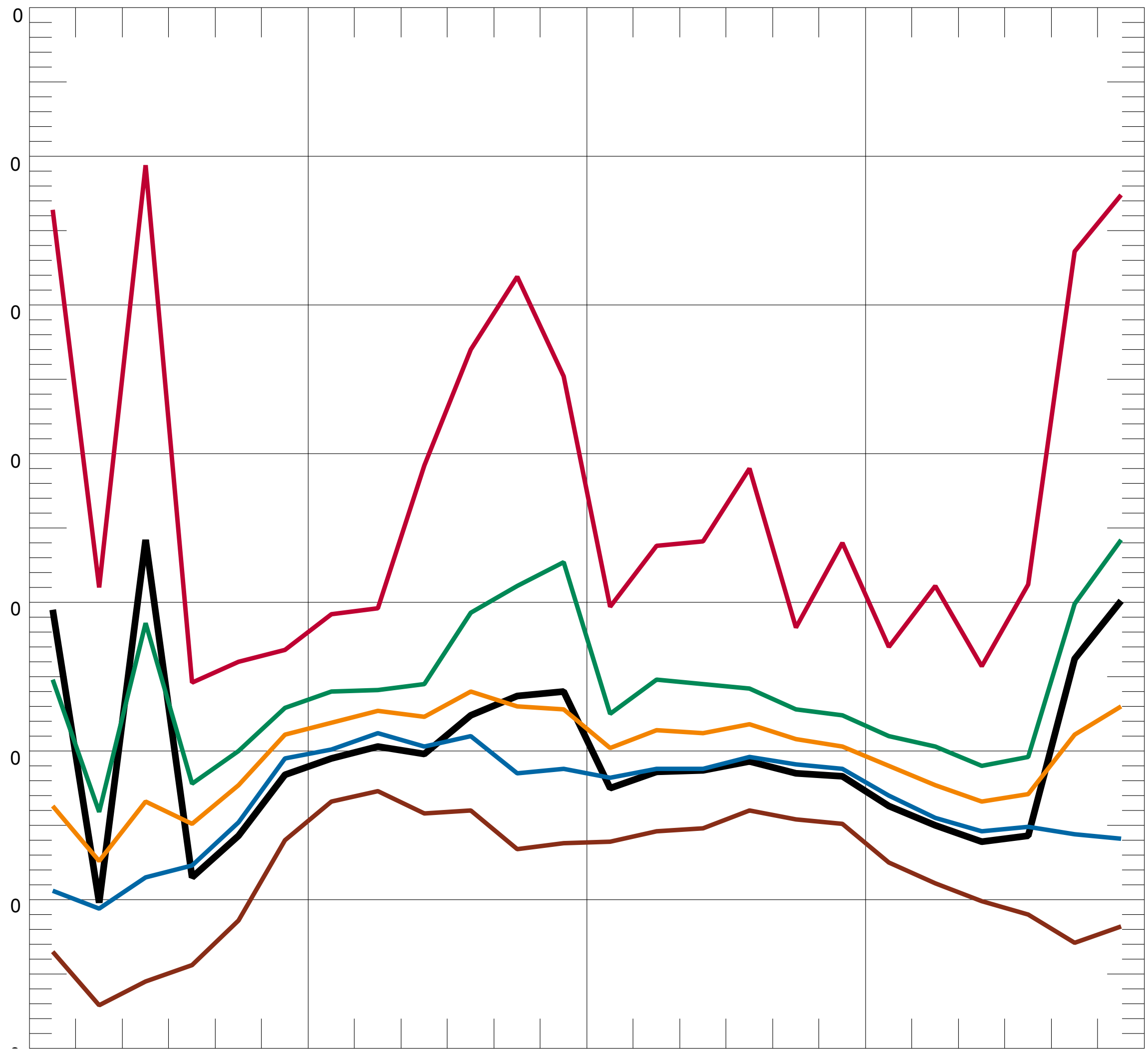

Figure A-21. Hourly Statistical Summary of Noise Levels on Nov 10, 2014 Location N2, 111-15th Avenue, Longview, WA

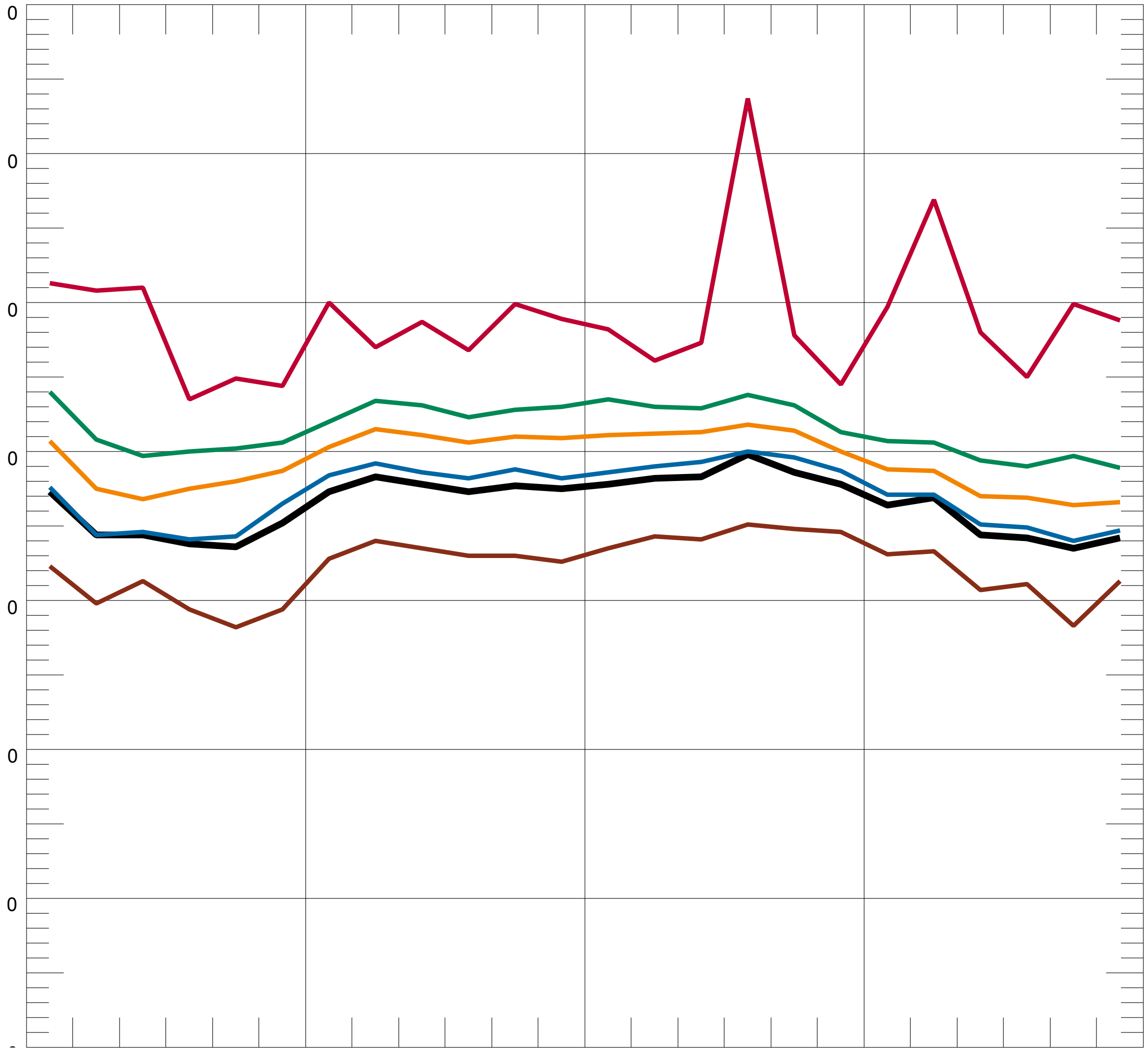

Figure A-22. Hourly Statistical Summary of Noise Levels on Nov 4, 2014 Location N3, 221 Beech Street at Alder St., Longview, WA

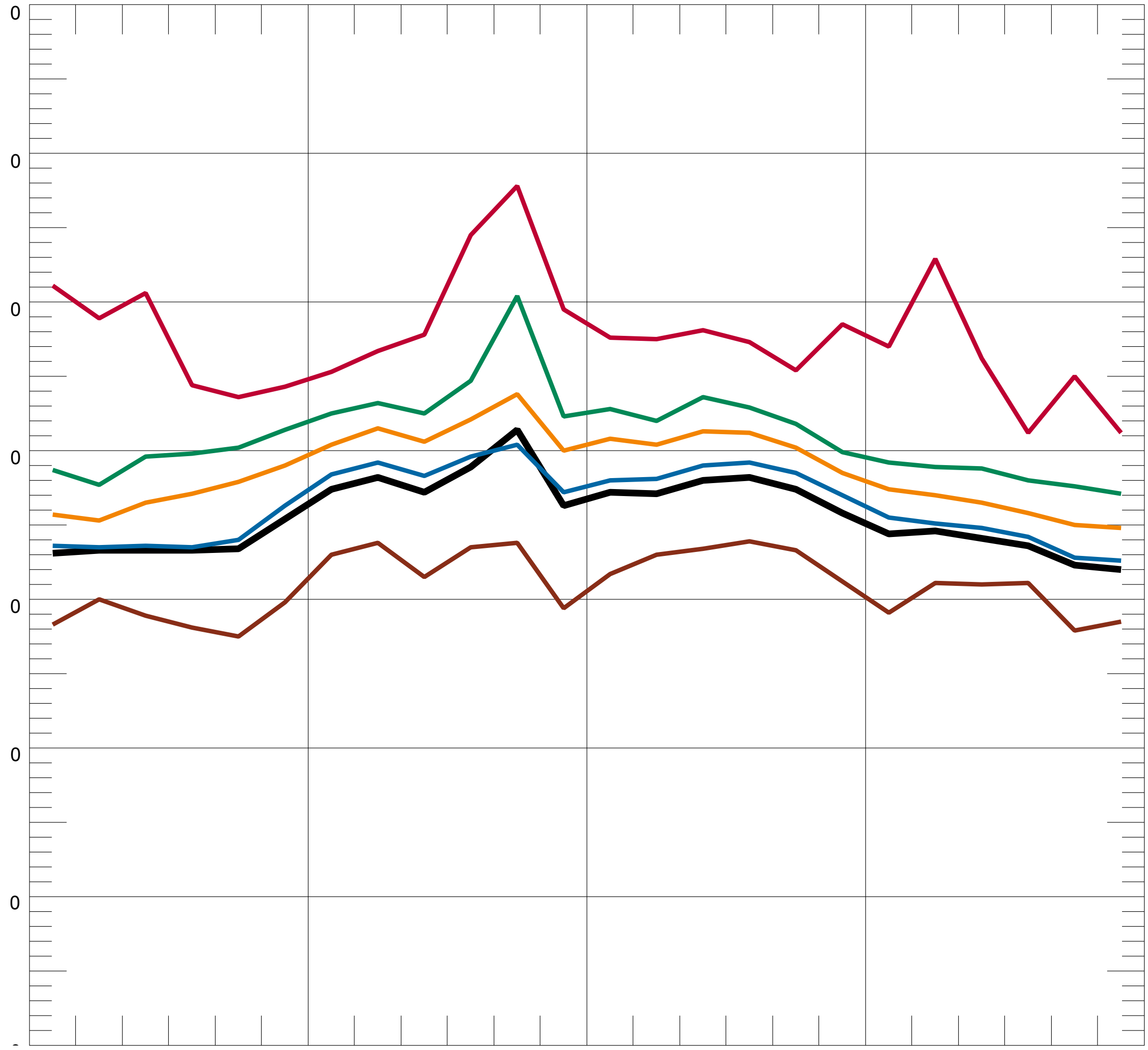

Figure A-23. Hourly Statistical Summary of Noise Levels on Nov 5, 2014 Location N3, 221 Beech Street at Alder St., Longview, WA

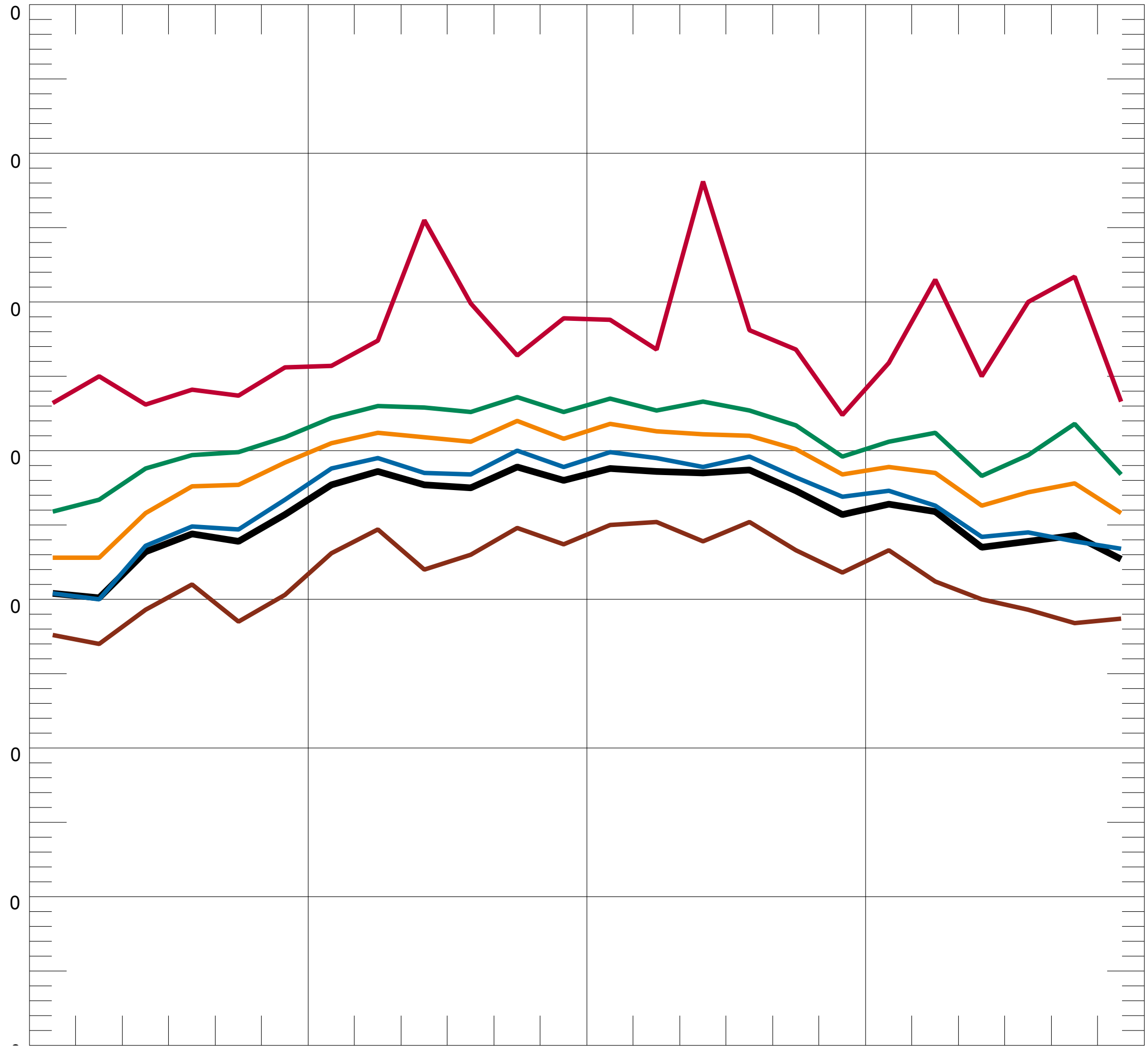

Figure A-24. Hourly Statistical Summary of Noise Levels on Nov 6, 2014 Location N3, 221 Beech Street at Alder St., Longview, WA

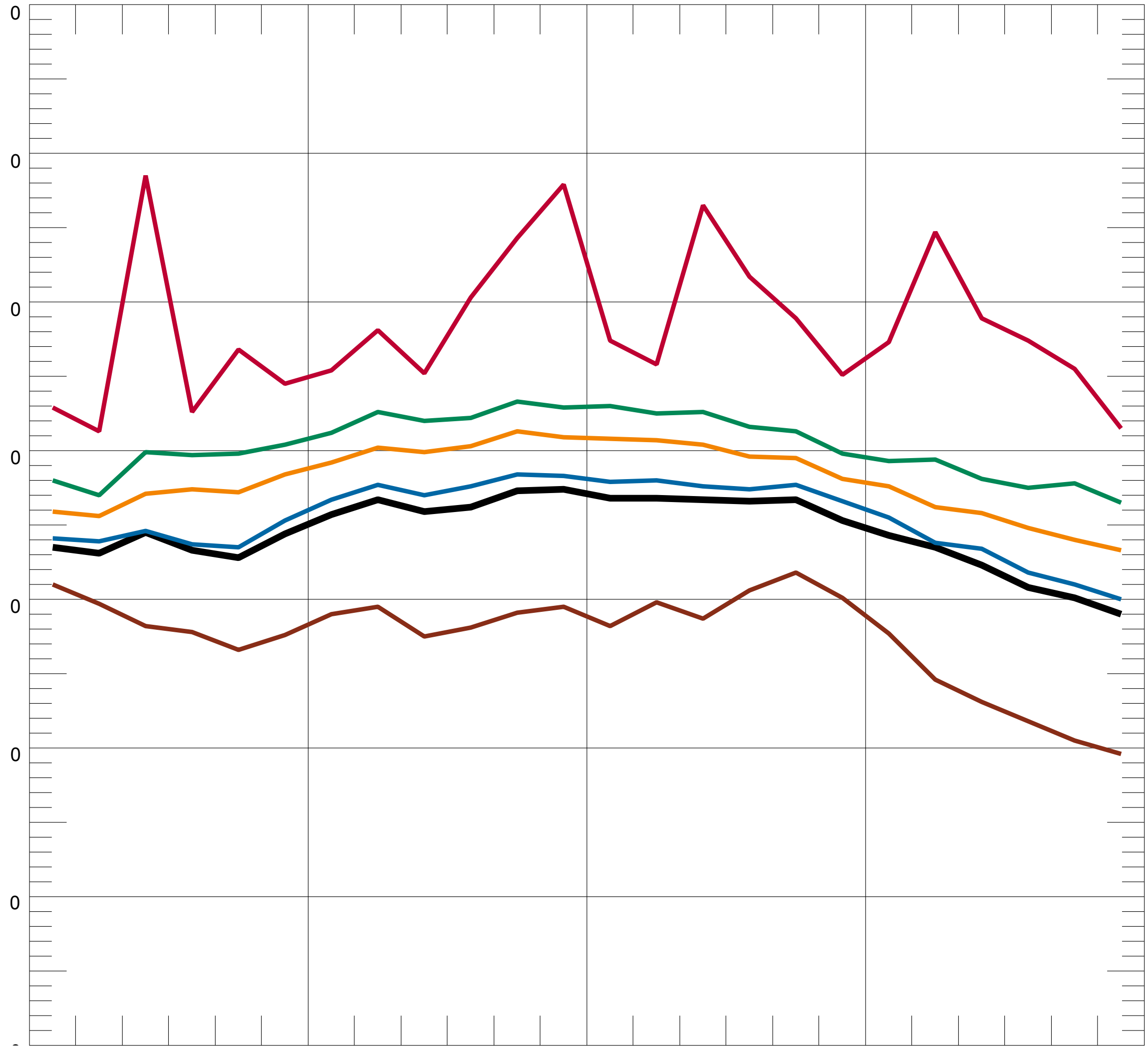

Figure A-25. Hourly Statistical Summary of Noise Levels on Nov 7, 2014 Location N3, 221 Beech Street at Alder St., Longview, WA

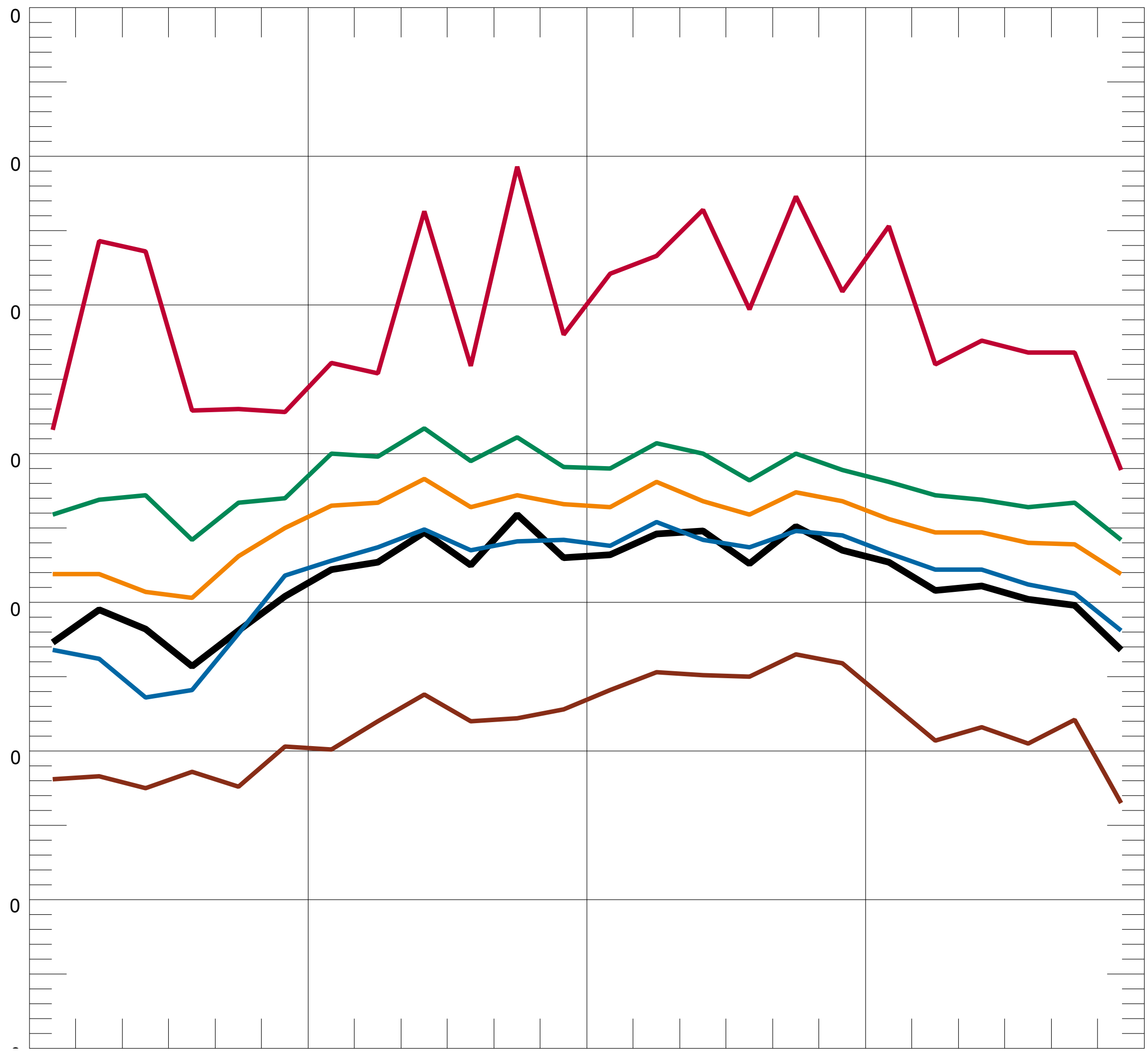

Figure A-26. Hourly Statistical Summary of Noise Levels on Nov 8, 2014 Location N3, 221 Beech Street at Alder St., Longview, WA

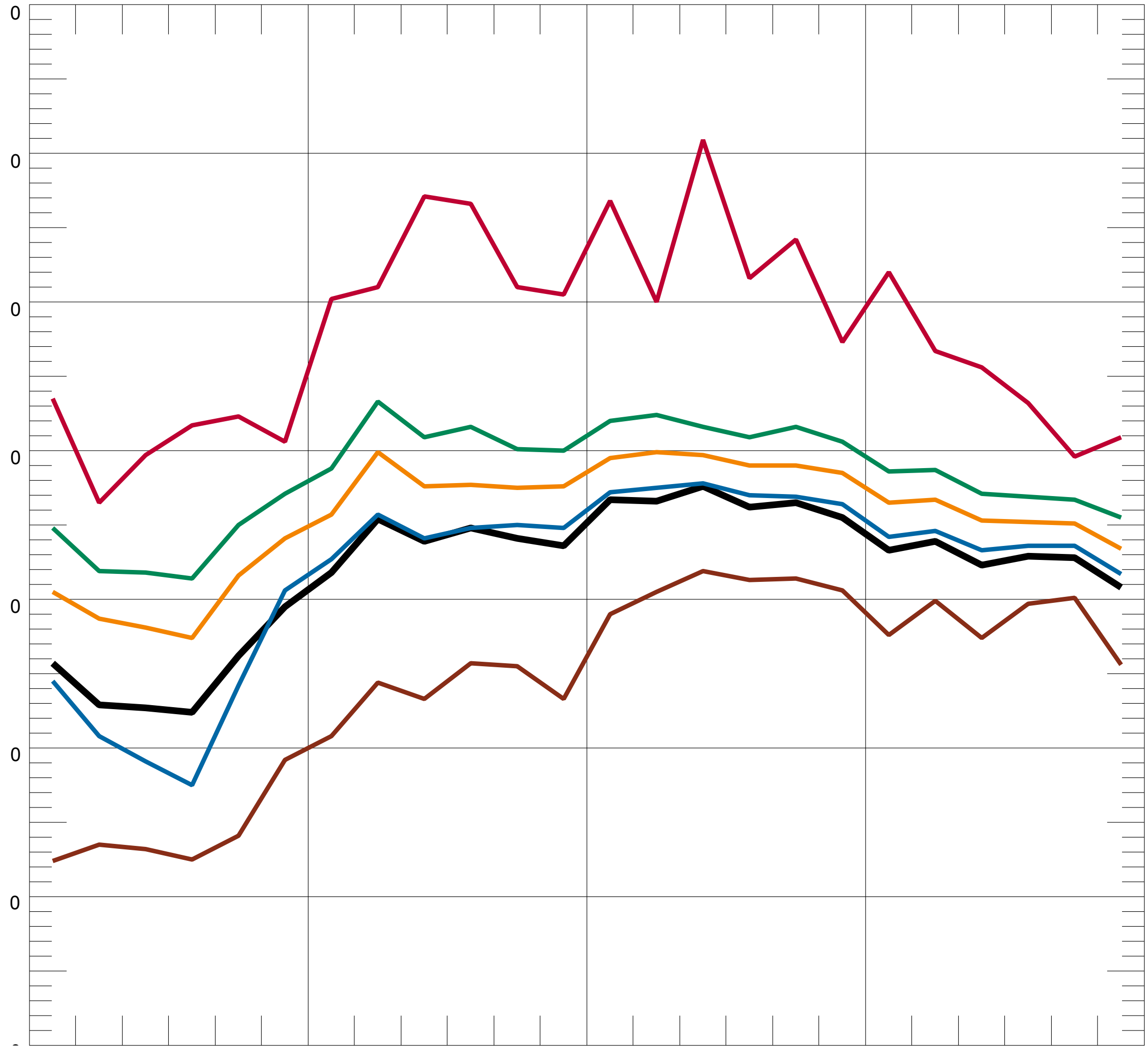

Figure A-27. Hourly Statistical Summary of Noise Levels on Nov 9, 2014 Location N3, 221 Beech Street at Alder St., Longview, WA

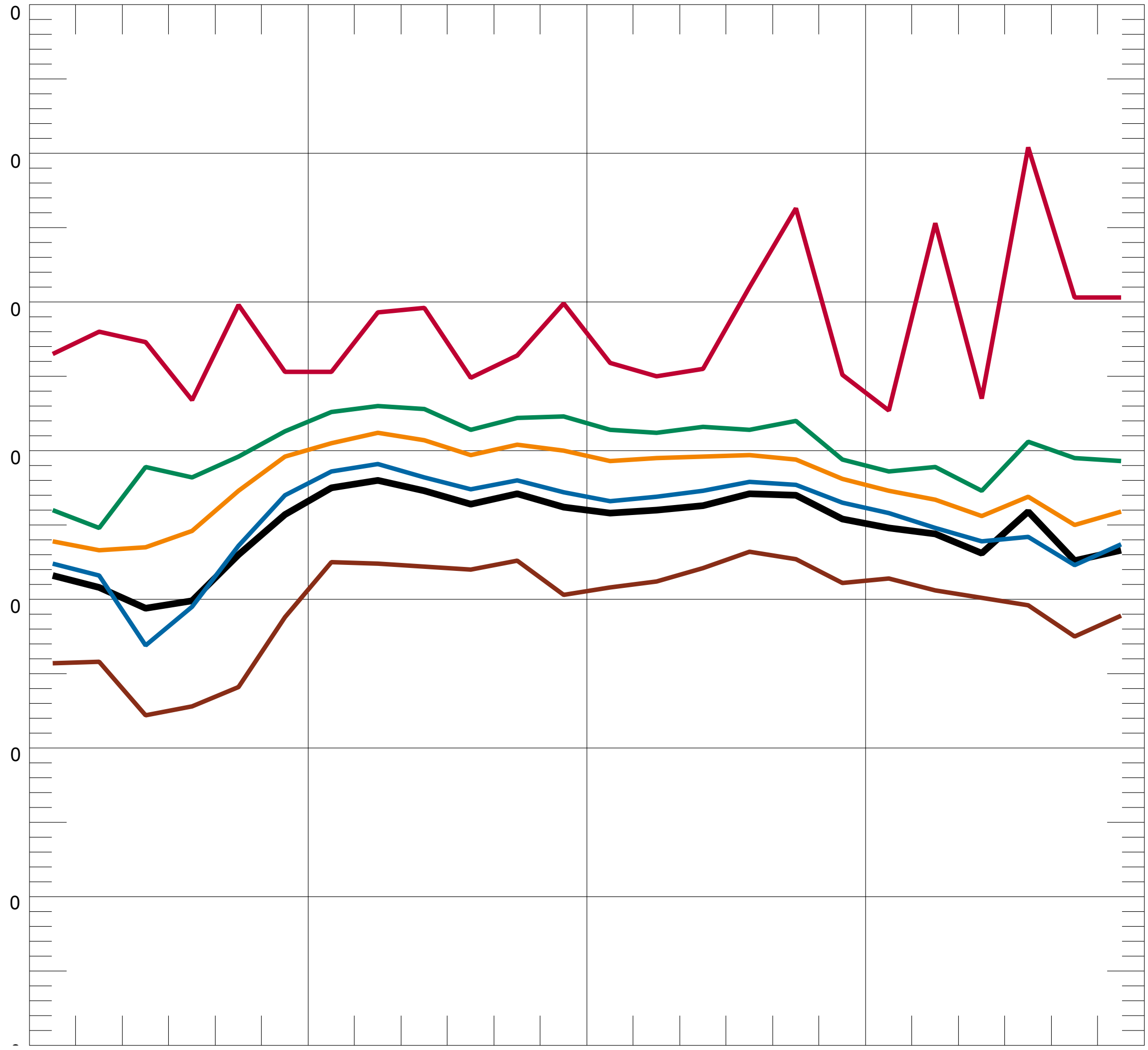

Figure A-28. Hourly Statistical Summary of Noise Levels on Nov 10, 2014 Location N3, 221 Beech Street at Alder St., Longview, WA

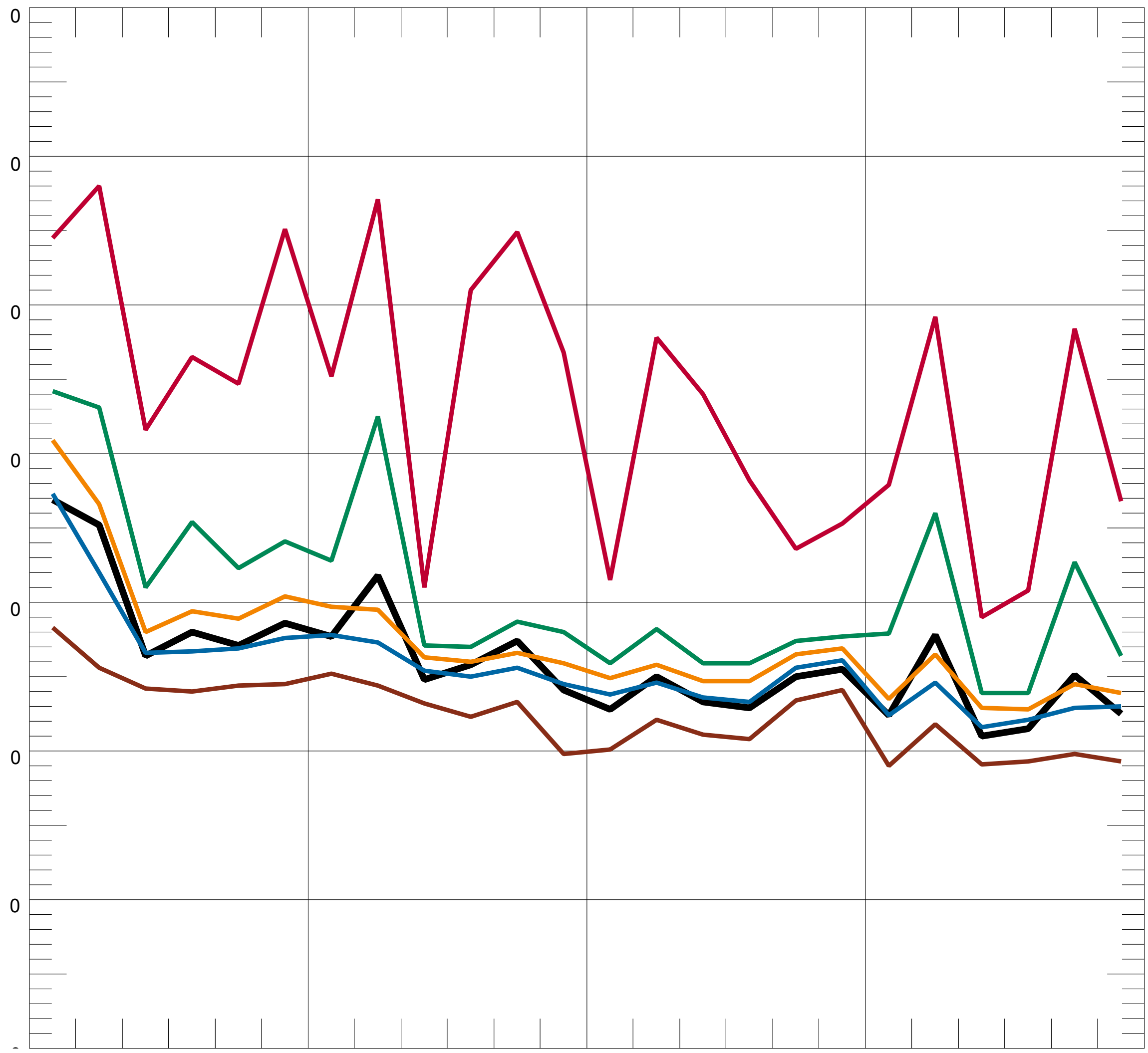

Figure A-29. Hourly Statistical Summary of Noise Levels on Nov 4, 2014 Location N4, 875-34th Avenue, Longview, WA

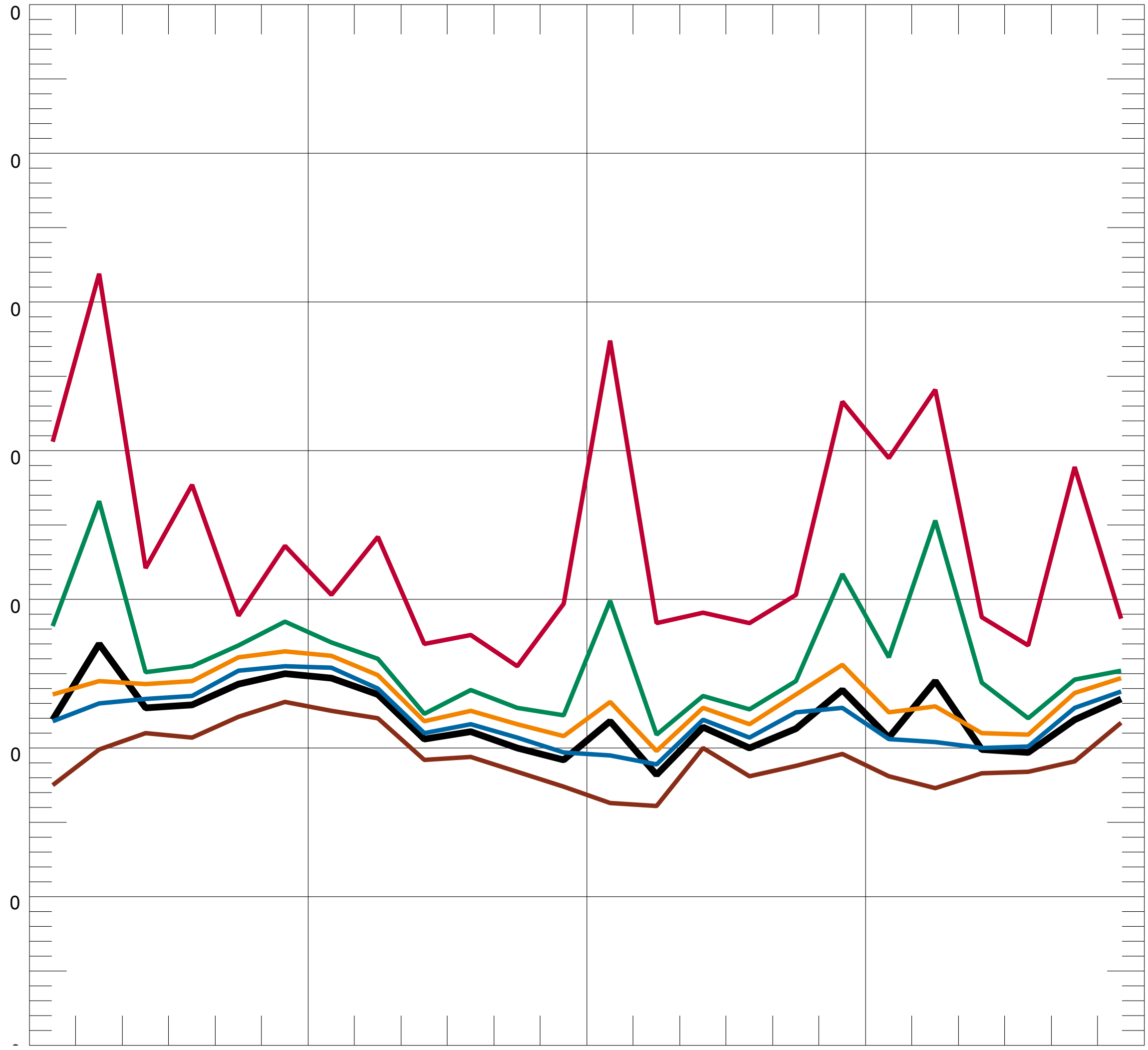

Figure A-30. Hourly Statistical Summary of Noise Levels on Nov 5, 2014 Location N4, 875-34th Avenue, Longview, WA

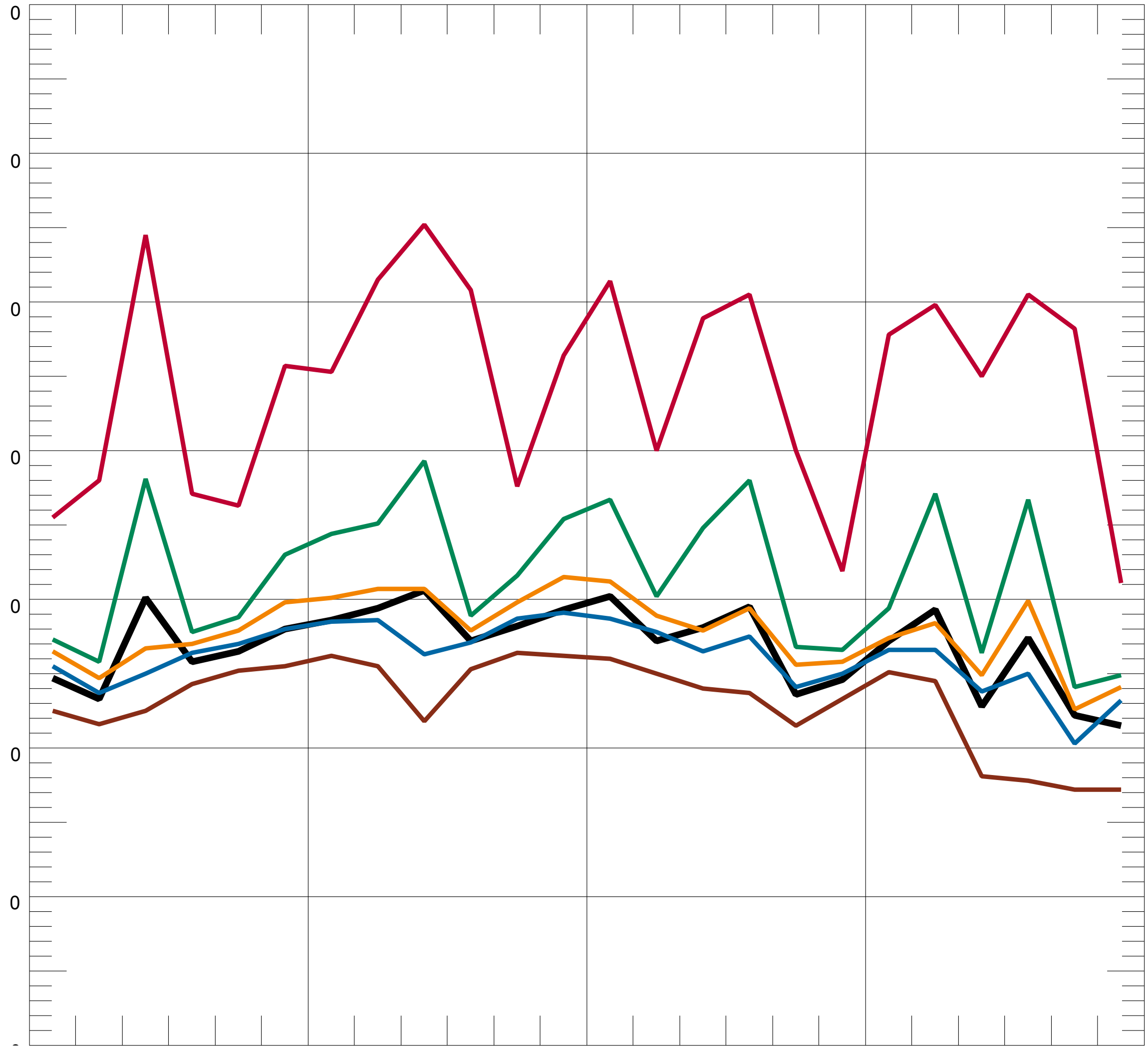

Figure A-31. Hourly Statistical Summary of Noise Levels on Nov 6, 2014 Location N4, 875-34th Avenue, Longview, WA

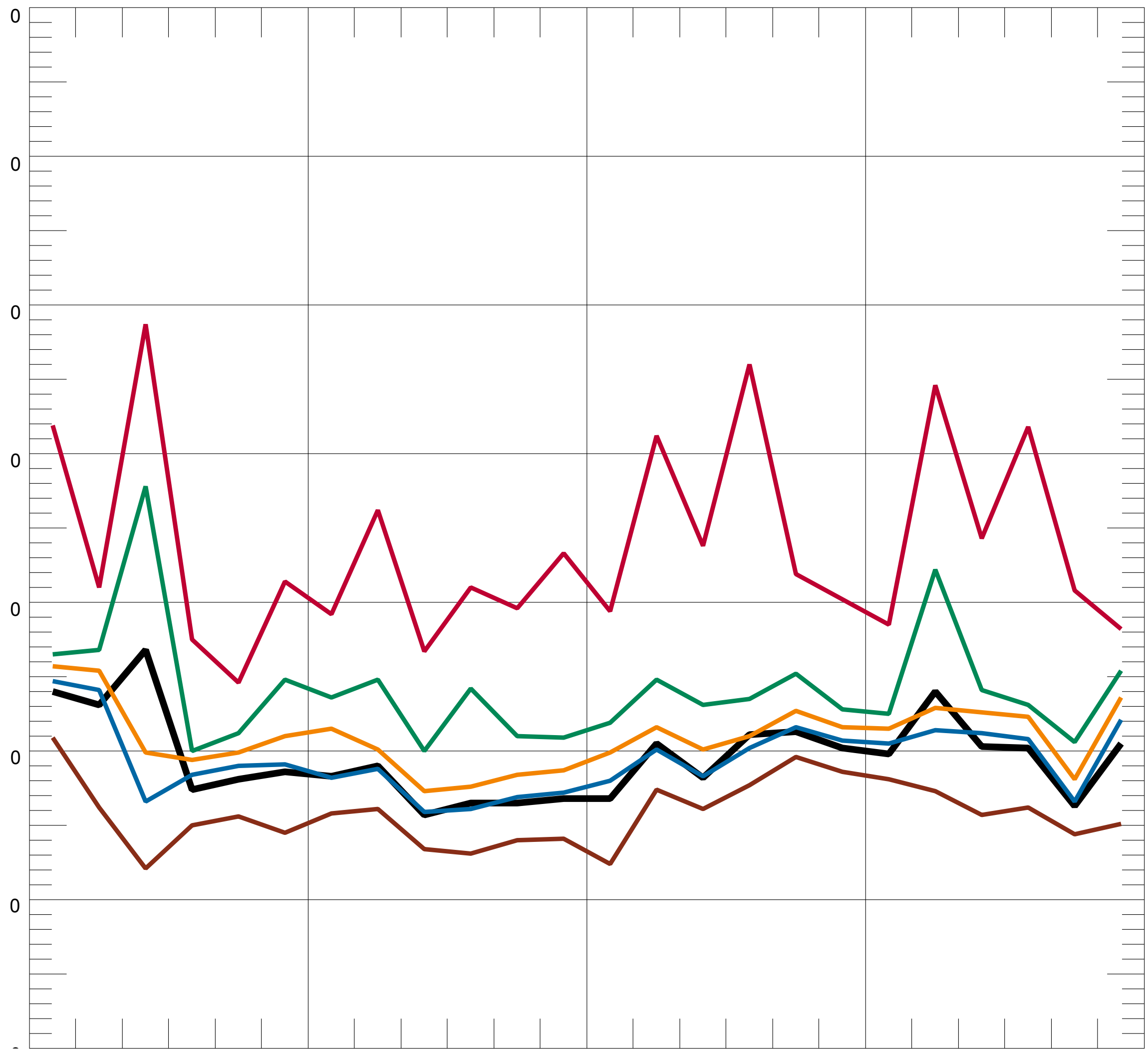

Figure A-32. Hourly Statistical Summary of Noise Levels on Nov 7, 2014 Location N4, 875-34th Avenue, Longview, WA

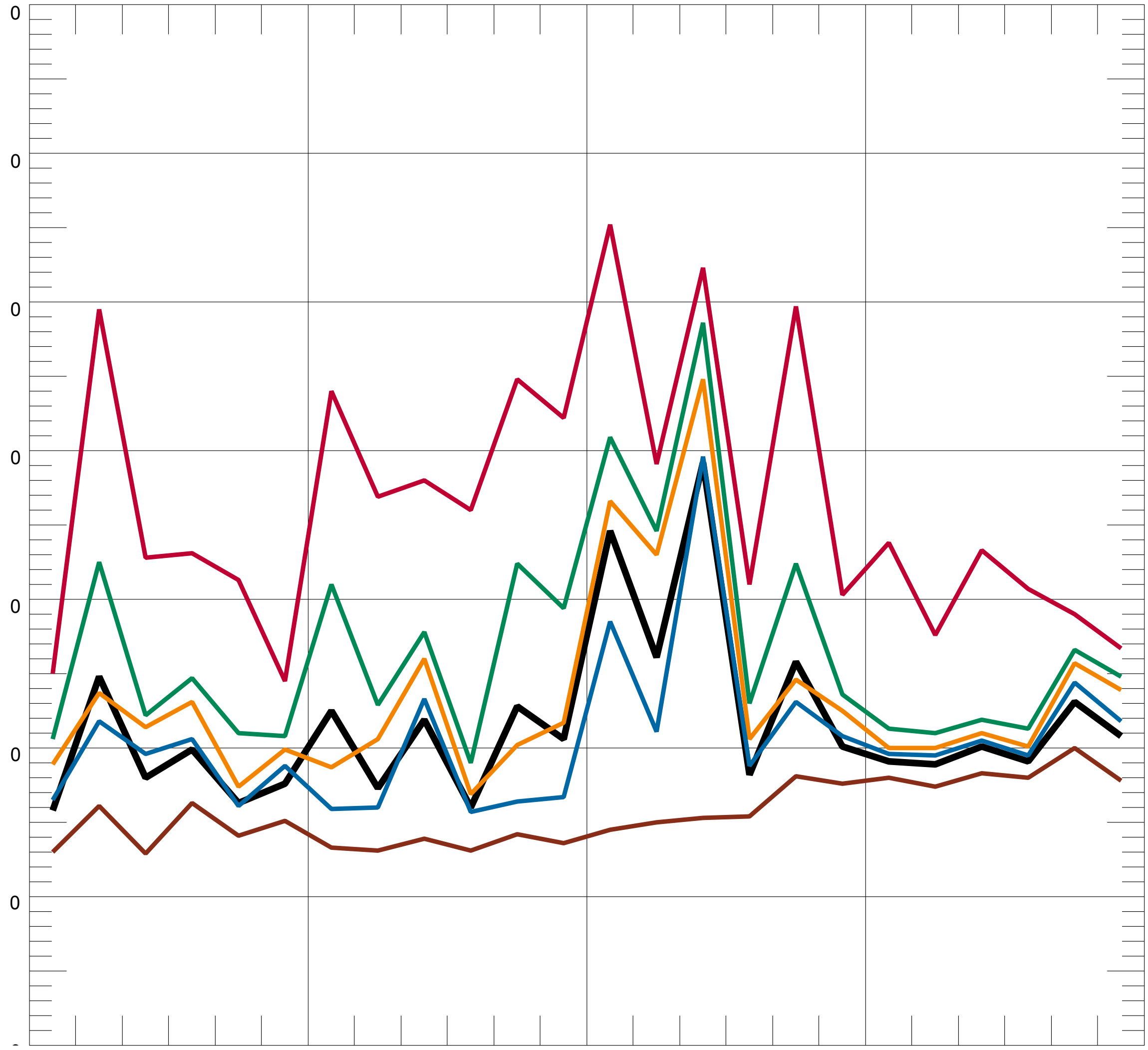

Figure A-33. Hourly Statistical Summary of Noise Levels on Nov 8, 2014 Location N4, 875-34th Avenue, Longview, WA

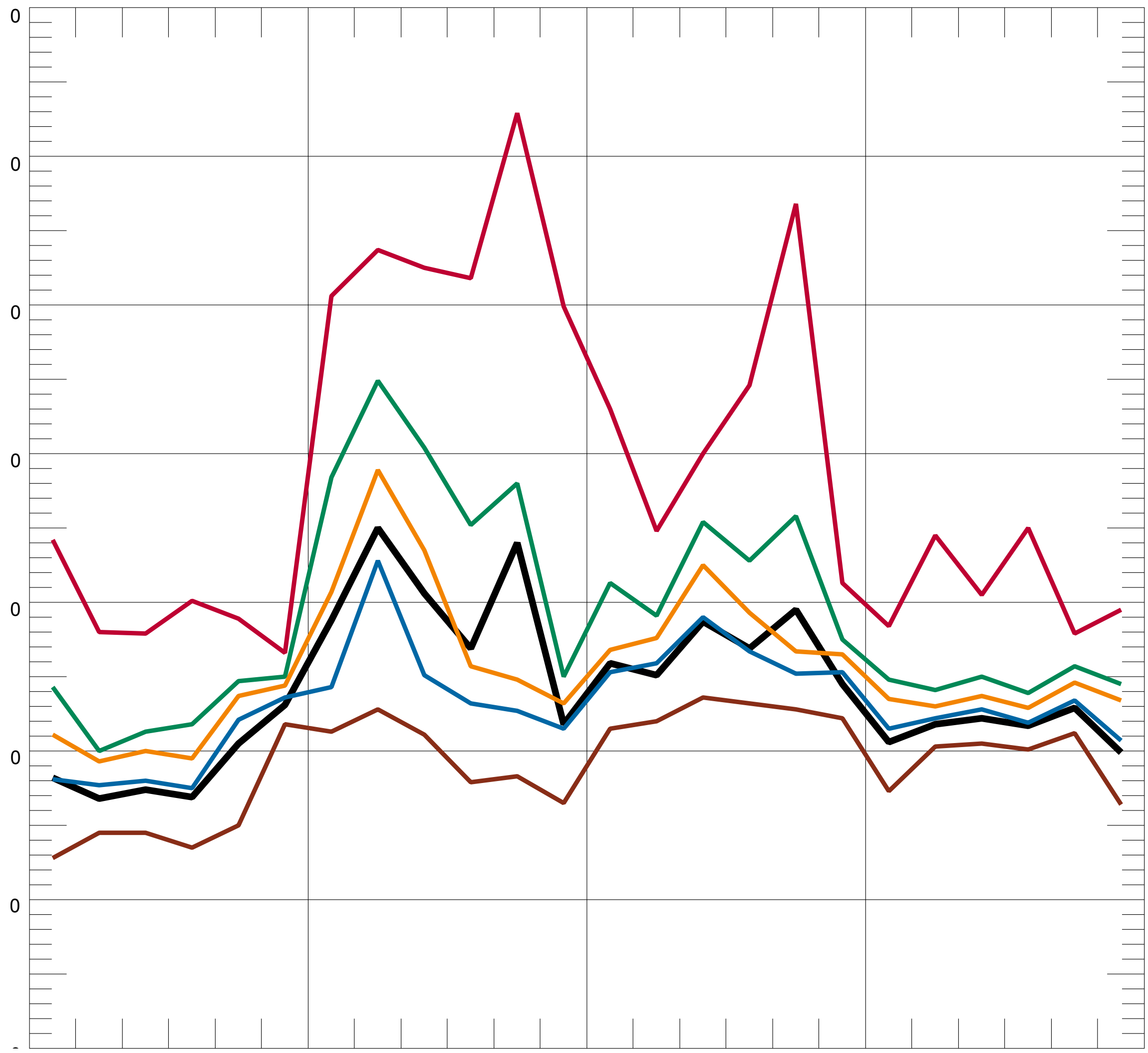

Figure A-34. Hourly Statistical Summary of Noise Levels on Nov 9, 2014 Location N4, 875-34th Avenue, Longview, WA

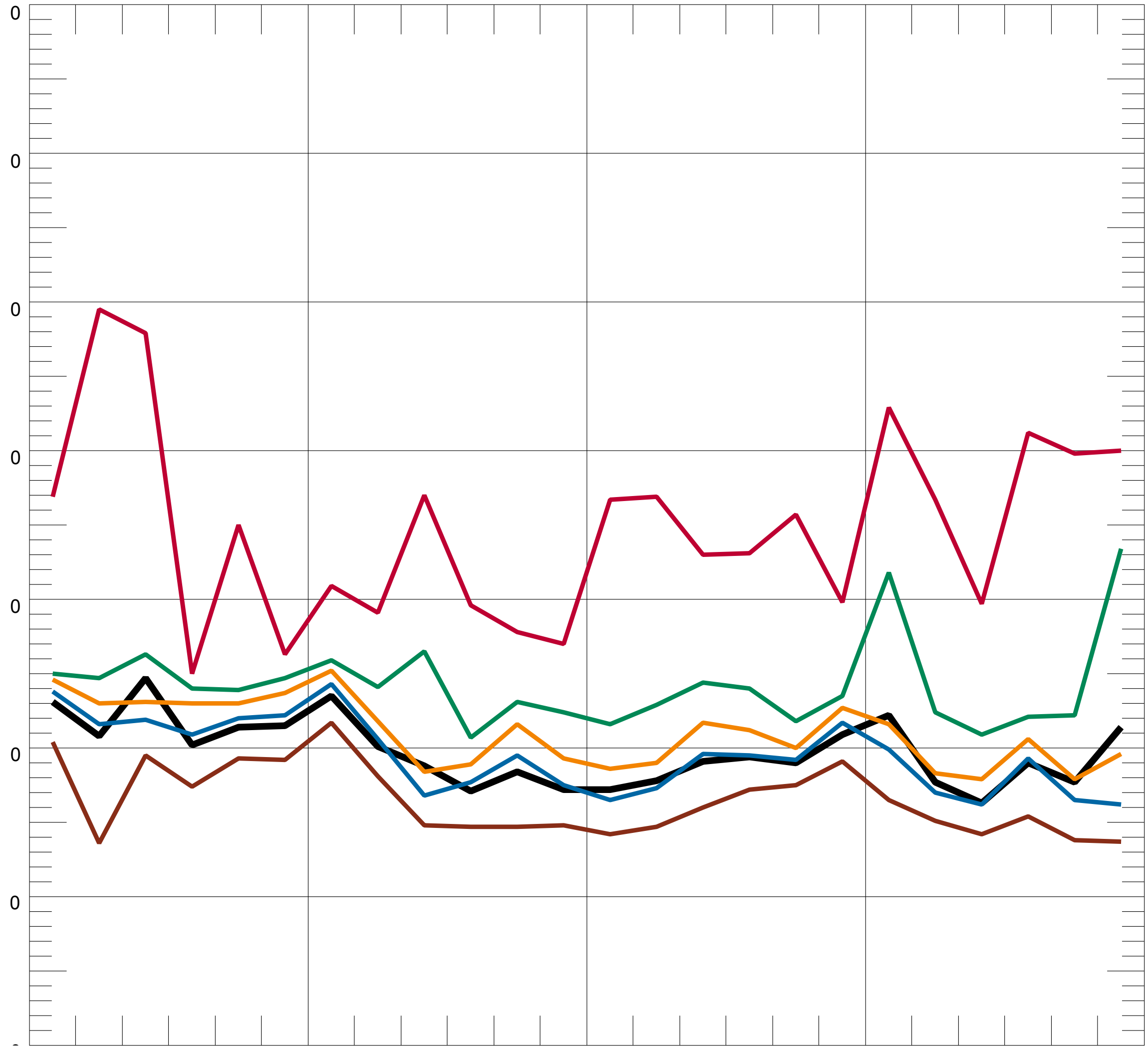

Figure A-35. Hourly Statistical Summary of Noise Levels on Nov 10, 2014 Location N4, 875-34th Avenue, Longview, WA

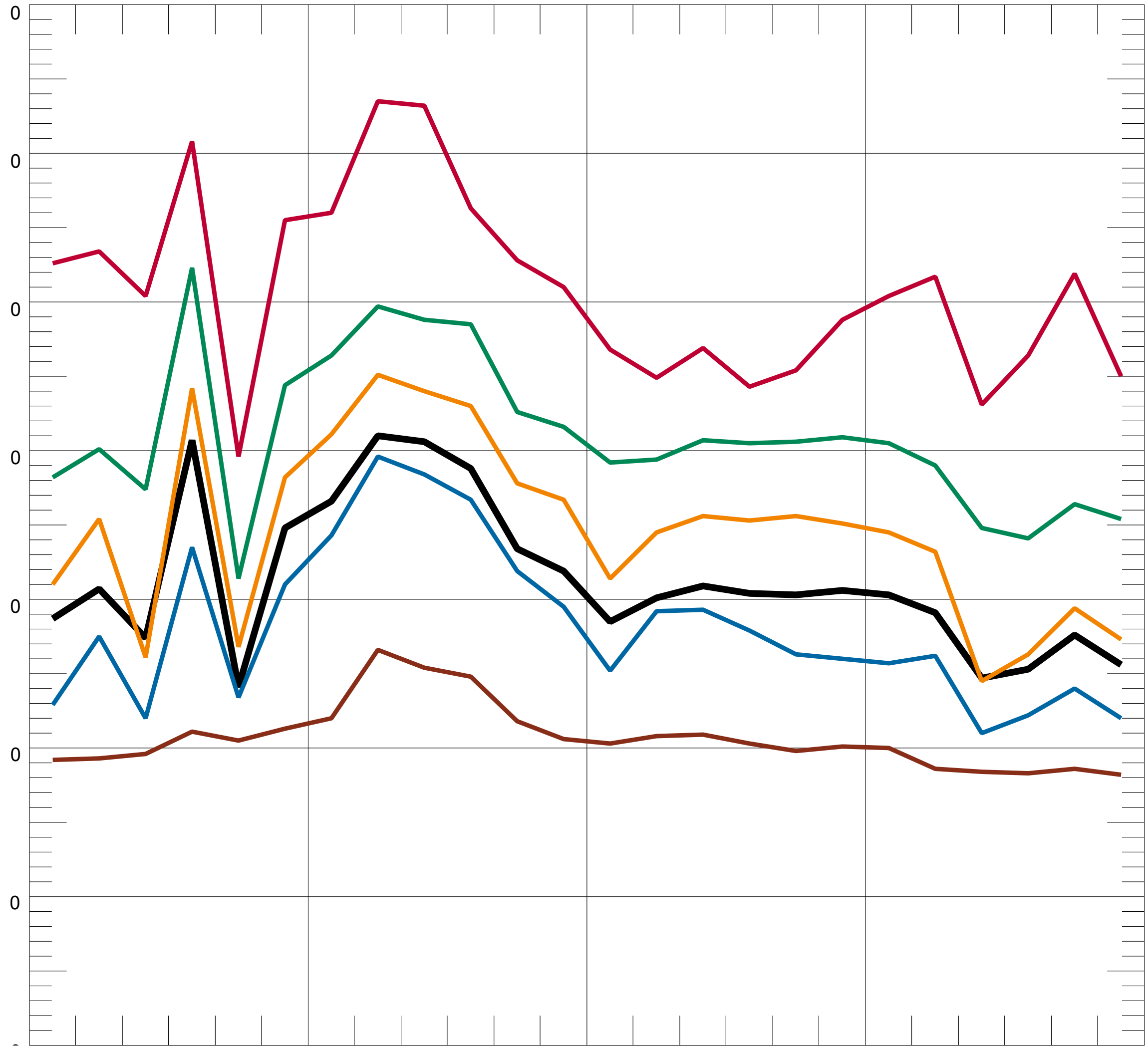

Figure A-36. Hourly Statistical Summary of Noise Levels on Oct 28, 2014 Location N5, 3600 Memorial Park Drive, Longview, WA

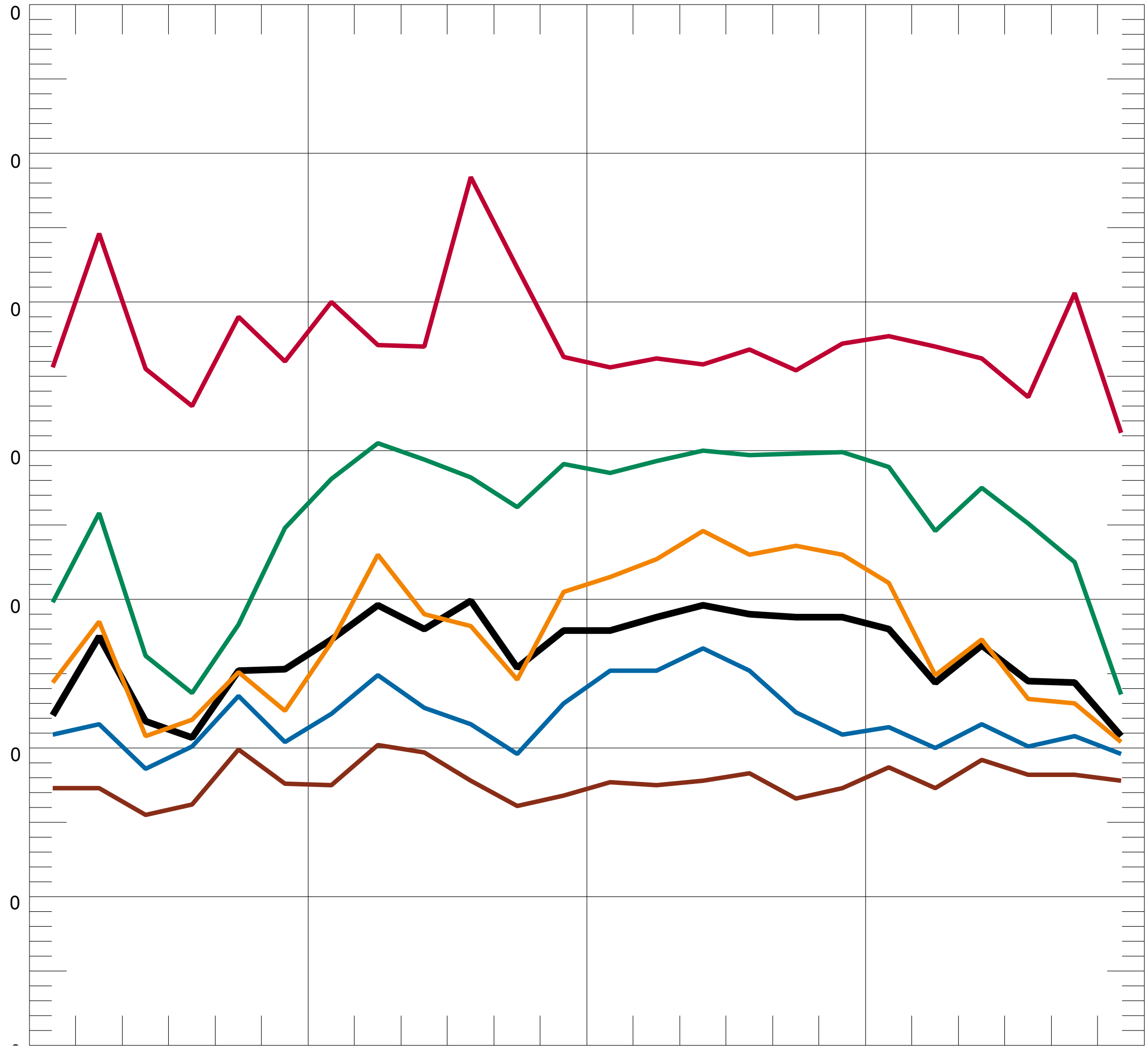

Figure A-37. Hourly Statistical Summary of Noise Levels on Oct 29, 2014 Location N5, 3600 Memorial Park Drive, Longview, WA

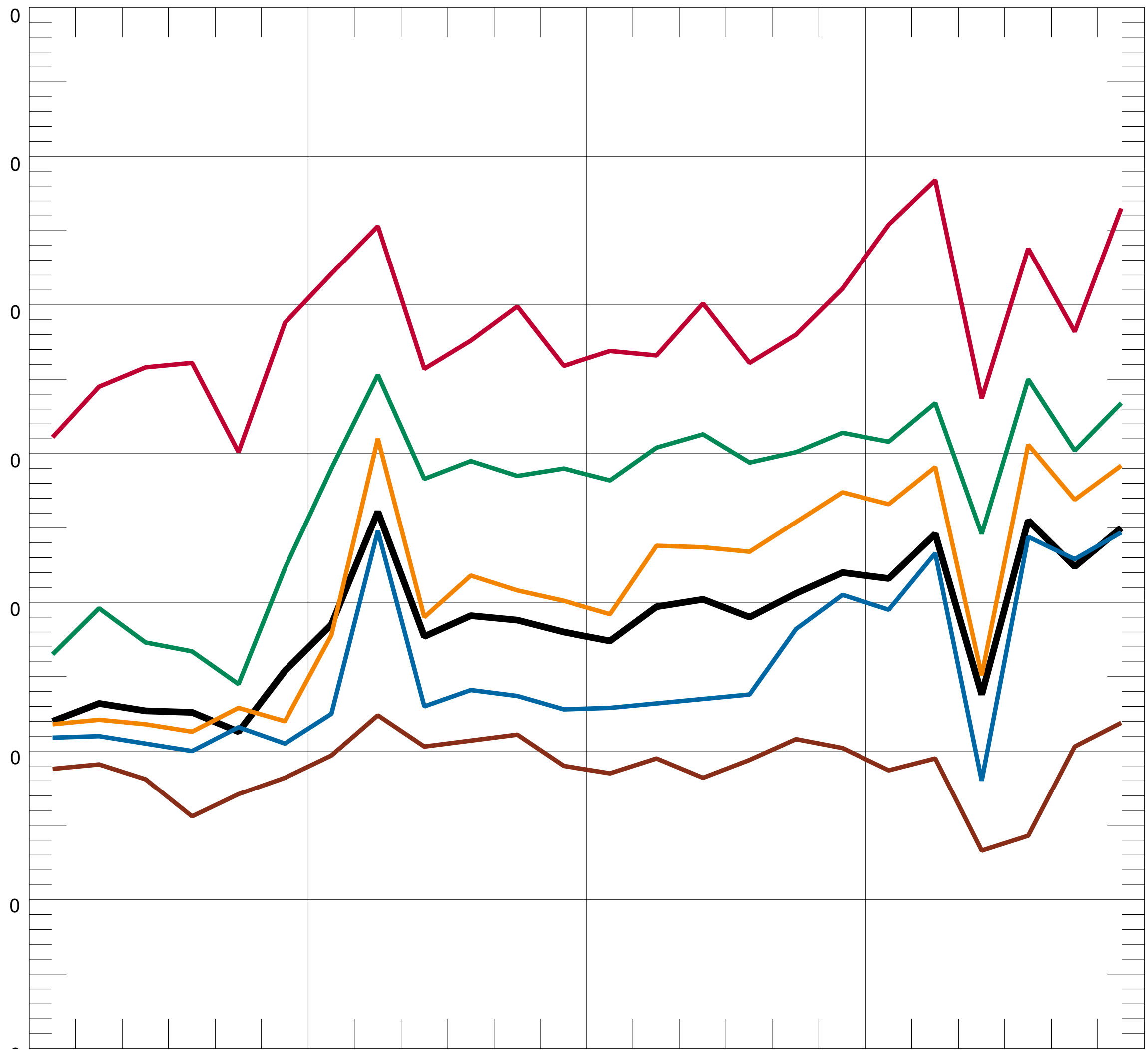

Figure A-38. Hourly Statistical Summary of Noise Levels on Oct 30, 2014 Location N5, 3600 Memorial Park Drive, Longview, WA

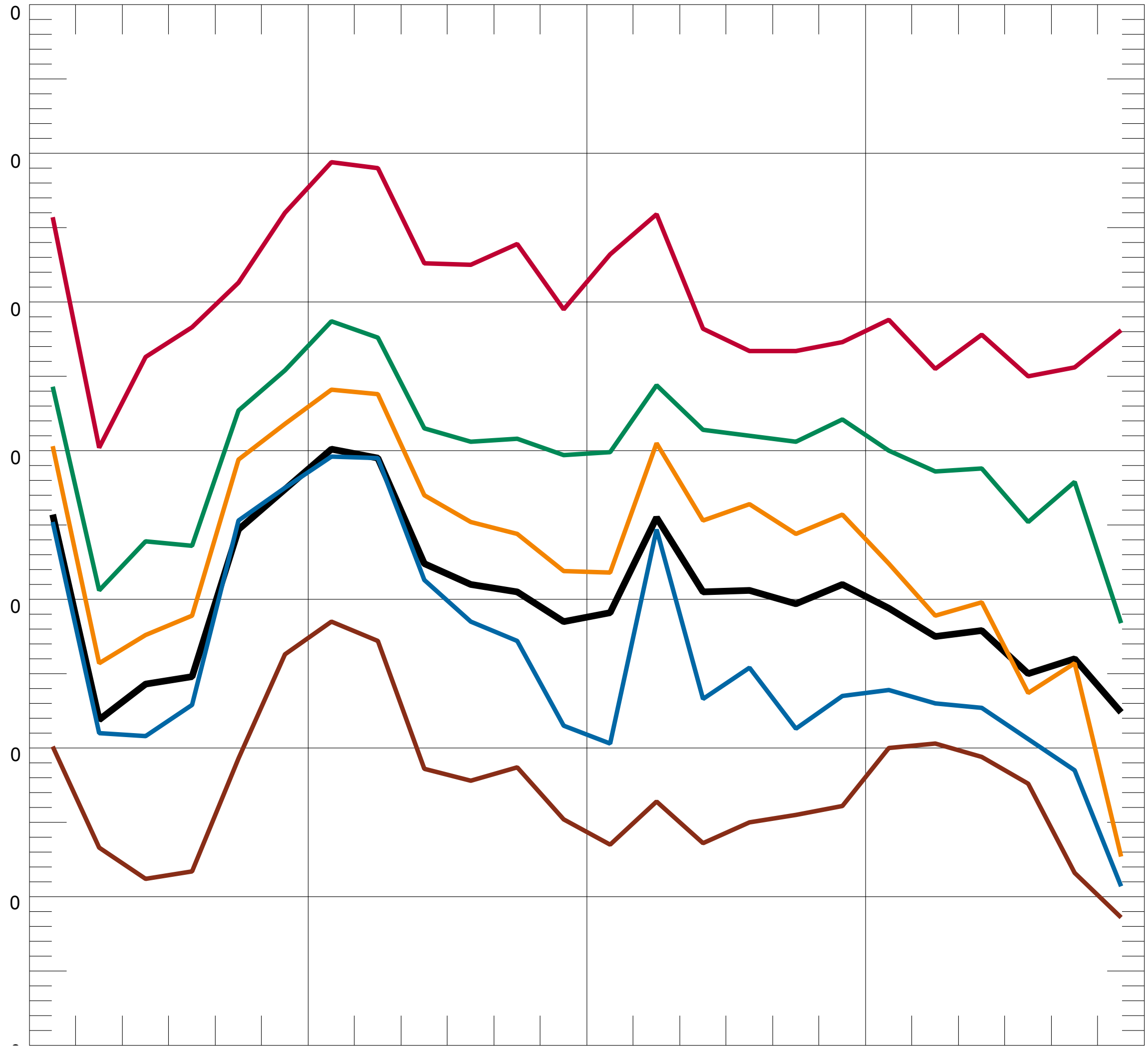

Figure A-39. Hourly Statistical Summary of Noise Levels on Oct 31, 2014 Location N5, 3600 Memorial Park Drive, Longview, WA

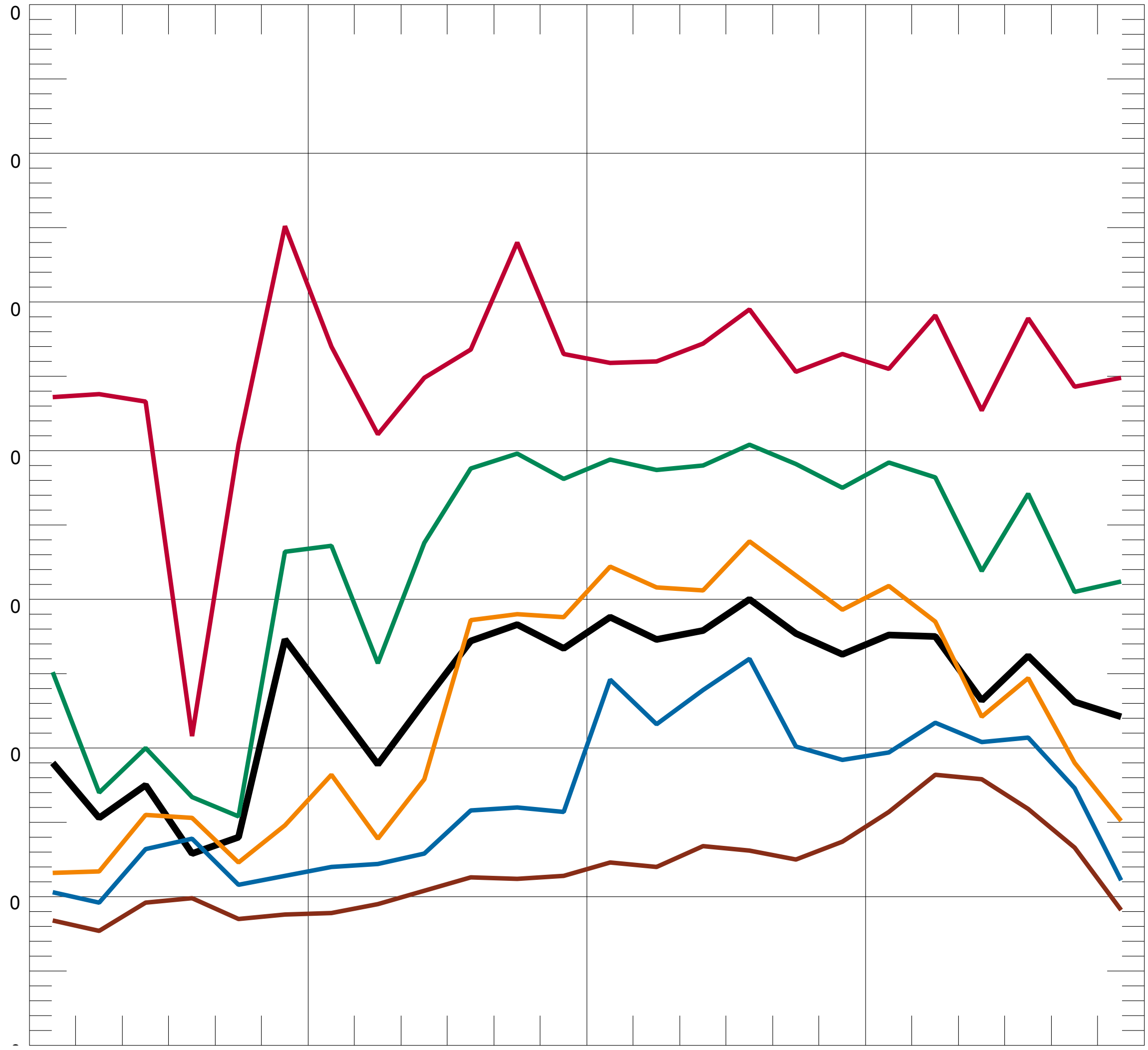

Figure A-40. Hourly Statistical Summary of Noise Levels on Nov 1, 2014 Location N5, 3600 Memorial Park Drive, Longview, WA

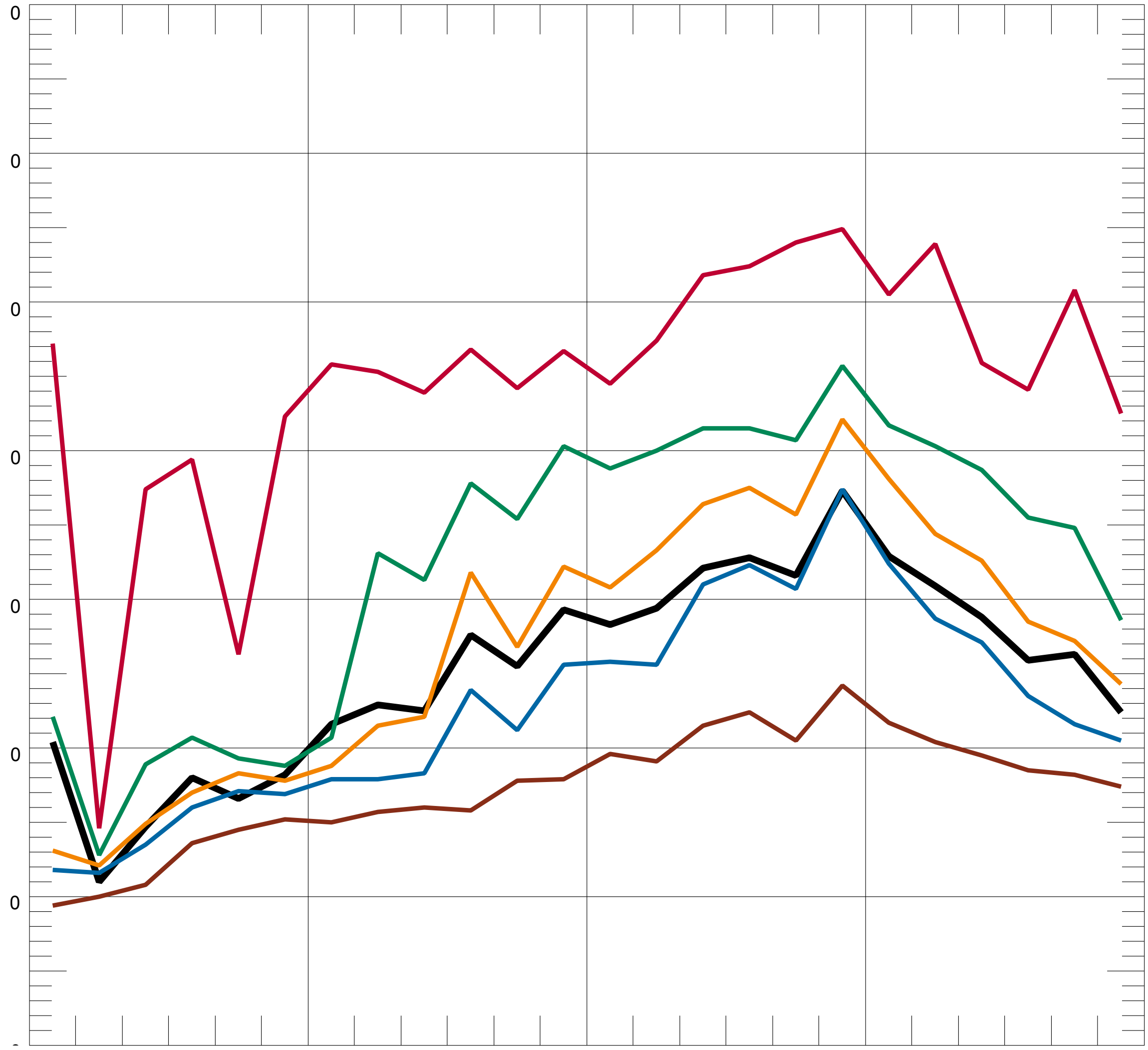

Figure A-41. Hourly Statistical Summary of Noise Levels on Nov 2, 2014 Location N5, 3600 Memorial Park Drive, Longview, WA

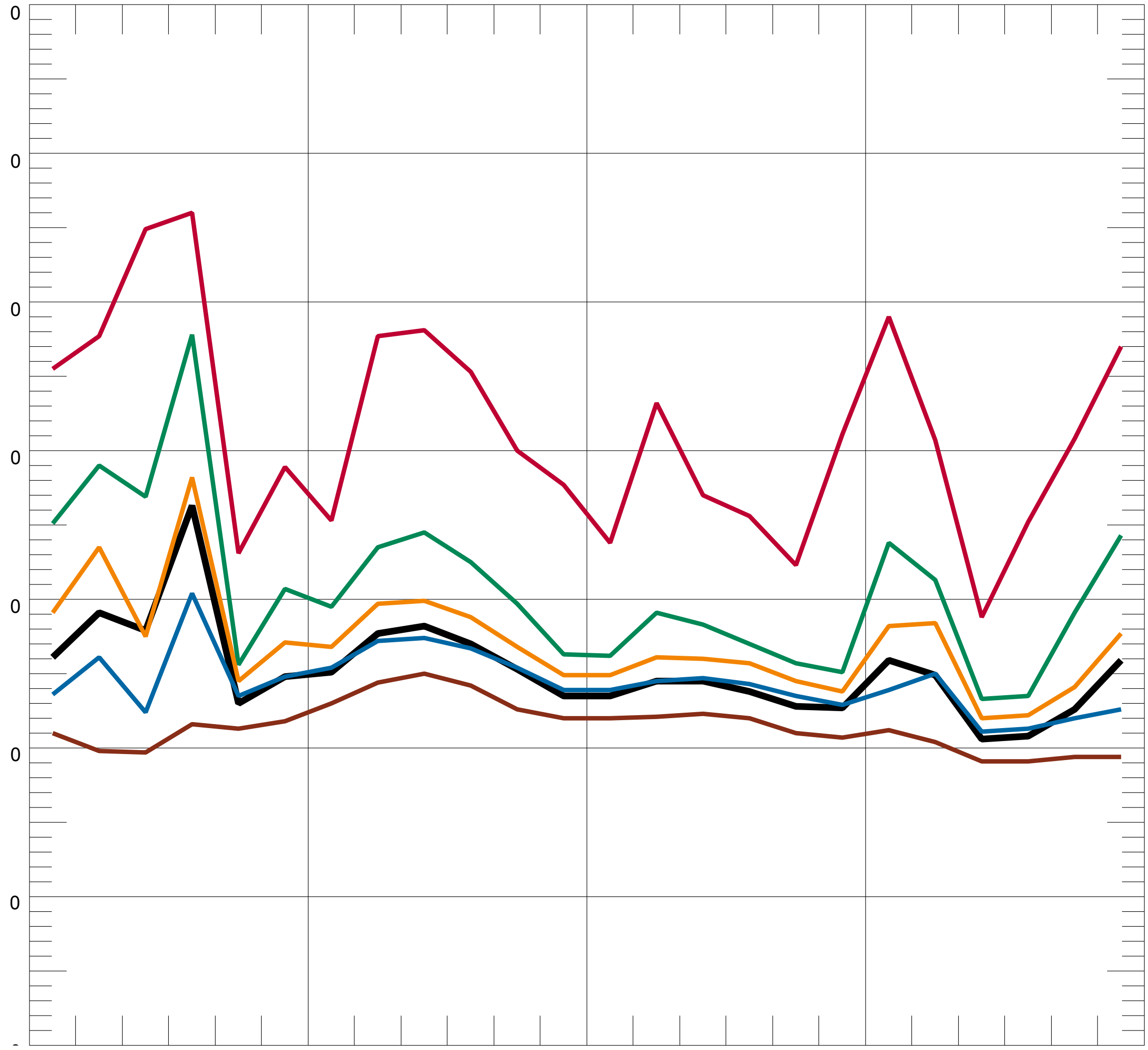

Figure A-42. Hourly Statistical Summary of Noise Levels on Oct 28, 2014 Location N6, 420 Rutherglen Drive, Longview, WA

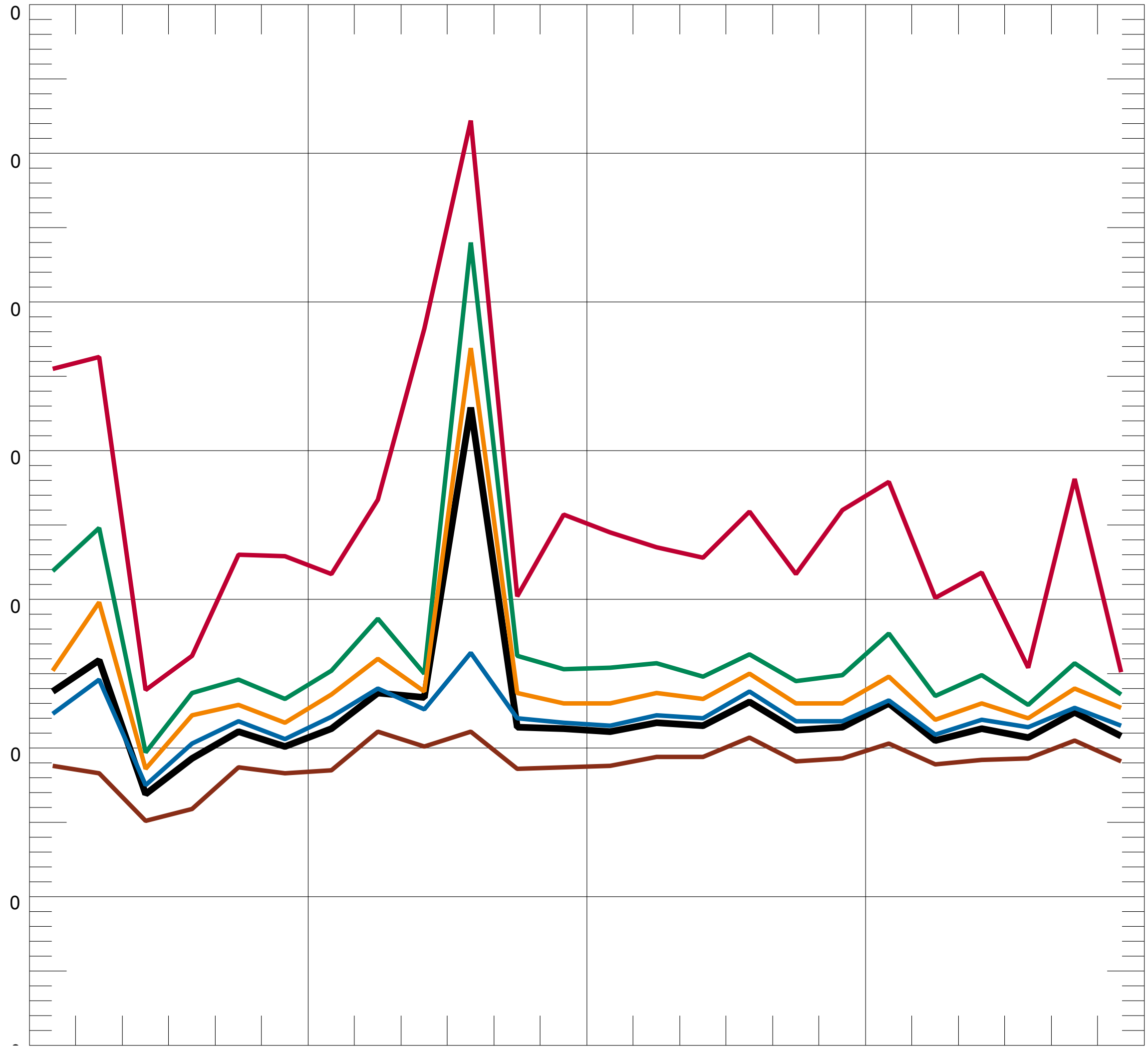

Figure A-43. Hourly Statistical Summary of Noise Levels on Oct 29, 2014 Location N6, 420 Rutherglen Drive, Longview, WA

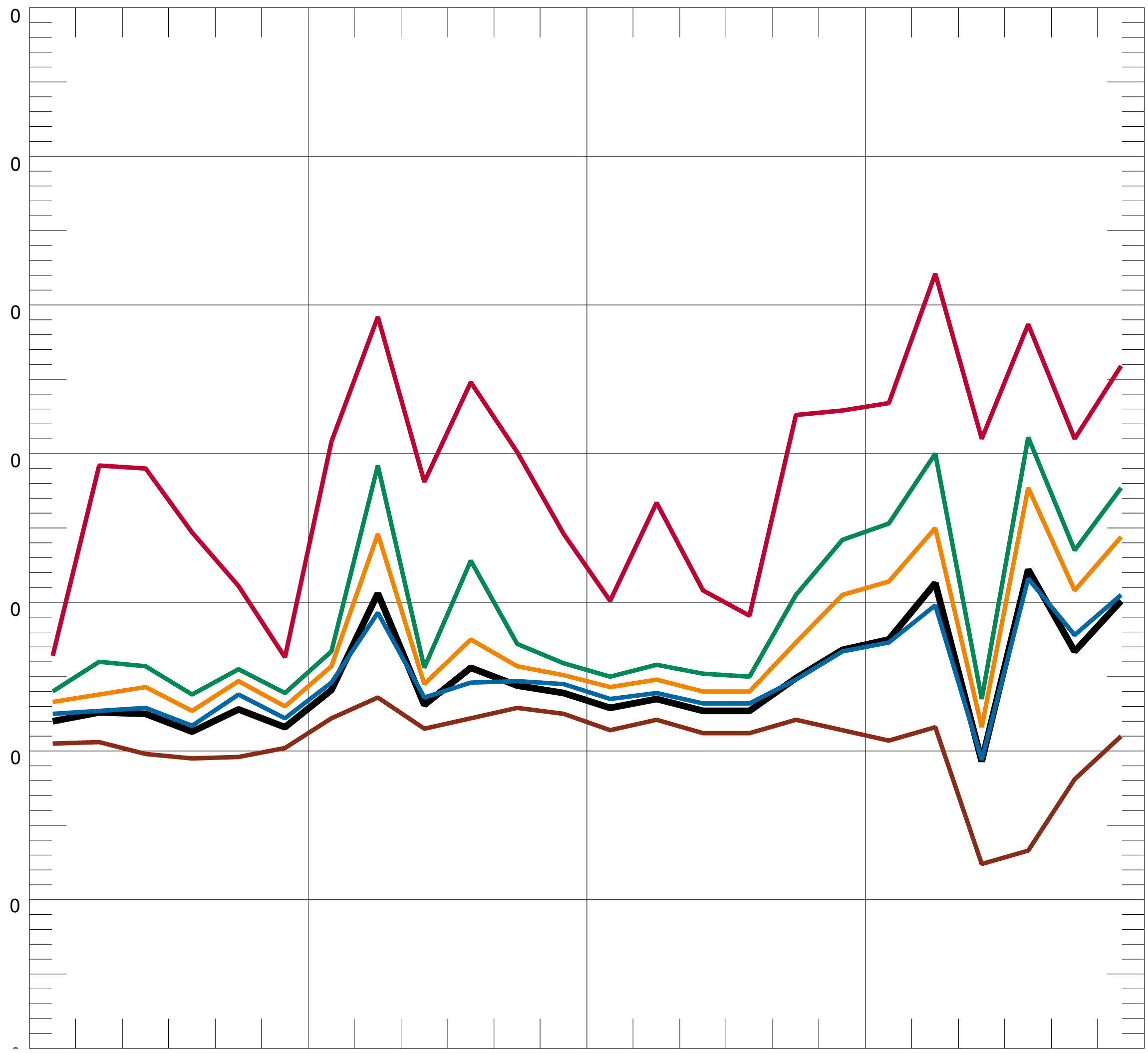

Figure A-44. Hourly Statistical Summary of Noise Levels on Oct 30, 2014 Location N6, 420 Rutherglen Drive, Longview, WA

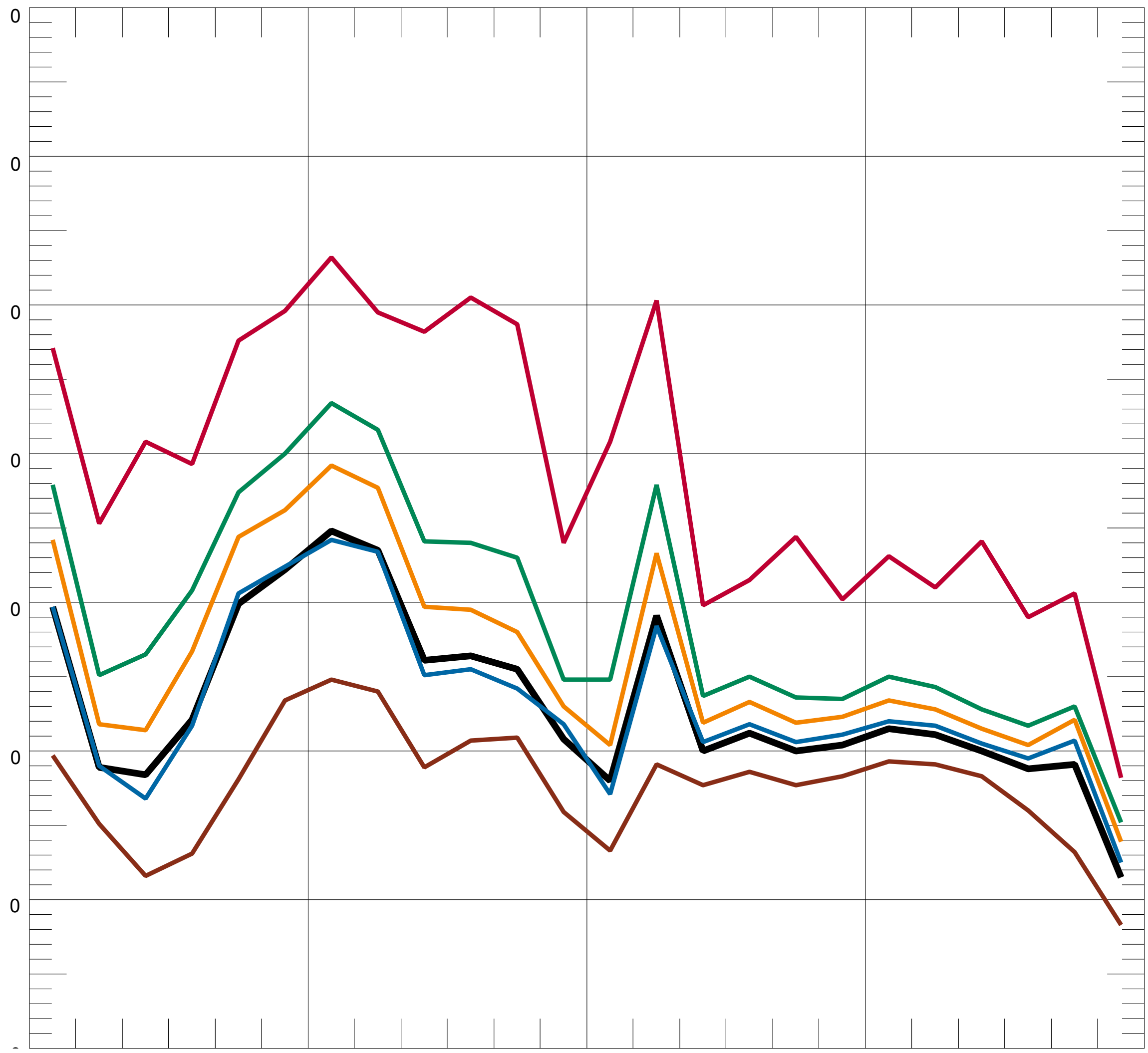

Figure A-45. Hourly Statistical Summary of Noise Levels on Oct 31, 2014 Location N6, 420 Rutherglen Drive, Longview, WA

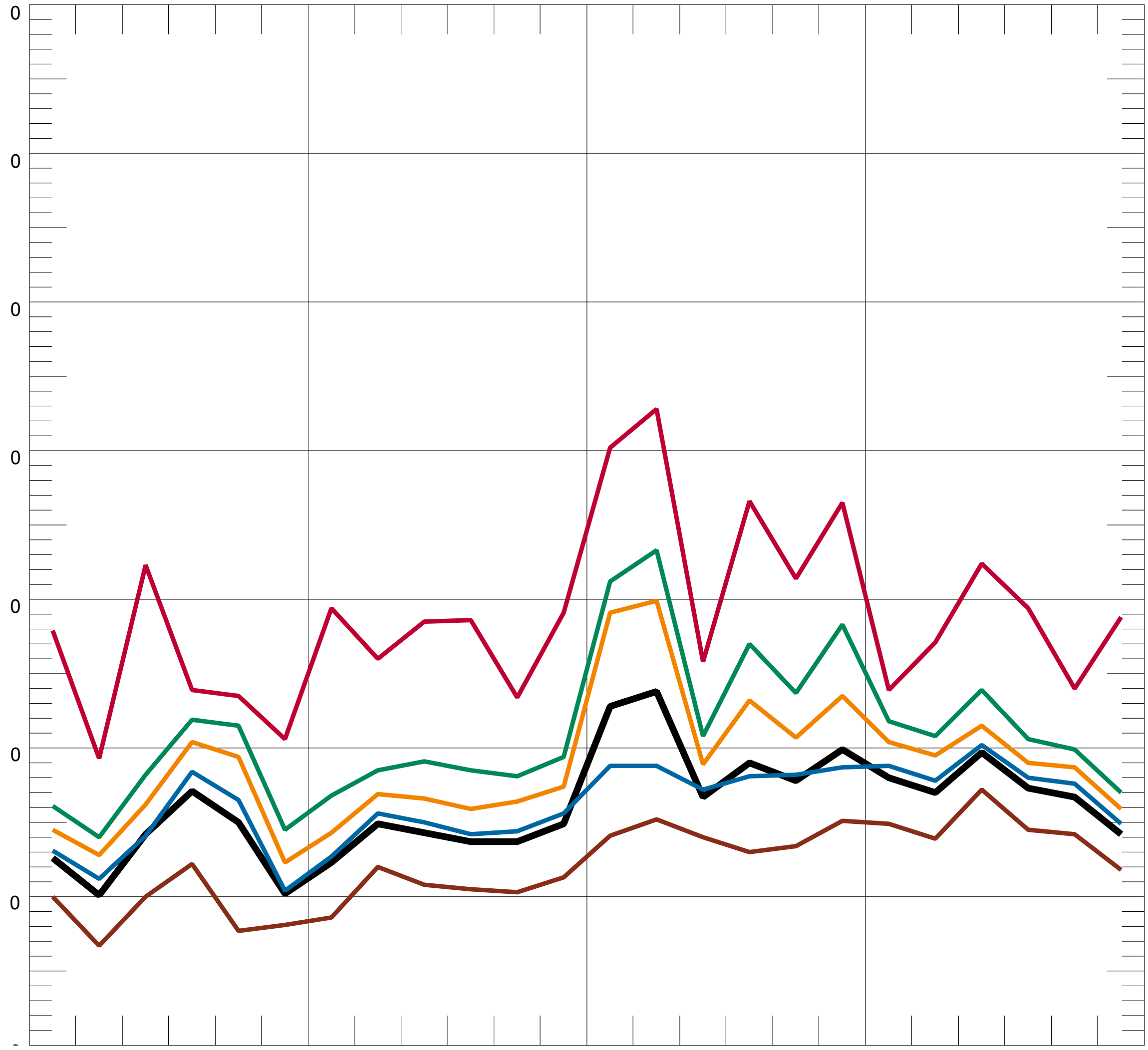

Figure A-46. Hourly Statistical Summary of Noise Levels on Nov 1, 2014 Location N6, 420 Rutherglen Drive, Longview, WA

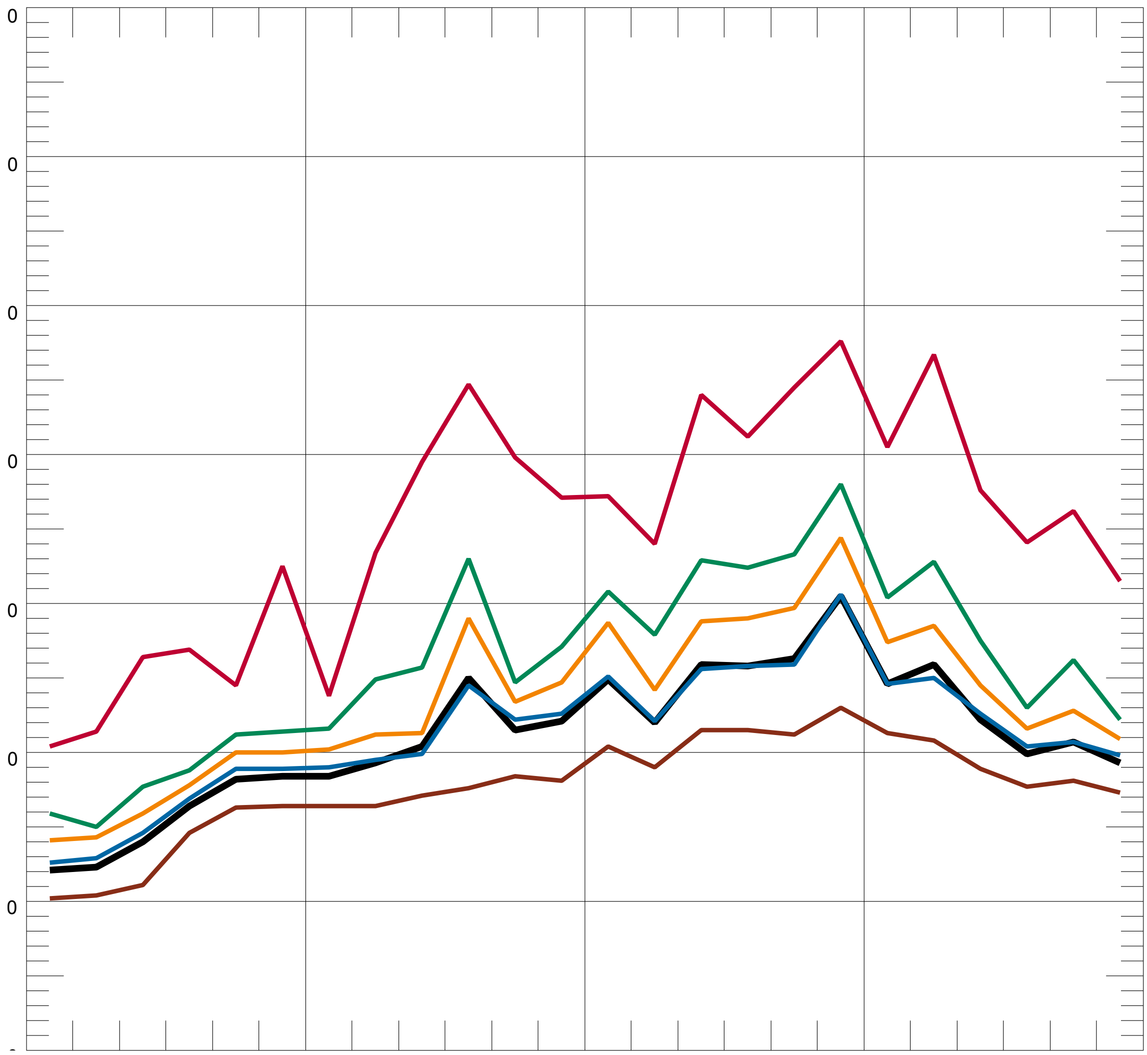

Figure A-47. Hourly Statistical Summary of Noise Levels on Nov 2, 2014 Location N6, 420 Rutherglen Drive, Longview, WA

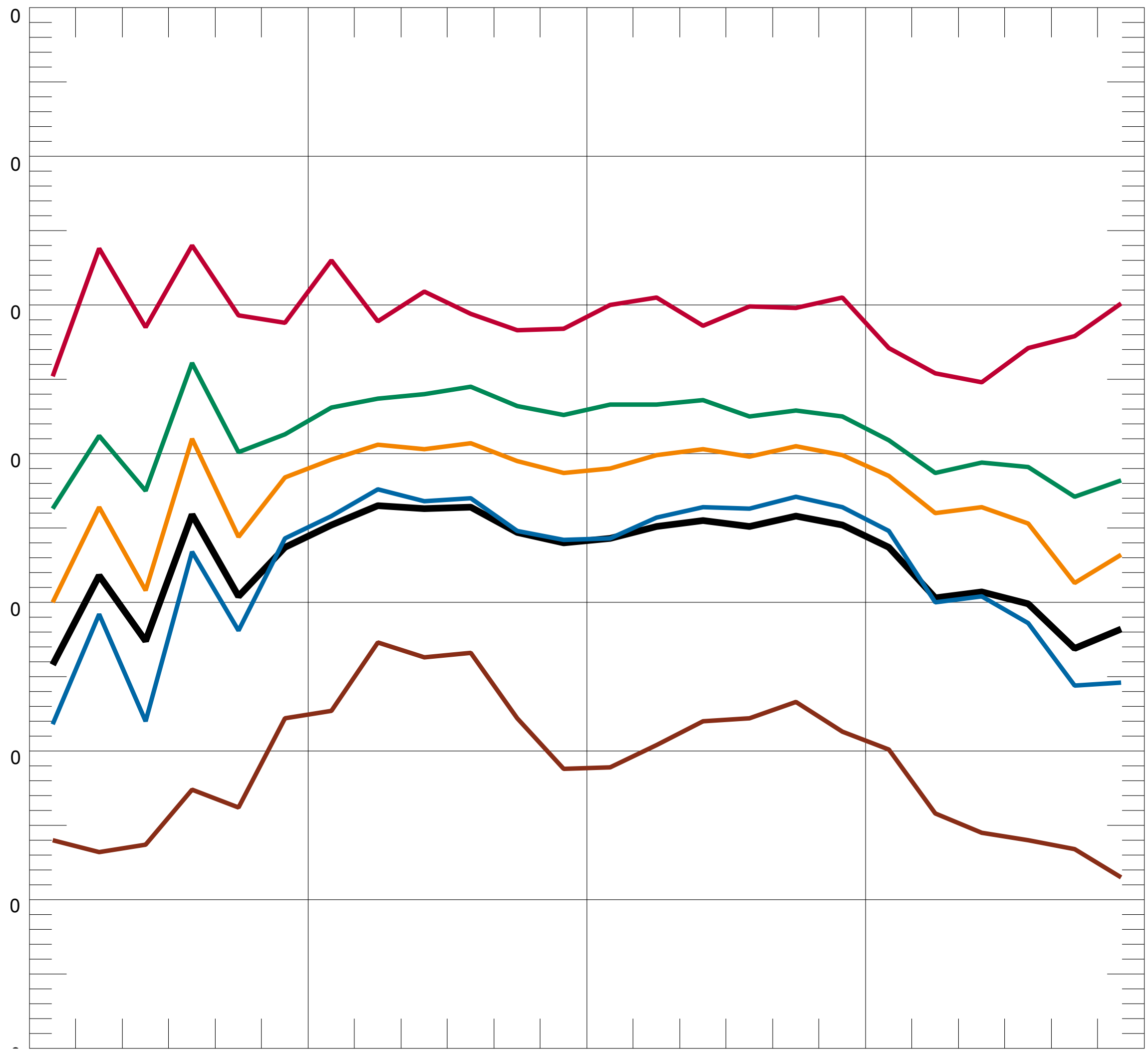

Figure A-48. Hourly Statistical Summary of Noise Levels on Oct 28, 2014 Location N7, 4723 Mount Solo Road, Longview, WA

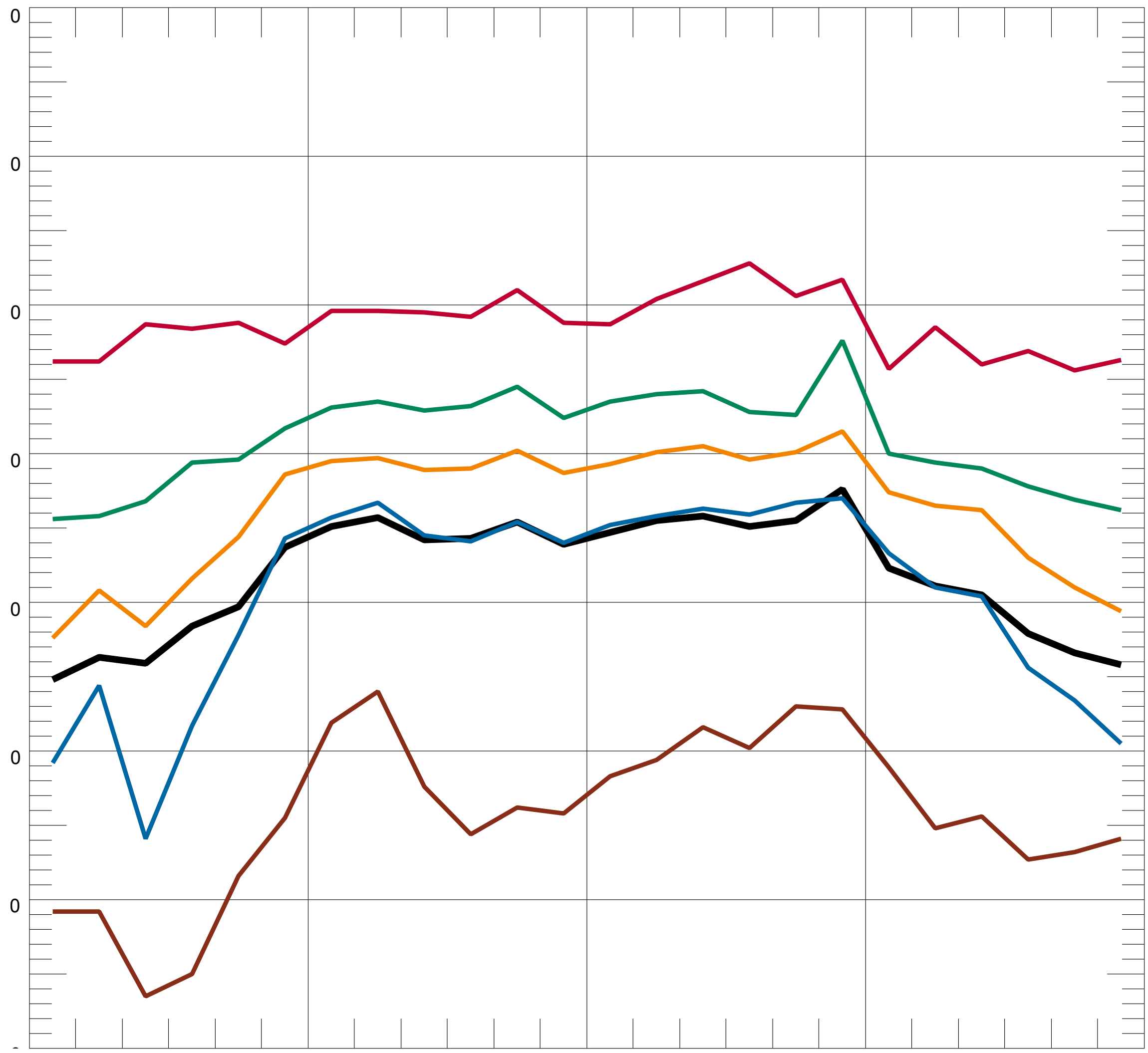

Figure A-49. Hourly Statistical Summary of Noise Levels on Oct 29, 2014 Location N7, 4723 Mount Solo Road, Longview, WA

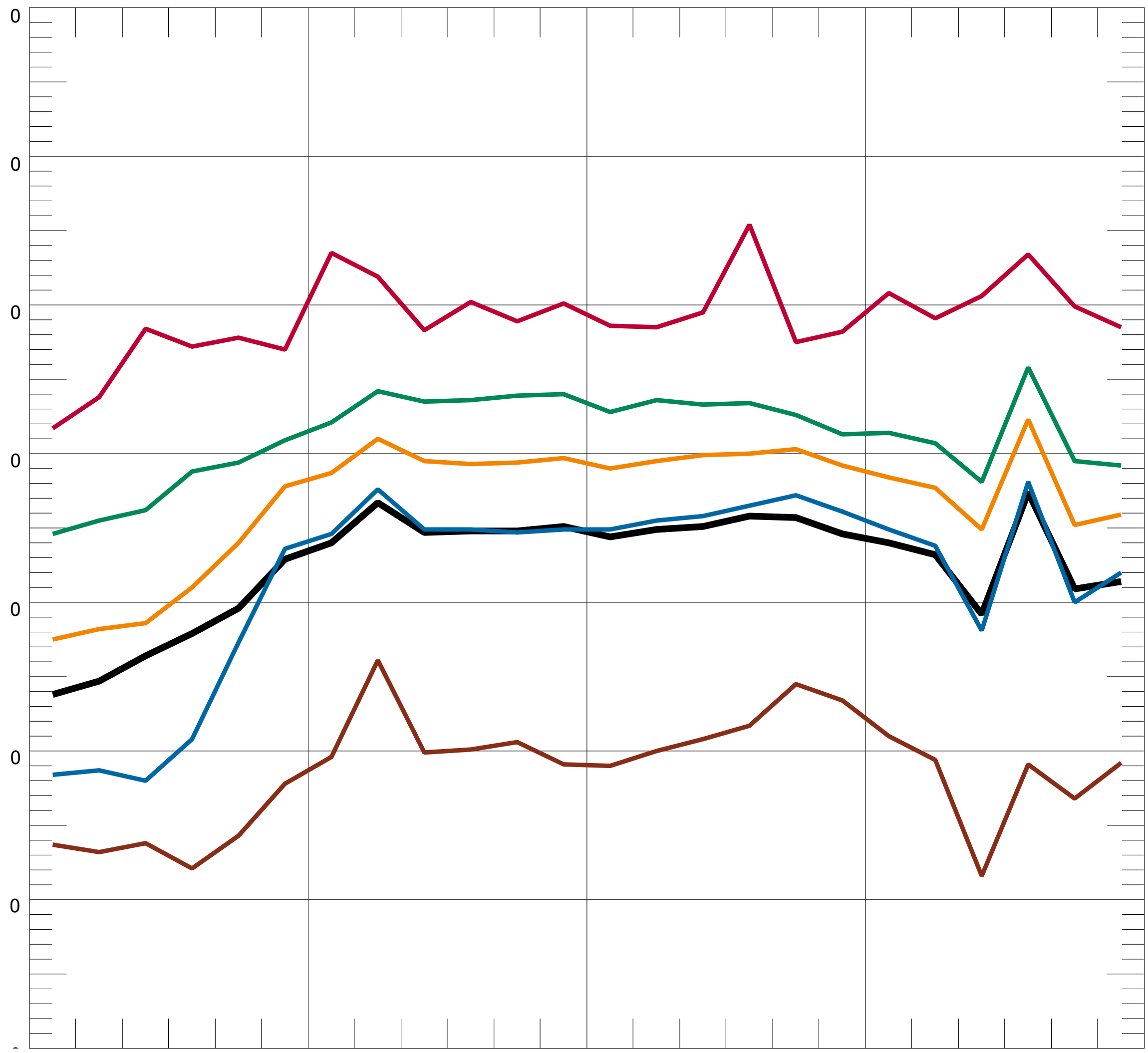

Figure A-50. Hourly Statistical Summary of Noise Levels on Oct 30, 2014 Location N7, 4723 Mount Solo Road, Longview, WA

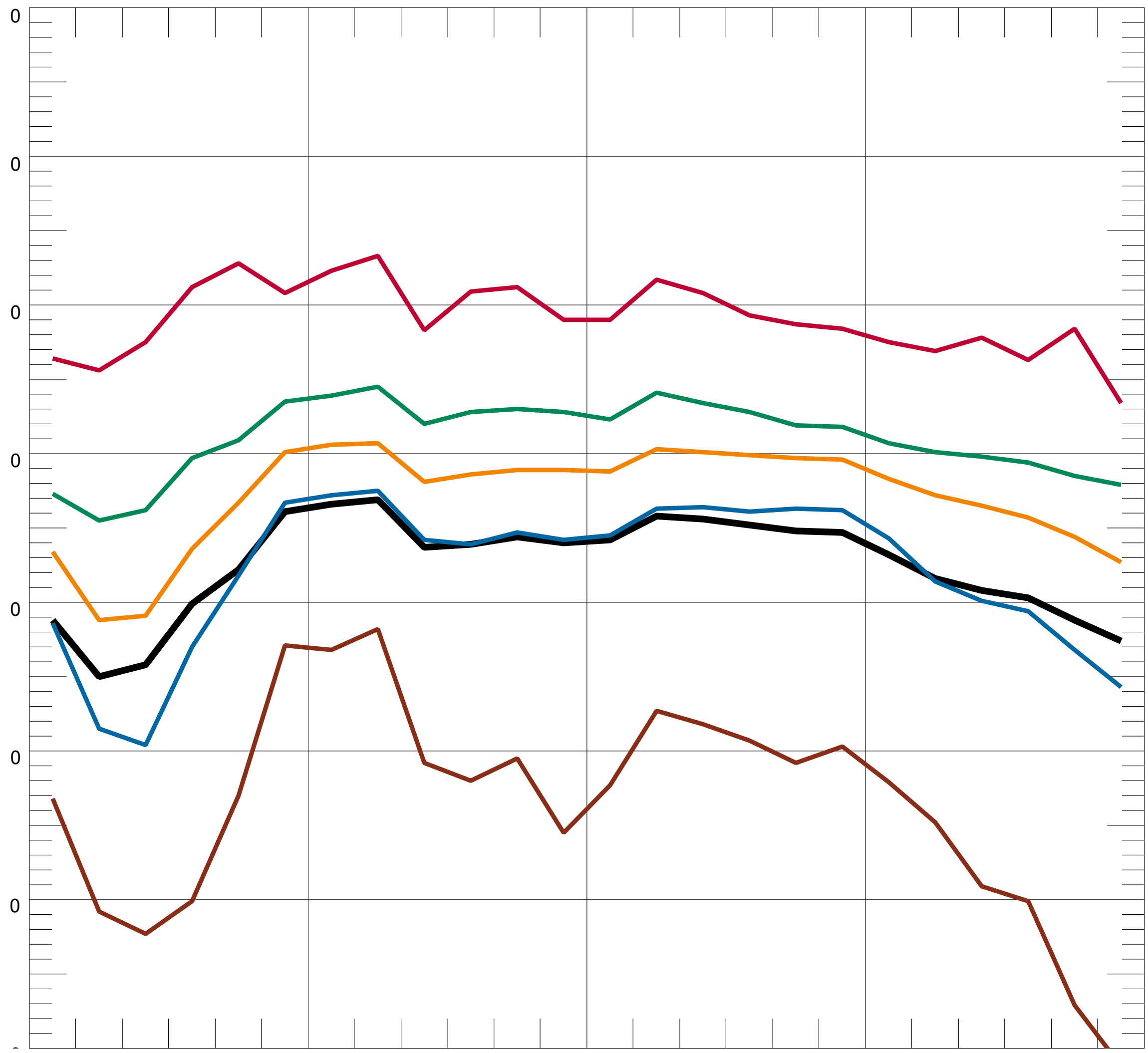

Figure A-51. Hourly Statistical Summary of Noise Levels on Oct 31, 2014 Location N7, 4723 Mount Solo Road, Longview, WA

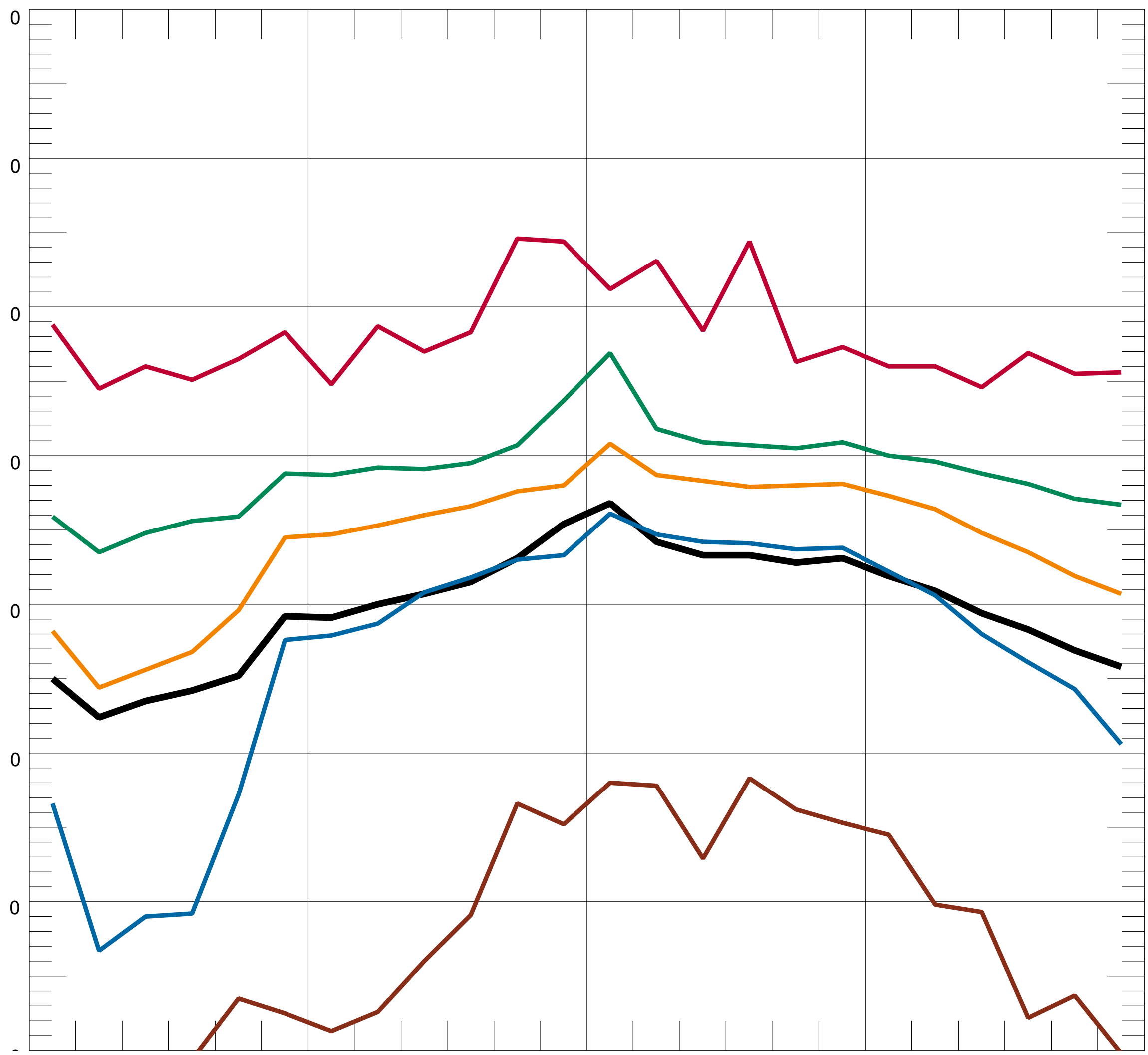

Figure A-52. Hourly Statistical Summary of Noise Levels on Nov 1, 2014 Location N7, 4723 Mount Solo Road, Longview, WA

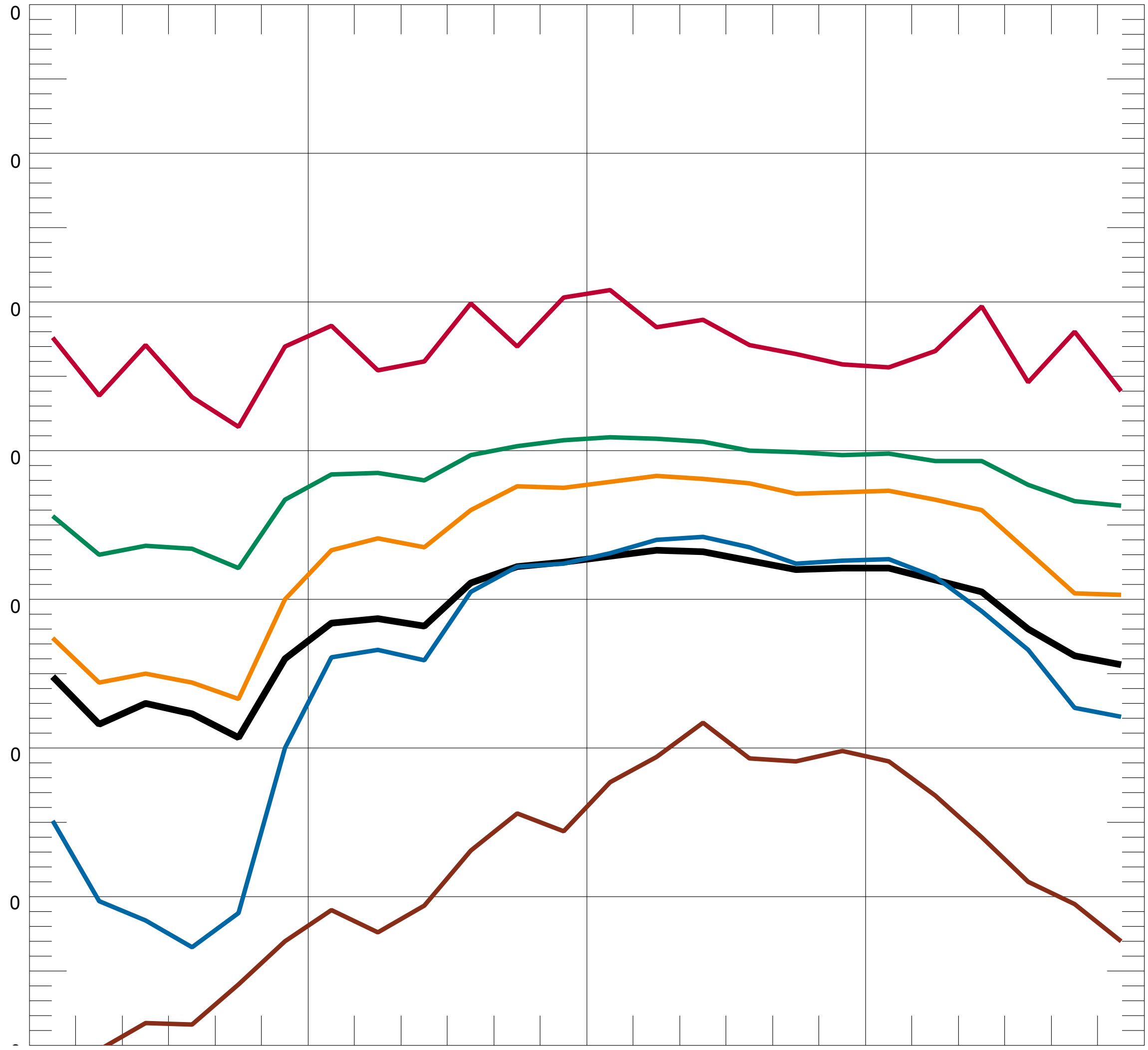

Figure A-53. Hourly Statistical Summary of Noise Levels on Nov 2, 2014 Location N7, 4723 Mount Solo Road, Longview, WA

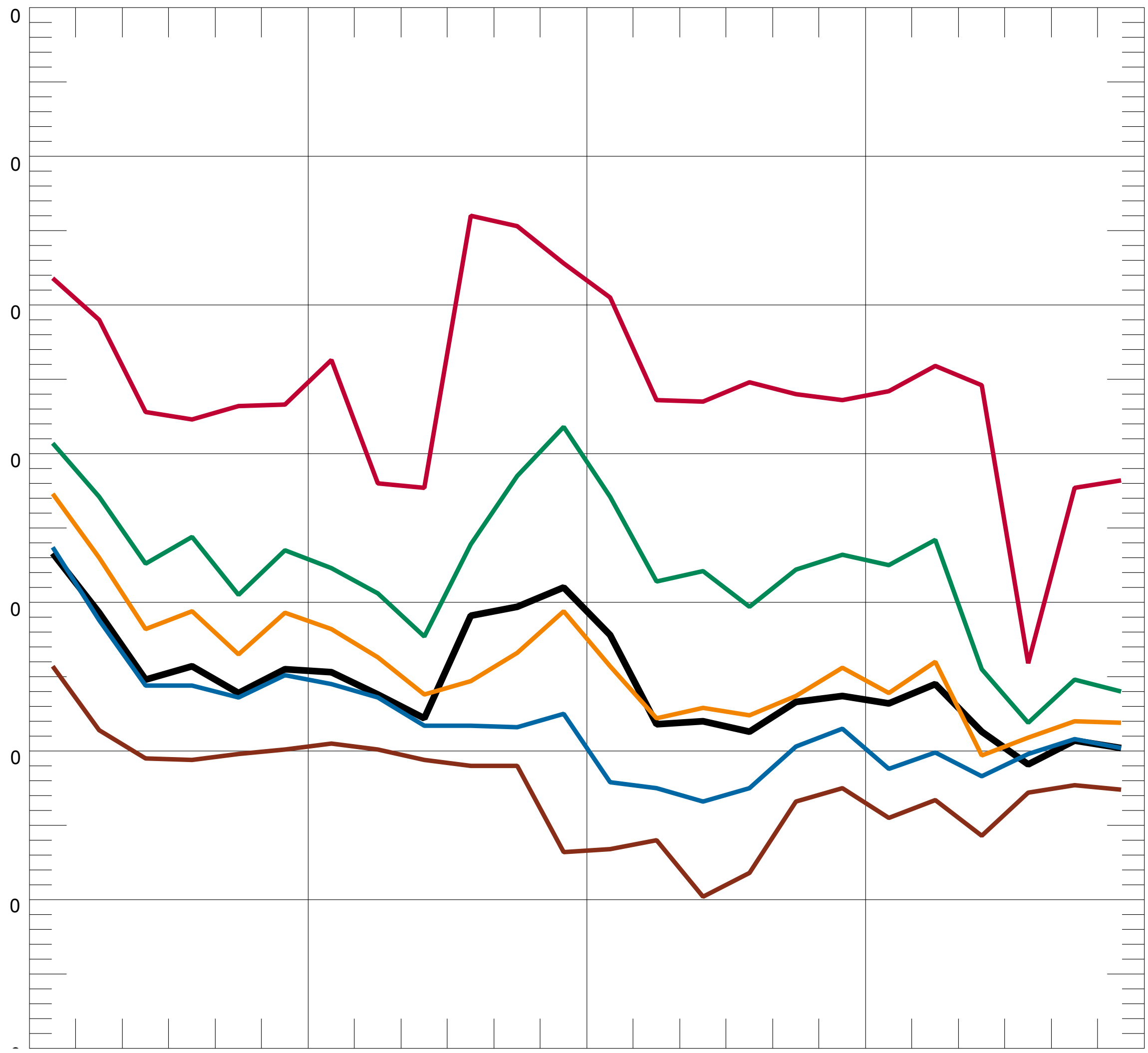

Figure A-54. Hourly Statistical Summary of Noise Levels on Nov 4, 2014 Location N8, 1719 Dorothy Avenue, Longview, WA

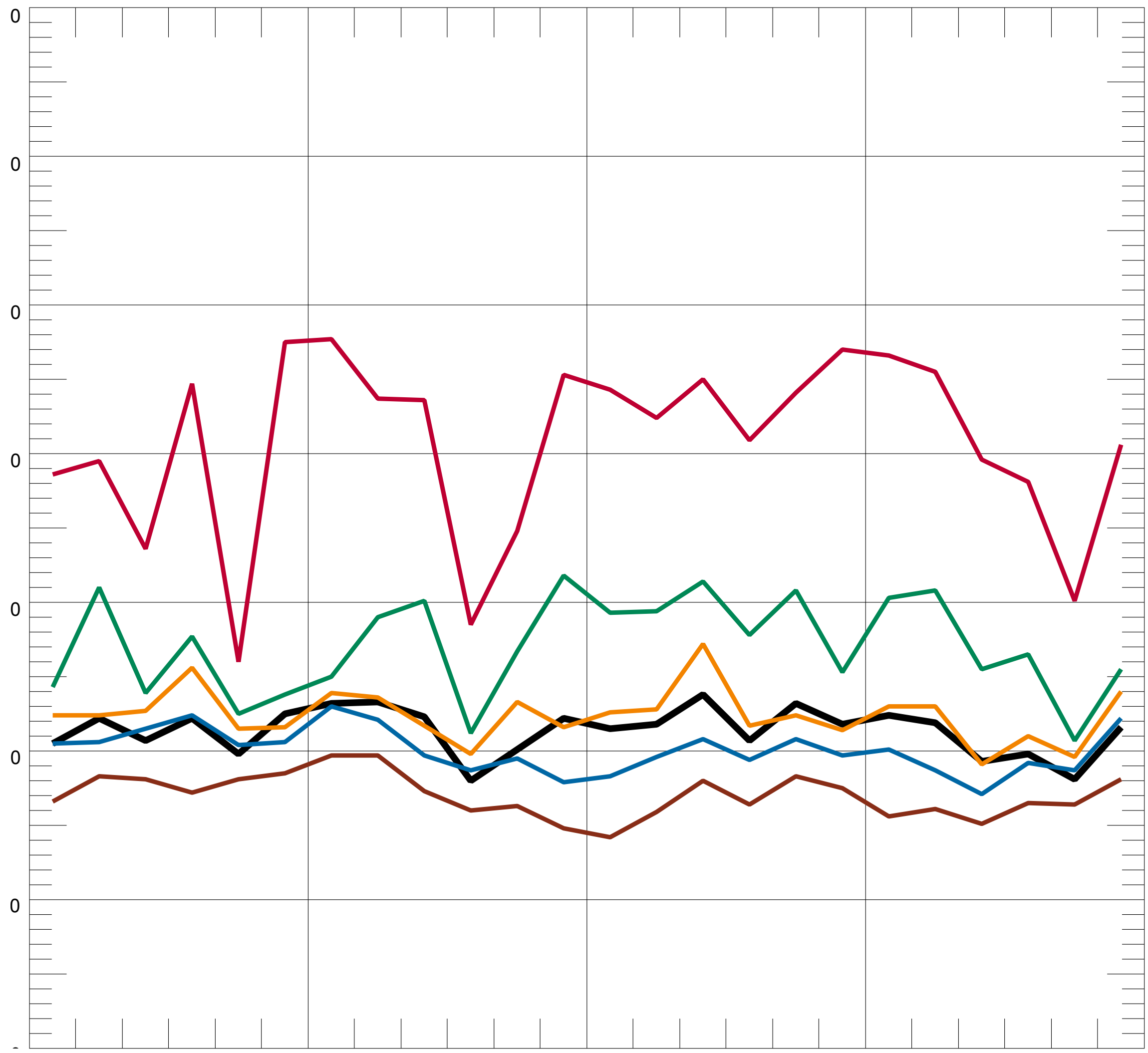

Figure A-55. Hourly Statistical Summary of Noise Levels on Nov 5, 2014 Location N8, 1719 Dorothy Avenue, Longview, WA

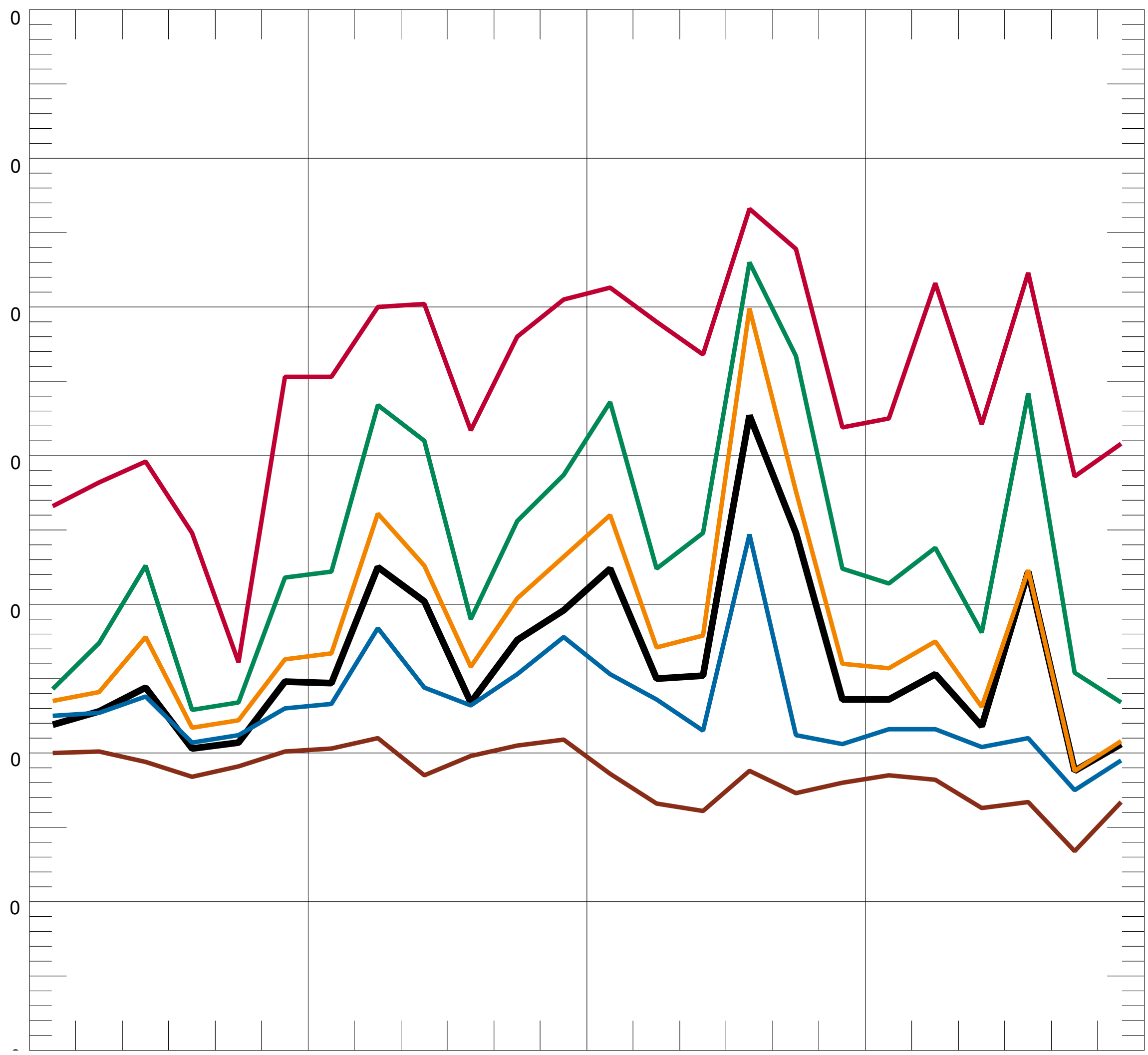

Figure A-56. Hourly Statistical Summary of Noise Levels on Nov 6, 2014 Location N8, 1719 Dorothy Avenue, Longview, WA

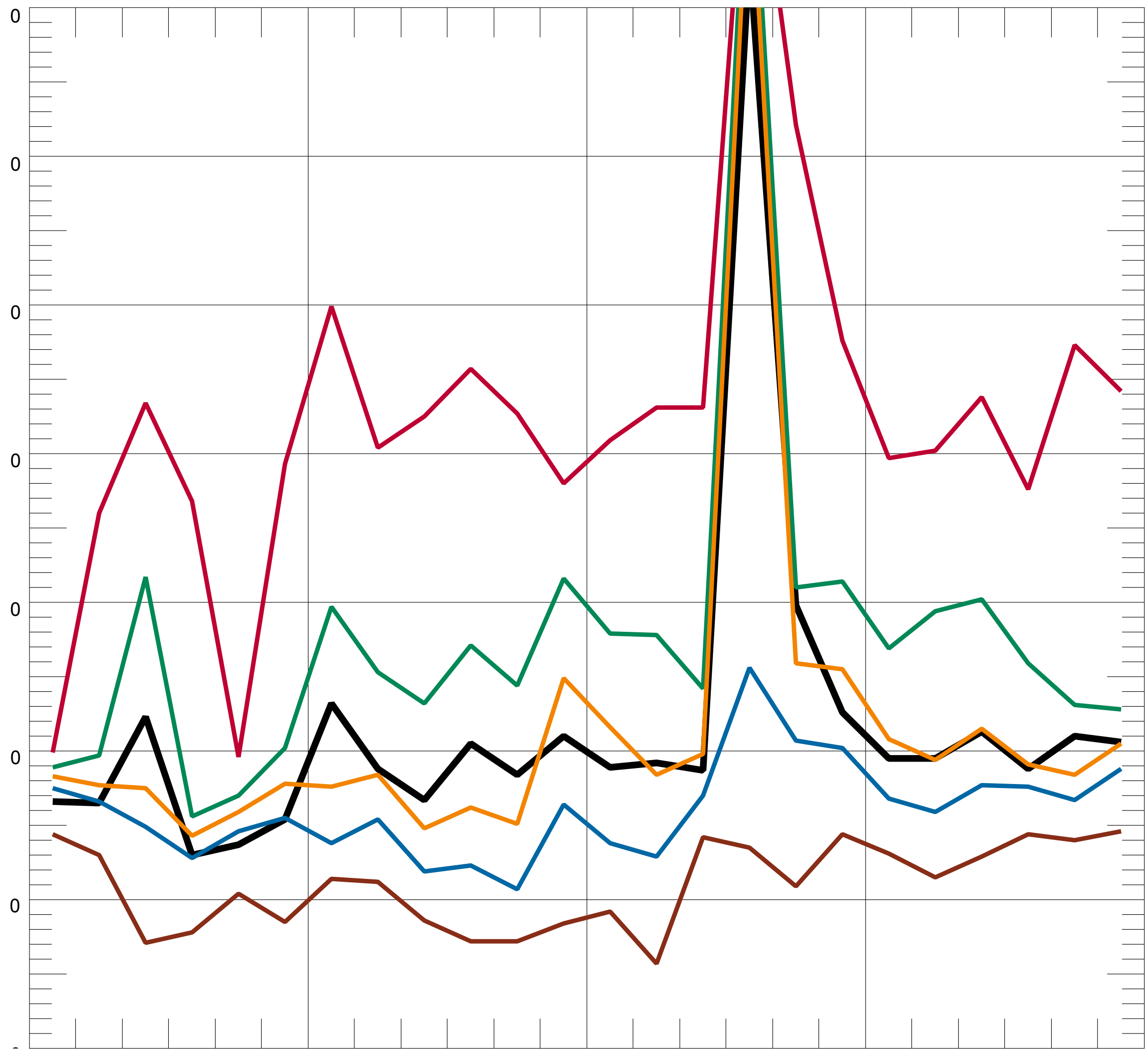

Figure A-57. Hourly Statistical Summary of Noise Levels on Nov 7, 2014 Location N8, 1719 Dorothy Avenue, Longview, WA

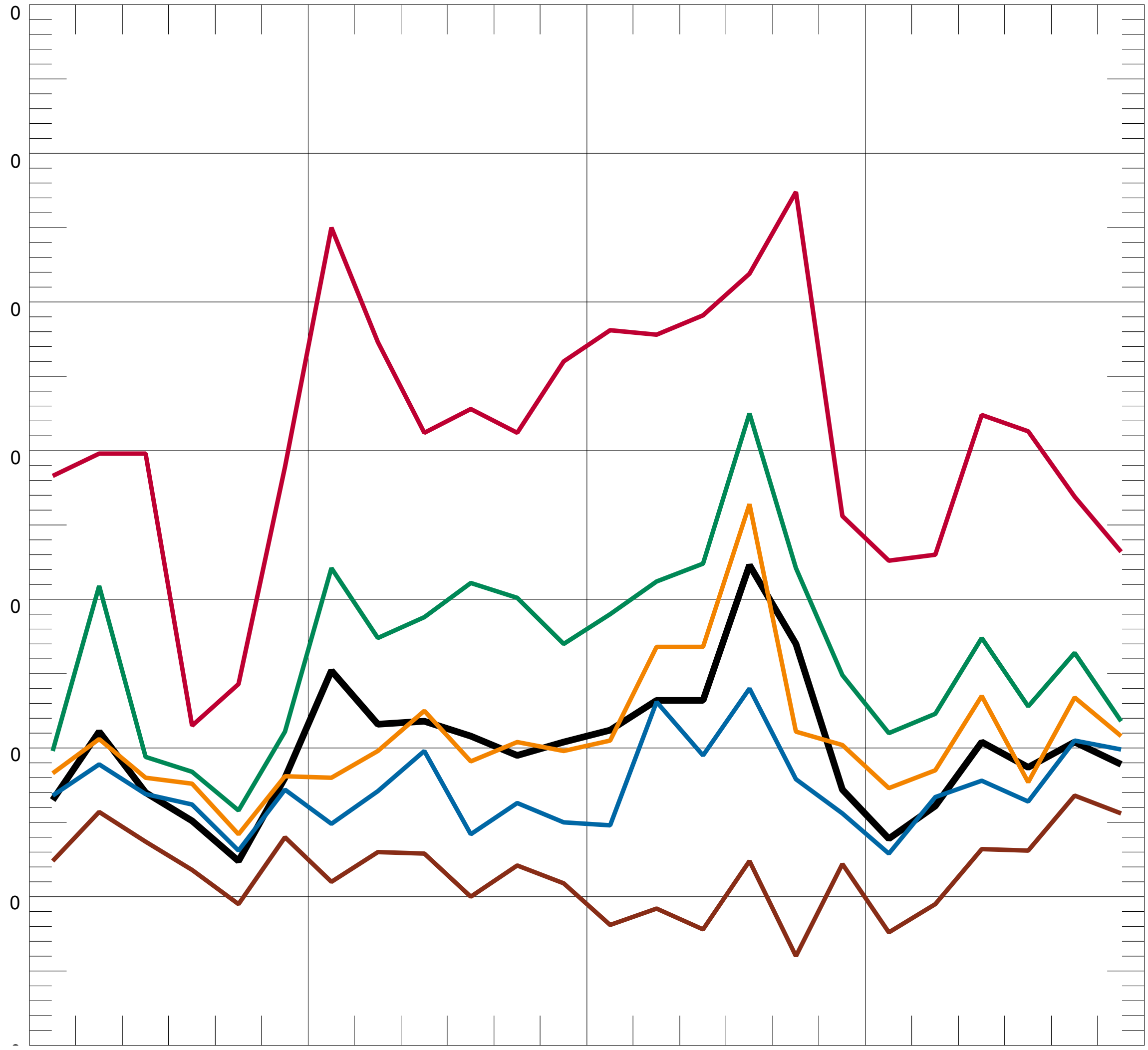

Figure A-58. Hourly Statistical Summary of Noise Levels on Nov 8, 2014 Location N8, 1719 Dorothy Avenue, Longview, WA

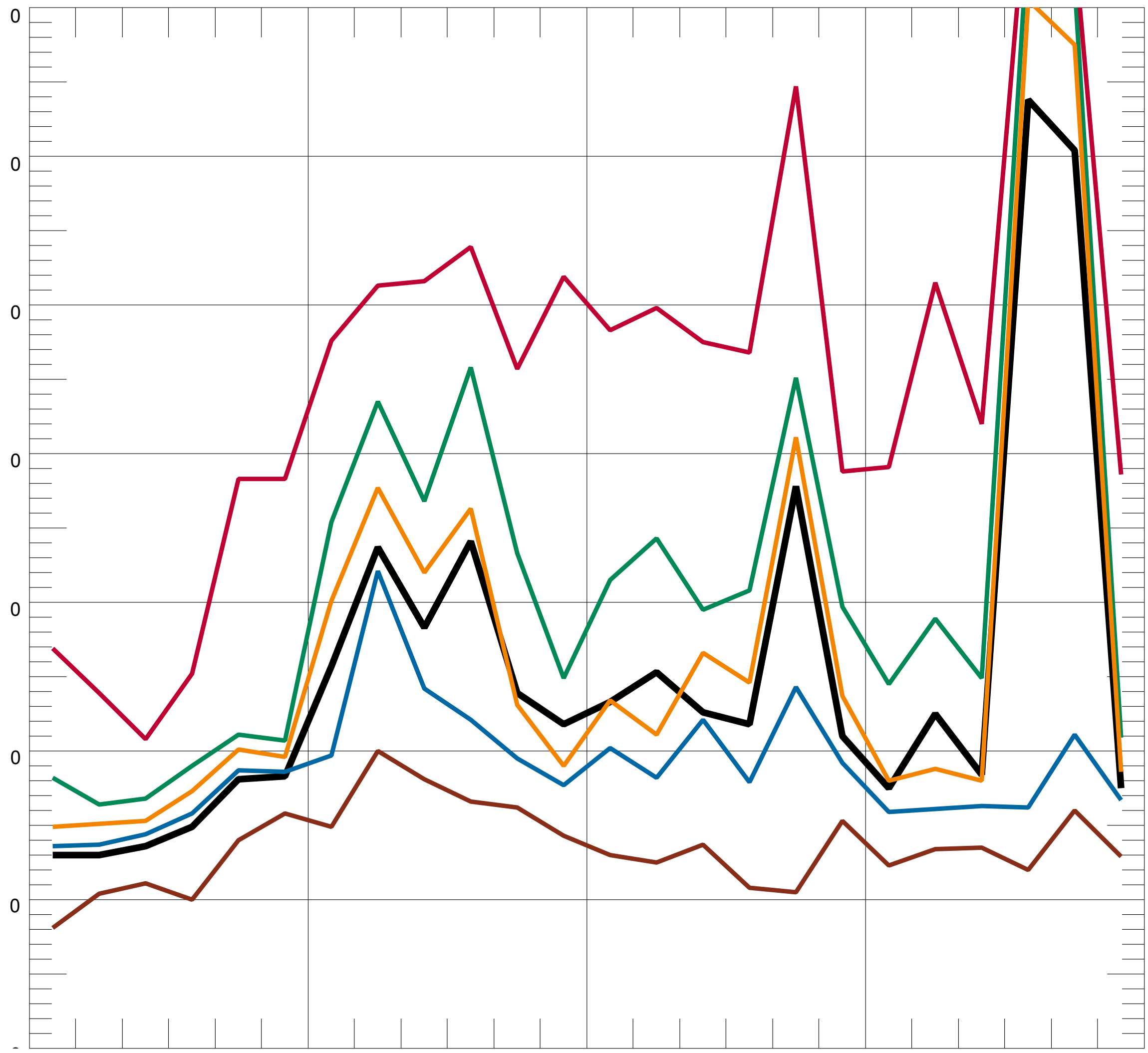

Figure A-59. Hourly Statistical Summary of Noise Levels on Nov 9, 2014 Location N8, 1719 Dorothy Avenue, Longview, WA

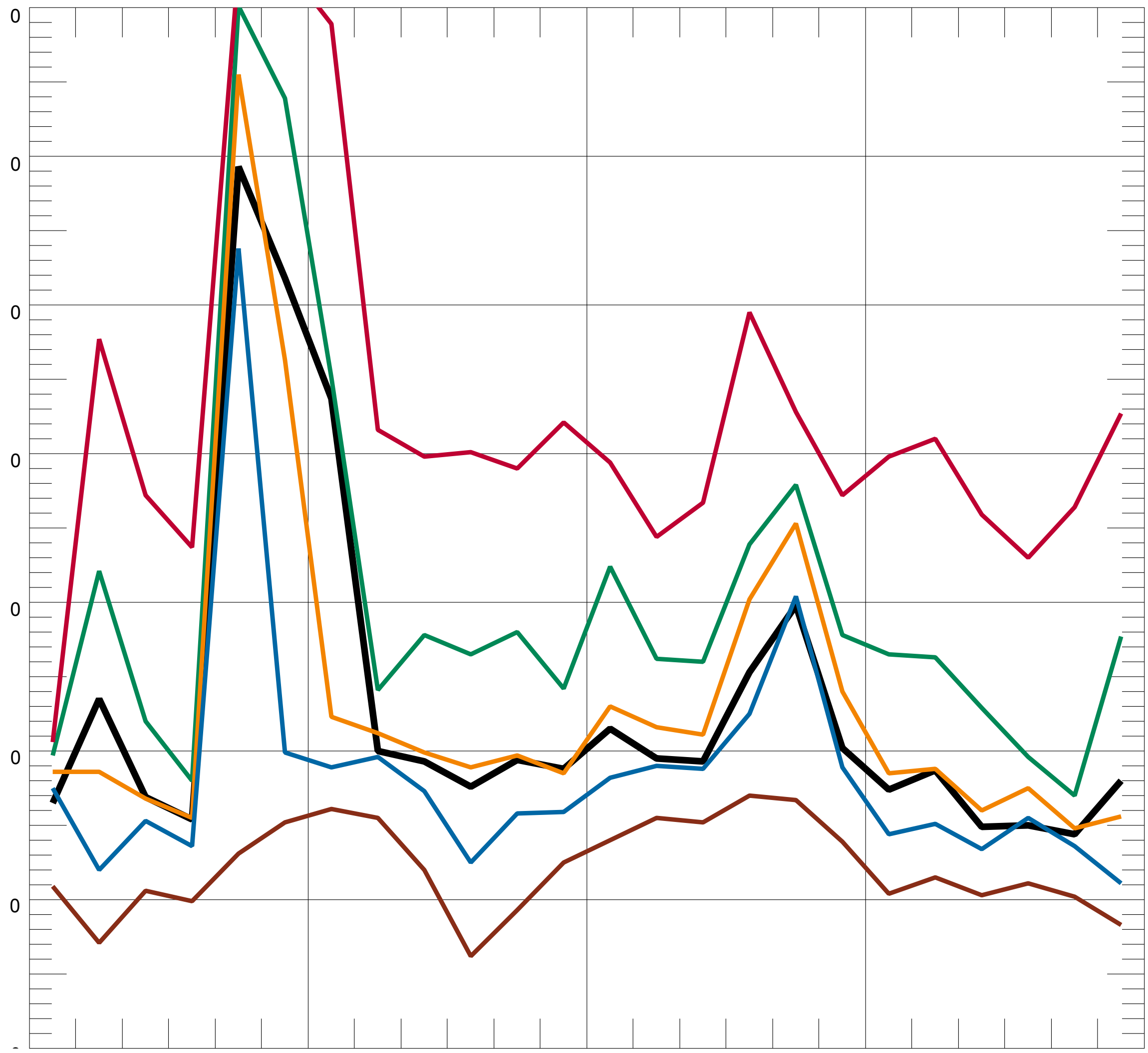

Figure A-60. Hourly Statistical Summary of Noise Levels on Nov 10, 2014 Location N8, 1719 Dorothy Avenue, Longview, WA

Appendix B

Construction Noise Impact Analysis

Appendix B

Construction Noise Impact Analysis

Table B-1 lists the predicted noise levels at noise-sensitive receivers in the study area during construction of the Proposed Action.

Table B-1. Predicted Construction Noise—Proposed Action

Address	Land Use	Construction $L_{eq,\ 8\ hour}$ (dBA)	Pile Driver L_{max} (dBA)	Construction + Pile Driver L_{max} (dBA)
104 Bradford Pl	Man. Home	79	80	83
114 Bradford Pl	SFR	72	76	78
4720 Mt. Solo Rd	SFR	63	67	68
4723 Mt. Solo Rd	Man. Home	62	66	68
4724 Solo Meadows Ln	SFR	62	66	67
4726 Mt. Solo Rd	Man. Home	62	66	68
4744 Mt. Solo Rd	SFR	61	65	66
4820 Mt. Solo Rd	SFR	60	64	66
4828a Mt. Solo Rd	SFR	60	64	65
4828b Mt. Solo Rd	SFR	60	63	65
4824 Mt. Solo Rd	SFR	60	64	65
115 Pioneer Mt Solo Cemetery Rd	SFR	59	63	65
120 Pioneer Mt Solo Cemetery Rd	SFR	58	62	64
Mt. Solo Cemetery	cemetery	59	63	64
130 Pioneer Mt. Solo Cemetery Rd	SFR	58	62	64
5006 Mt Solo Rd	SFR	58	62	63
5008 Mt Solo Rd	Man. Home	58	62	63
5005 Mt Solo Rd	SFR	58	61	63
5041 Mt Solo Rd	SFR	57	61	62
137 Ridgecrest Dr	SFR	58	62	63
141 Ridgecrest Dr	Man. Home	58	61	63
142 Ridgecrest Dr	SFR	58	62	63
149 Ridgecrest Dr	Man. Home	57	60	62
150 Ridgecrest Dr	Man. Home	57	61	63
160 Ridgecrest Dr	Man. Home	57	60	62
129 Ridgecrest Dr	Man. Home	59	63	64
103 Ridgecrest Ln	Man. Home	59	63	64
107 Ridgecrest Ln	Man. Home	58	62	64
111 Ridgecrest Ln	Man. Home	58	62	63
115 Ridgecrest Ln	SFR	59	62	64
127 Ridgecrest Ln	SFR	60	63	65
134 Ridgecrest Ln	SFR	60	64	65
120 Ridgecrest Ln	Man. Home	60	64	65

Address	Land Use	Construction $L_{eq,\ 8\ hour}$ (dBA)	Pile Driver L_{max} (dBA)	Construction + Pile Driver L_{max} (dBA)
108 Ridgecrest Ln	Man. Home	60	64	65
106 Ridgecrest Ln	Man. Home	60	63	65
116 Ridgecrest Dr	Man. Home	60	64	66
104 Ridgecrest Dr	Man. Home	62	66	68
124 Solo Meadows Ln	Man. Home	60	64	65
114 Solo Meadows Ln	Man. Home	61	65	67
110 Solo Meadows Ln	Man. Home	62	66	67
106 Solo Meadows Ln	SFR	62	66	68
101 Solo View Dr	Man. Home	63	67	68
107 Southcrest Ln	SFR	61	65	67
115 Southcrest Ln	SFR	60	64	65
125 Pionte Rd	SFR	60	63	65
108 Southcrest Ln	SFR	61	65	67
123 Solo View Dr	Man. Home	62	66	67
127 Solo View Dr	Man. Home	63	67	68
120 Bridgeview Ln	SFR	65	68	70
115 Bridgeview Ln	SFR	63	67	68
129 Solo View Dr	SFR	63	66	68
131 Solo View Dr	Man. Home	62	66	67
151 Solo View Dr	SFR	62	65	67
164 Rutherglen Dr	Man. Home	61	64	66
232 Rutherglen Dr	SFR	60	64	66
222 Rutherglen Dr	SFR	60	64	65
Evergreen St & 46th Ave	SFRs	58	61	63
44th Ave	SFRs	58	61	63
42nd Ave	SFRs	58	61	63
Alter St	SFRs	58	61	63
Olive Way	SFRs	58	61	63
2133 38th Ave	SFR	58	61	63
2137 38th Ave	SFR	58	61	63
38th Ave	SFRs	58	61	63
2185 38th Ave	MFR	57	61	62
36th Ave	SFRs	57	61	62
Shelly Pl	SFRs	58	62	63
Olive Ct	SFRs	57	60	62
Longview Memorial Park	cemetery	57	61	62
2017a 48th Ave	SFR	56	60	61
2017b 48th Ave	SFR	56	59	61
2018 48th Ave	Man. Home	56	60	61
Charles St	SFRs	56	60	61
Julie Pl	SFRs	56	60	62

Address	Land Use	Construction $L_{eq, 8 hour}$ (dBA)	Pile Driver L_{max} (dBA)	Construction + Pile Driver L_{max} (dBA)
Zirkel Ct	SFRs	57	60	62

Notes:
dBA = A-weighted decibel; SFRs = single-family residences, MFRs = multifamily residences

MILLENNIUM BULK TERMINALS–LONGVIEW SEPA ENVIRONMENTAL IMPACT STATEMENT

SEPA AIR QUALITY TECHNICAL REPORT

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Acronyms and Abbreviations

°F	degrees Fahrenheit
Applicant	Millennium Bulk Terminals–Longview, LLC
BNSF	BNSF Railway Company
CFR	Code of Federal Regulations
CO	carbon monoxide
DPM	diesel particulate matter
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HAP	hazardous air pollutant
lb/day	pounds per day
NAAQS	National Ambient Air Quality Standards
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NEPA	National Environmental Policy Act
NO_2	nitrogen dioxide
NO_x	nitrogen oxide
NW AIRQUEST	Northwest International Air Quality Environmental Science and Technology Consortium
O_3	ozone
OLM	Ozone Limiting Method
PM	particulate matter
PM2.5	particulate matter less than 2.5 micrometers in diameter
PM10	particulate matter less than 10 micrometers in diameter
ppb	parts per billion
ppm	parts per millions
Proposed Action	Millennium Bulk Terminals—Longview project
RCW	Revised Code of Washington
SEPA	Washington State Environmental Policy Act
SO_2	sulfur dioxide
SWCAA	Southwest Clean Air Agency
TAP	toxic air pollutant
tpy	tons per year
TSP	total suspended particules
$\mu g/m^3$	micrograms per cubic meter
USC	United States Code
VOC	volatile organic compound
WAC	Washington Administrative Code

Chapter 1
Introduction

This technical report assesses the potential air quality impacts of the proposed Millennium Bulk Terminals—Longview project (Proposed Action) and No-Action Alternative. This report describes the regulatory setting, establishes the method for assessing potential air quality impacts, presents the historical and current air quality conditions in the study area, and assesses potential impacts.

1.1 Project Description

Millennium Bulk Terminals—Longview, LLC (Applicant) proposes to construct and operate a coal export terminal in Cowlitz County, Washington, along the Columbia River (Figure 1). The coal export terminal would receive coal from the Powder River Basin in Montana and Wyoming and the Uinta Basin in Utah and Colorado via rail, then load and transport the coal by ocean-going ships via the Columbia River and Pacific Ocean to overseas markets in Asia. The coal export terminal would be capable of receiving, stockpiling, blending, and loading coal by conveyor onto ships for export. Construction of the coal export terminal would begin in 2018. For the purpose of this analysis, it is assumed the coal export terminal would operate at full capacity in 2028.

The following subsections present a summary of the Proposed Action and No-Action Alternative. For detailed information on these alternatives, see the Washington State Environmental Policy Act (SEPA) Alternatives Technical Report (ICF International 2016).

1.1.1 Proposed Action

The Proposed Action would develop a coal export terminal on 190 acres (project area). The project area is located within an existing 540-acre area currently leased by the Applicant at the former Reynolds Metals Company facility, and land currently owned by Bonneville Power Administration. The project area is adjacent to the Columbia River in unincorporated Cowlitz County, Washington near Longview city limits (Figure 2).

The Applicant currently and separately operates, and would continue to separately operate, a bulk product terminal on land leased by the Applicant. Industrial Way (State Route 432) provides vehicular access to the Applicant's leased land. The Reynolds Lead and the BNSF Spur, both operated by Longview Switching Company,[1] provide rail access to the Applicant's leased area from a point on the BNSF Railway Company (BNSF) main line (Longview Junction, Washington) located to the east in Kelso, Washington. Ships access the Applicant's leased area via the Columbia River and berth at an existing dock (Dock 1) operated by the Applicant in the Columbia River.

[1] Longview Switching Company is jointly owned by BNSF Railway Company (BNSF) and Union Pacific Railroad.

Figure 1. Project Vicinity

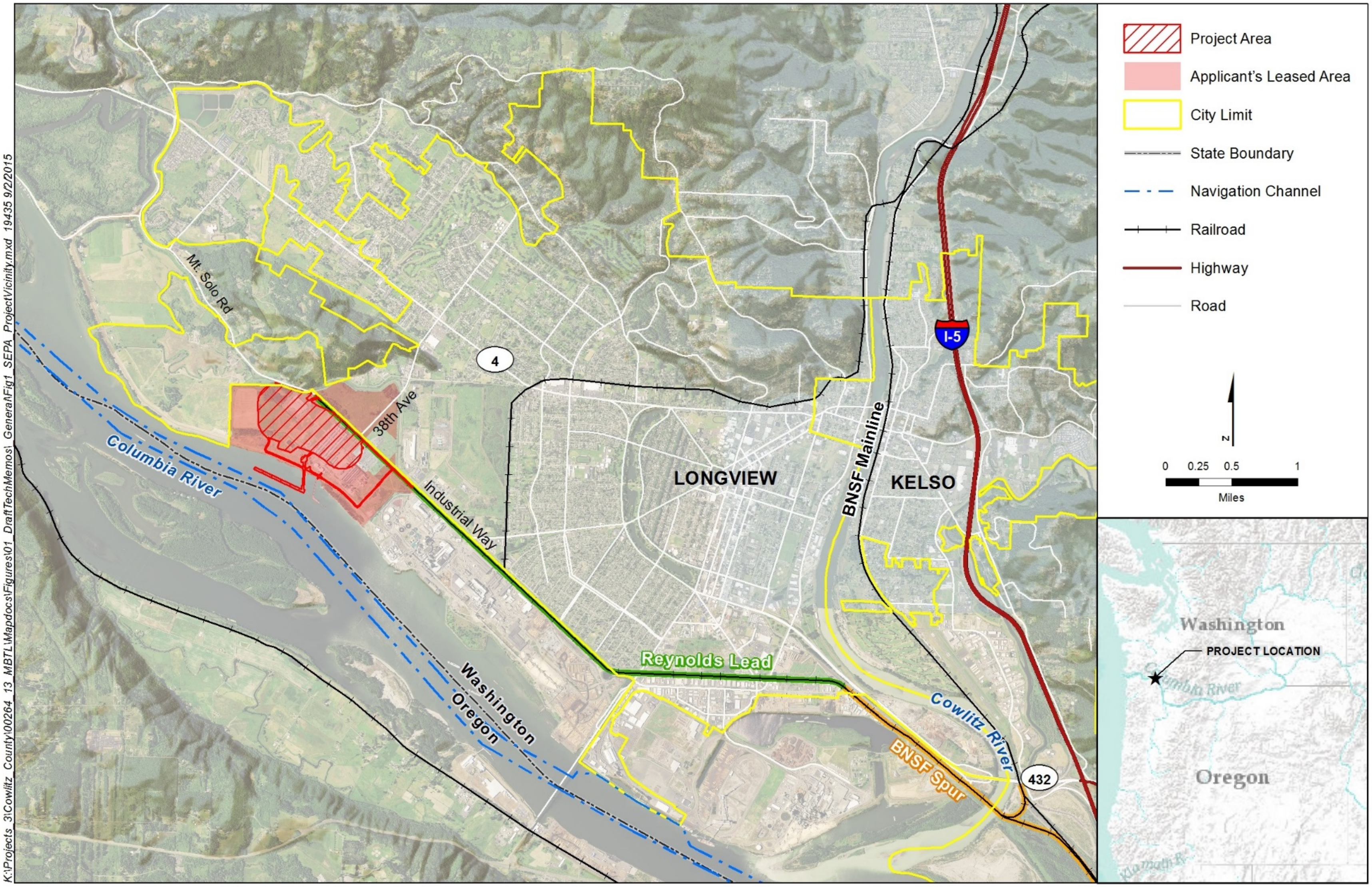
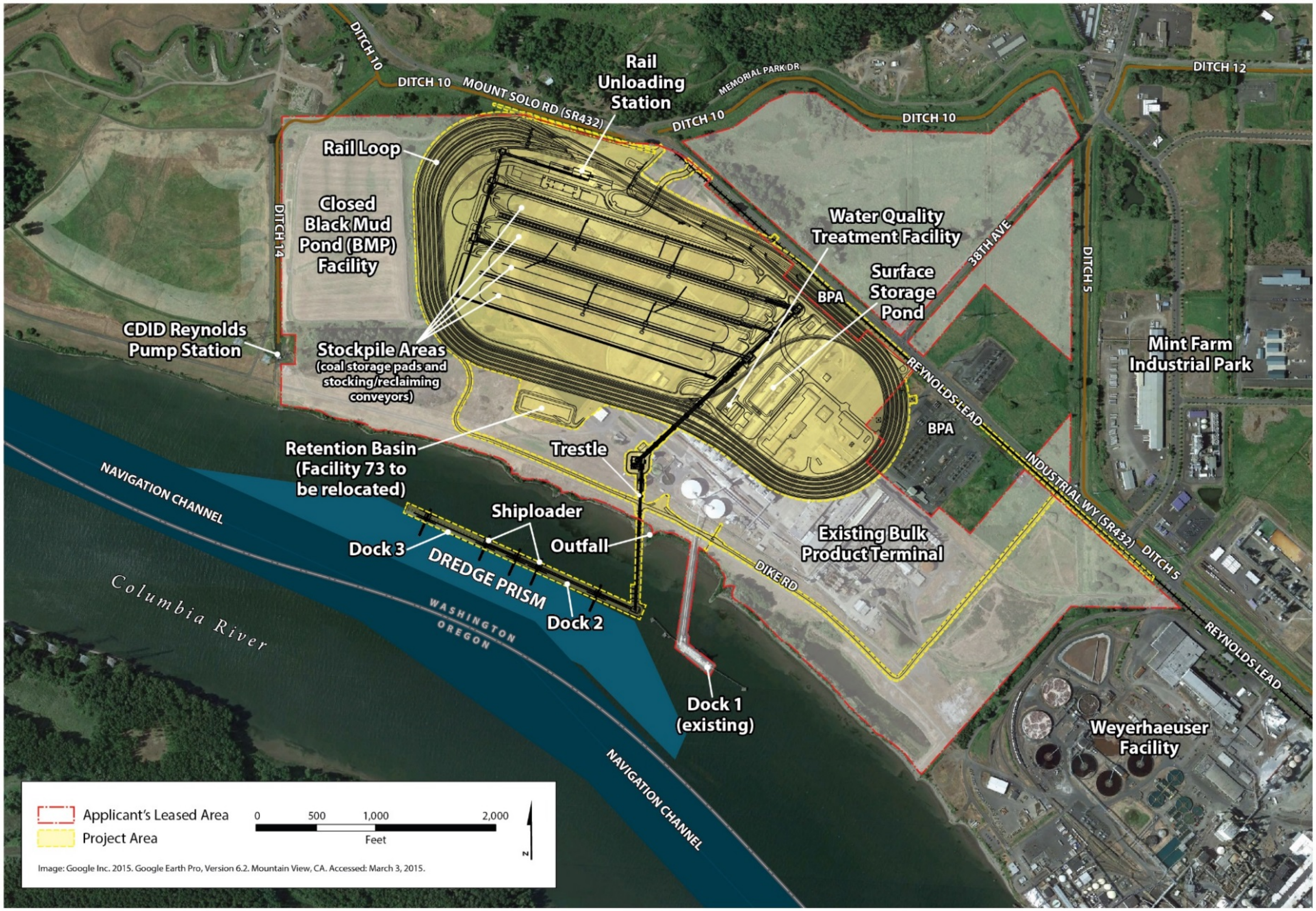


Figure 2. Proposed Action



Under the Proposed Action, BNSF or Union Pacific Railroad trains would transport coal in rail cars from the BNSF main line at Longview Junction, Washington, to the project area via the BNSF Spur and Reynolds Lead. Coal would be unloaded from rail cars, stockpiled and blended, and loaded by conveyor onto ocean-going ships at two new docks (Docks 2 and 3) on the Columbia River for export.

Once construction is complete, the Proposed Action would have an annual throughput capacity of up to 44 million metric tons.[2] The coal export terminal would consist of one operating rail track, eight rail tracks for the storage of rail cars, rail car unloading facilities, stockpile areas for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks 2 and 3), and ship-loading facilities on the two docks. Dredging of the Columbia River would be required to provide access to and from the Columbia River navigation channel and for berthing at the two new docks.

Vehicles would access the project area from Industrial Way (State Route 432). Ships would access the project area via the Columbia River and berth at one of the two new docks. Terminal operations would occur 24 hours per day, 7 days per week. The coal export terminal would be designed for a minimum 30-year period of operation.

1.1.2 No-Action Alternative

Under the No-Action Alternative, the proposed export terminal would not be constructed. Current operations of the bulk product terminal, which include the storage and transport of alumina and up to 150,000 metric tons per year of coal. Importing of alumina would continue and increase in the project area using Dock 1. The Applicant could expand the existing bulk product terminal onto the 190-acre project area, developing storage and shipment facilities to bulk product terminal operations. Coal and alumina would continue to be stored, transferred, and shipped. Additional bulk product transfers activities involving products such as calcine pet coke, coal tar pitch, cement, fly ash, and sand or gravel could also be pursued, and new or revised permits could be required. These operations would involve storage and upland transfer of bulk products, which would use existing or new buildings. Construction of new buildings could involve demolition and replacement of existing buildings and new or modified permits. Any new construction would be limited to uses allowed under existing Cowlitz County development regulations and federal and state permits.

1.2 Regulatory Setting

Different jurisdictions are responsible for the regulation of air quality. These jurisdictions and their regulations, statutes, and guidance that apply to air quality are summarized in Table 1.

Table 1. Regulations, Statutes, and Guidance for Air Quality

Regulation, Statute, Guideline	Description
Federal	
National Environmental Policy Act (42 USC 4321 *et seq.*)	Requires the consideration of potential environmental effects. NEPA implementation procedures are set forth in the President's Council on Environmental Quality's Regulations for Implementing NEPA (49 CFR 1105).

[2] A metric ton is the U.S. equivalent to a tonne per the International System of Units, or 1,000 kilograms or approximately 2,204.6 pounds.

Regulation, Statute, Guideline	Description
Clean Air Act and Amendments	As amended in 1970, 1977, and 1990, requires the U.S. Environmental Protection Agency to develop and enforce regulations to protect the public from air pollutants and their health impacts.
National Ambient Air Quality Standards (U.S. Environmental Protection Agency)	Specifies the maximum acceptable ambient concentrations for seven criteria air pollutants: CO, lead, NO_2, O_3, PM10 and PM2.5, and SO_2. Primary NAAQS set limits to protect public health, and secondary NAAQS set limits to protect public welfare. Geographic areas where concentrations of a given criteria pollutant exceed NAAQS are classified as nonattainment areas for that pollutant.
State	
Washington State Environmental Policy Act (WAC 197-11, RCW 43.21C)	Requires state and local agencies in Washington to identify potential environmental impacts that could result from governmental decisions.
Washington State General Regulations For Air Pollution Sources (WAC 173-400) and Washington State Clean Air Act (RCW 70.94)	Establishes the rules and procedures to control or prevent the emissions of air pollutants. Provides the regulatory authority to control emissions from stationary sources, reporting requirements, emissions standards, permitting programs, and the control of air toxic emissions.
Washington State Operating Permit Regulation (WAC 173-401)	Establishes the elements for the state air operating permit program.
Washington State Controls for New Sources of Toxic Air Pollutants (WAC 173-460)	Establishes the systematic control of new or modified sources emitting toxic air pollution to prevent air pollution, reduce emissions, and maintain air quality that will protect human health and safety.
Washington State Ambient Air Quality Standards (WAC 173-476)	Establishes maximum acceptable levels in the ambient air for particulate matter, lead, SO_2, NO_2, O_3, and CO.
Local	
Cowlitz County SEPA Regulations (CCC 19.11)	Provide for the implementation of SEPA in Cowlitz County.
Southwest Clean Air Agency (SWCAA 400)	General regulations for regulating stationary sources of air pollution within Clark, Cowlitz, Lewis, Skamania, and Wahkiakum counties of Washington.

Notes:
USC = United States Code; NEPA = National Environmental Policy Act; CFR = Code of Federal Regulations; CO = carbon monoxide; NO_2 = nitrogen oxides; O_3 = ozone; PM2.5 = particulate matter up to 2.5 micrometers in size; PM10 = particulate matter up to 10 micrometers in size; SO_2 = sulfur dioxide; NAAQS = National Ambient Air Quality Standards; HAPs = hazardous air pollutants; WAC = Washington Administrative Code; RCW = Revised Code of Washington; SEPA = Washington State Environmental Policy Act; SWCAA = Southwest Clean Air Agency

The federal Clean Air Act and the Clean Air Act Amendments form the basis for a broad range of regulations that control allowable emissions and ambient concentrations of air pollutants in the environment. The National Ambient Air Quality Standards (NAAQS) were established by the U.S. Environmental Protection Agency (EPA) under authority of the Clean Air Act to protect the public from air pollution. Air pollutants for which there are NAAQS are called *criteria pollutants*. Geographic areas where concentrations of a given criteria pollutant exceed an ambient air quality standard are classified as *nonattainment areas* for that pollutant.

Under the federal Clean Air Act, the states are authorized to administer these programs and monitor air quality in different areas to determine if those areas are meeting the NAAQS.

Under RCW 70.94, local counties can choose to form a county authority or join a multi-county authority. Cowlitz County is part of the multi-county air pollution control authority. The Southwest Clean Air Agency (SWCAA) maintains compliance with the NAAQS for most stationary source types of air pollutants via an air permitting programs (Revised Code of Washington [RCW] 70.94.053 and 70.94.057 and SWCAA 400-020). This authority includes the regulation of fugitive dust sources (SWCAA-400-040) as well as vented emissions.

Other federal air quality regulatory programs for major stationary sources include Prevention of Significant Deterioration, National Emission Standards for Hazardous Air Pollutants (NESHAPS), Title V Air Permitting Program, and New Source Performance Standards (NSPS). None of these programs are expected to apply to the Proposed Action because stationary source emissions are well below major source thresholds, and because current NESHAPS and NSPS standards do not apply to the proposed facility type. The state also has rules for toxic air pollutants (TAPs) that are applicable to stationary sources. These rules were established to provide systematic control of TAP emissions (which include both carcinogens and noncarcinogens) in order to maintain the protection of human health and safety.

EPA first began regulating on-road mobile sources in 1970 as part of the Clean Air Act. EPA was given the added regulatory authority under Section 213 in the 1990 Clean Air Act Amendments to control emissions from nonroad engines (e.g., construction equipment, locomotives, and vessels). An extensive number of exhaust emissions standards and regulations have been issued by EPA since 1990 on all classes of nonroad engines including construction equipment, locomotives, vessels, off-road vehicles, and lawn and garden equipment. Regulations that are relevant to the Proposed Action include locomotive emission standards for new and re-built locomotive engines and the North America Emission Control Area for marine vessels limiting the sulfur content in fuel oil. No provisions have been made to allow states (other than California) or local authorities to impose additional regulations on these source categories.

1.2.1 Current NAAQS and Washington State Ambient Air Quality Standards

Table 2 lists both the federal and state ambient air quality standards for six criteria air pollutants and total suspended particulates. Annual standards are never to be exceeded. Short-term standards are not to be exceeded more than once per year, unless noted. The NAAQS consist of primary standards and secondary standards. Primary standards are designed to protect public health, including protecting the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards are designed to protect public welfare from effects such as visibility reduction, soiling, and nuisance (e.g., preventing air pollution damage to vegetation). Compared to the NAAQS, the Washington State Department of Ecology (Ecology) has established additional state ambient standards for sulfur dioxide for other averaging periods, which applies to the Proposed Action.

Table 2. Federal and Washington State Ambient Air Quality Standards

Pollutant	Federal Primary	Federal Secondary	State
Carbon monoxide			
8-hour average[a]	9 ppm	No standard	9 ppm
1-hour average[a]	35 ppm	No standard	35 ppm
Ozone			
8-hour average[b,c]	0.070 ppm	0.070 ppm	0.075 ppm
Nitrogen dioxide			
1-hour average[d]	100 ppb	No standard	100 ppb
Annual average	53 ppb	53 ppb	53 ppb
Sulfur dioxide			
Annual average	No standard	No standard	0.02 ppm
24-hour average[e]	No standard	No standard	0.14 ppm
3-hour average[e]	No standard	0.50 ppm	0.50 ppm
1-hour average[f]	75 ppb	No standard	75 ppb
Lead			
Rolling 3-month average	0.15 μg/m³	0.15 μg/m³	0.15 μg/m³
PM10			
24-hour average[g]	150 μg/m³	150 μg/m³	150 μg/m³
PM2.5			
Annual average[h]	12 μg/m³	15 μg/m³	12 μg/m³
24-hour average[i]	35 μg/m³	35 μg/m³	35 μg/m³

Notes:

[a] Not to be exceeded on more than 1 day per calendar year as determined under the conditions indicated in 173 WAC 476.

[b] In December 2015, EPA lowered the federal standard for 8-hour ozone from 0.075 ppm to 0.070 ppm.

[c] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.070 ppm.

[d] 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years.

[e] Not to be exceeded more than once per calendar year.

[f] 99th percentile of 1-hour daily maximum concentrations averaged over 3 years.

[g] Not to be exceeded more than once per year average over 3 years.

[h] Annual mean averaged over 3 years.

[i] 98th percentile averaged over 3 years.

Source: 173 WAC 476; U.S. Environmental Protection Agency 2012.

ppm = parts per million; ppb= parts per billion; PM10 = particulate matter with a diameter of 10 micrometers or less; PM2.5 = particulate matter with a diameter of 2.5 micrometers or less; μg/m³ = micrograms per cubic meter

1.2.2 Federal and State Air Toxics

Under the federal Clean Air Act, EPA is also required to control air toxics, which are pollutants known or suspected to cause cancer or other serious health effects, such as birth defects or reproductive effects. Examples of air toxics include benzene, formaldehyde, and toluene. EPA has identified 188 air toxics, which it refers to as *hazardous air pollutants* (HAPs). EPA's control of these pollutants differs from its control of criteria air pollutants discussed above. No ambient air quality standards have been established for air toxics. Instead, EPA has identified all major industrial stationary sources that emit these pollutants, and has developed national technology-based performance standards to significantly reduce their emissions and ensure that major sources of these toxics are controlled, regardless of geographic location.

Ecology pursues reductions in TAPs, including diesel particulate matter (DPM), listed in Washington Administrative Code 173-460-150, from new or modified stationary sources.[3] In general, all sources that require a notice of construction application are required to assess its TAP emissions from stationary sources with a review of the best available control technology for toxic air pollutants, quantification of emissions, and human health protection demonstration. The objective is to reduce or eliminate TAPs from stationary sources prior to their generation whenever economically and technically practicable. However, the only new stationary source emission considered under the Proposed Action is fugitive coal dust. Fugitive coal dust itself is not a TAP, but components of it may be, so this rule may apply. SWCAA has a separate list of pollutants which may apply to emissions under the Proposed Action from this stationary source.

1.2.3 Attainment Status

Based on monitoring information collected over a period of years, EPA and Ecology designate regions as being attainment or nonattainment areas for regulated air pollutants. Attainment status indicates that air quality in an area meets the federal, health-based ambient air quality standards. Nonattainment status indicates that air quality in an area does not meet those standards. If the measured concentrations in a nonattainment area improve to levels consistently below the federal standards, Ecology and EPA can reclassify the nonattainment area to a maintenance area. In this situation, Ecology and the local clean air agency are required to implement maintenance plans to ensure ongoing emissions reductions, and continuous compliance with the federal standards.

Cowlitz County is currently designated unclassifiable-attainment for all NAAQS. This designation means that EPA and Ecology expect the area to meet air quality standards despite a lack of monitoring data. Currently, Ecology and SWCAA only operate a particulate matter less than 2.5 micrometers in diameter (PM2.5) air quality monitor.

1.3 Study Area

The study area for direct impacts on air quality is defined as the project area and emissions from Proposed Action-related trains along the Reynolds Lead and BNSF Spur. For indirect impacts, the study area comprises Cowlitz County, including vessel activity on the Columbia River. Emissions are aggregated and regulated at a larger scale than a localized study, and therefore direct and indirect emissions are combined. An assessment of air quality impacts from Proposed Action-related trains and vessels in Washington State is also addressed in this analysis.

[3] A stationary source refers to an emissions source of air pollution that does not move.

Chapter 2
Existing Conditions

This chapter explains the methods for assessing the existing conditions and determining impacts, and describes the existing conditions in the study area as they pertain to air quality.

2.1 Methods

The air quality analysis evaluated emissions from construction and terminal operations.

Air emissions for the Proposed Action were estimated for carbon monoxide (CO), volatile organic compounds (VOCs), nitrogen oxide (NO_x), particulate matter less than 10 micrometers in diameter (PM10), PM2.5, and sulfur dioxide (SO_2) to evaluate the impact on air quality. Because construction emissions are temporary and have a short period of activity, these emissions are only evaluated in comparison with emissions thresholds. Operational emissions, however, are evaluated in comparison to their impacts on air quality.

The methods used to assess construction-related air quality impacts was designed to estimate the strength of emissions during the peak construction period and to identify the maximum daily emissions. Sources of construction emissions included emissions from construction equipment, river barges, fugitive dust from earthwork activity, vehicle crossing delays, and construction worker commute vehicles.

The air quality assessment for terminal operations considered on-site activities that would generate potential fugitive emissions of particulate matter from the handling and transfer of coal, including unloading coal from rail cars, transferring coal on conveyors, piling coal onto storage piles, and loading coal onto ships. The coal transfers would occur in enclosed areas (i.e., rotary coal car dump and conveyors), as well as areas that are not enclosed (i.e., coal piles and the unloading of rail cars). In addition, the air quality assessment considered locomotive exhaust emissions that occur during the unloading and movement of coal cars, hoteling emissions during vessel loading, emissions from tugs used to maneuver vessels into the terminal, and emissions from operations (e.g., loader) and maintenance equipment.

The operational sources of emissions were assessed for their potential local air quality impacts using EPA's standard regulatory air dispersion model, AERMOD (Version 14134). AERMOD is the appropriate tool for this application as the air quality impacts are localized and AERMOD is designed to assess emissions for multiple point, area, and volume sources in simple and complex terrain, and uses hourly meteorological on-site data. AERMOD output results are compared to the federal and state ambient air quality standards presented in Table 2. Appendix A provides details of the analysis and list of the applicable VOCs and HAPs.

2.1.1 Data Sources

The following sources of information were used to determine the emissions impacts from the Proposed Action.

- California's Air Resource Board, Appendix D, *Emission Estimation Methodology for Ocean Going Vessels* (California Air Resource Board 2011).
- Northwest International Air Quality Environmental Science and Technology Consortium (2015)
- Millennium Coal Export Terminal, Longview Washington, *Environmental Report Air Quality Analysis, Appendix L – Air Quality Modeling Analysis* prepared by URS Corporation (URS Corporation 2015).
- National Climatic Data Center Longview, Washington Monthly Climate Normals, Daily and Monthly Temperature Extremes and Precipitation Averages and Extremes by Month (National Climatic Data Center 2011).
- EPA's *Compilation of Air Pollutant Emission Factors* (U.S. Environmental Protection Agency 1995a, 1995b, 1995c, 1996).
- EPA's User's Guide and Addendum for the AMS/EPA Regulatory Model—AERMOD (U.S. Environmental Protection Agency 2004, 2014).
- EPA's Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data (U.S. Environmental Protection Agency 2000).
- EPA's NONROAD Model (Nonroad engines, equipment, and vehicles), Version 2008a (U.S. Environmental Protection Agency 2009).
- EPA's Federal Marine Compression-Ignition Engines – Exhaust Emission Standards (U.S. Environmental Protection Agency 2012).
- Ecology statewide emissions inventory levels (Washington State Department of Ecology 2014).

2.1.2 Impact Analysis Approach

The following sections describe the approach that was taken for the construction impact analysis and the operations impact analysis.

2.1.2.1 Construction Impact Analysis Approach

The Applicant has identified three construction scenarios:

- **Truck.** If material is delivered by truck, it is assumed that approximately 88,000 truck trips would be required over the construction period. Approximately 56,000 loaded trucks would be needed during the peak construction year.
- **Rail.** If material is delivered by rail, it is assumed that approximately 35,000 loaded rail cars would be required over the construction period. Approximately two-thirds of the rail trips would occur during the peak construction year.
- **Barge.** If material is delivered by barge, it is assumed that approximately 1,130 barge trips would be required over the construction period. Approximately two-thirds of the barge trips would occur during the peak construction year. Because the project area does not have an existing barge dock, the material would be off-loaded at an existing dock elsewhere on the Columbia River and transported to the project area by truck.

Emissions included in the construction analysis include those from barge and truck emissions associated with the delivery of construction supplies and materials, in addition to direct emissions from construction equipment exhaust and fugitive dust emissions. Earthwork activity would take place during the first 18 months of construction. Based on the frequency and duration of use and fuel types, emissions were estimated based on either the EPA AP-42 compilation of emissions factors or EPA's NONROAD2008a model for non-road construction equipment activity. A brief description and key assumptions are presented in the following sections for each source type.

Construction Equipment

Construction equipment exhaust emissions are the result of fuel combustion. This includes activity associated with rail infrastructure, construction of the conveyor and transfer stations, and surge bins, dock, and trestles. Combustion emissions estimates were obtained by applying the EPA NONROAD2008a emissions model (U.S. Environmental Protection Agency 2009) for nonroad equipment activity as reported in the *Environmental Report Air Quality Analysis, Appendix L – Air Quality Modeling Analysis* prepared by URS (URS Corporation 2015). Construction activity was assumed to occur 8 hours per day, 5 days per week, 52 weeks per year, with the exception of track laying machines, which were assumed to occur only 4 hours per day. Emissions factors were then combined with maximum numbers of equipment operated, duration of use, and horsepower to obtain annual emissions. Diesel particulate emissions were derived from PM10 emissions estimates for diesel-powered equipment, which included most on-site combustion sources as well as barges. Additional details on the approach are identified in Appendix A for annual emissions and maximum daily emissions.

River Barges

Emissions estimates for barge engines were based on EPA's approach for large diesel engines[4] (U.S. Environmental Protection Agency 1996). The river barge was assumed to use ultra-low sulfur diesel, with less than 15 parts per million (ppm) sulfur content. The barge positioning time was assumed to take 1 hour (0.5 hour in and 0.5 hour out), with 753 round trips during the peak construction period (average of 2.9 daily). Additional details on this approach are identified in Appendix A for annual emissions and maximum daily emissions.

Fugitive Dust from Earthwork Activity

Fugitive dust emissions were estimated using a conservative approach for construction equipment (U.S. Environmental Protection Agency 1995a). This method uses a generic, all-inclusive, emissions factor of 1.2 tons particulate matter (PM)/acre-month for land preparation activities. Land clearing, excavation, earth moving (cut and fill), and other miscellaneous dust-generating activities that typically occur during construction are included as part of this emissions factor. All earthwork for the project area was assumed to occur evenly over a 1-year period, and the standard best management practice of watering to minimize fugitive dust emissions was assumed to be used as well. Additional details on this approach are identified in Appendix A for annual emissions and maximum daily emissions.

[4] The sum of HAPs factors was obtained from Tables 3.4-3 and 3.4-4 from EPA *AP-42, Section 3.4 Large Stationary Diesel and All Stationary Dual-fuel Engines* (U.S. Environmental Protection Agency 1996).

Vehicle Delays at Rail Crossings

Off-site emissions associated with vehicle delays at train crossings from construction-related locomotives transporting construction materials along the Reynolds Lead and BNSF Spur are included in the analysis.

Construction Worker Commute Vehicles

During peak construction, up to 200 construction workers may commute to the project area. Off-site emissions associated with commute vehicles for construction workers are included in the analysis. Additional details on this approach are identified in Appendix A.

2.1.2.2 Operations Impact Analysis Approach

The on-site transfer and storage of coal would create fugitive emissions of coal dust due to product movement and wind erosion. In addition, combustion emissions from rail and vessel movement, as well as some nonroad equipment emissions associated with the operation and maintenance of the terminal, are included in the analysis. The project area also includes emissions at Docks 2 and 3, as well as maneuvering to dock vessels at the terminal; these on-site emissions were considered in the analysis as well. The approach taken to address emissions associated with coal storage and handling, locomotive, vessel, vehicle delays at rail crossings, and employee commute vehicles is described below. A section that describes how emissions were characterized for air quality modeling is also presented below.

Coal Storage and Handling

Most on-site coal movement would occur in enclosed areas, including the rotary coal car dump and conveyors. Some transfer activities at the coal storage piles would not be enclosed; however, the conveyors, transfer towers, and the coal storage piles themselves would have systems in place for dust control (watering or dry fogging). Watering of the coal storage piles would help to reduce wind erosion. In general, the combination of these passive (enclosures) and active (watering, fogging) control systems would provide a high level of dust control (up to 99%); however, because these control systems would not operate with negative pressure, a more conservative 95% effectiveness assumption was used. This approach is consistent with a similar type facility that was issued a draft permit from Oregon Department of Environmental Quality. To account for the reduction in emissions from watering of the coal within the project area (URS Corporation 2014), only a 95% effectiveness in reducing coal dust emissions was assumed in this analysis.

Locomotives

The impact analysis approach for rail operations used EPA projected emissions factors (grams per gallon [g/gal]) for line-haul locomotives, which are based on projected changes in locomotive fleet over the next 30 years (U.S. Environmental Protection Agency 2009). These emissions were based on locomotive engine load and associated fuel consumption during transport to and from the coal export terminal, the unloading of coal from train cars, as well as the total annual coal throughput. Key assumptions for rail included an estimated duration of 111 minutes (1.85 hours) to unload a 125-car unit train (ICF International and Hellerworx 2016). It was assumed that all locomotives would use ultra-low-sulfur diesel (15 ppb sulfur). Appendices that present this approach in detail are identified in Table 3.

Vessel

The impact analysis approach for vessel operations assumed that each vessel receiving coal would need three tugs to maneuver the ship, and would require 3 hours total time to assist with docking and departing operations. Further, it was estimated that an average of 13 hours would be needed to load each vessel with coal, and during this period of time, the vessel would be hoteling using auxiliary engines. The typical main and auxiliary engine size was based on Lloyd's Register of Ships Sea-web (Sea-Web 2015).[5] To comply with International Maritime Organization 2016 Emission Control Areas for North America, all vessels were assumed to use the maximum allowed sulfur content marine distillate fuel of 0.1% (1,000 ppm). It was also assumed that all tugboats would use ultra-low-sulfur diesel (15 ppb sulfur). To estimate the vessel emissions outside Cowlitz County but within Washington State, a one-way travel distance of 51.5 miles (Cowlitz County line to 3 nautical miles beyond the mouth of the Columbia River) was used in the analysis along with a round-trip travel time of 8.2 hours. Appendices that present this approach in detail are identified in Table 3.

Vehicle Delays at Train Crossings

Off-site emissions associated with vehicle delays at train crossings from locomotives transporting coal along the Reynolds Lead and BNSF Spur are included in this analysis. Appendices that present this approach in detail are identified in Table 3.

Employee Commute Vehicles

The impact analysis approach for employee vehicle emissions assumed approximately 135 vehicles commuting to and from the project area each day, and an average travel time of 24.1 minutes. Appendices that present this approach in detail are identified in Table 3.

Table 3. Summary of Operational Emissions, Source Type, and Appendix References for Details on the Emissions Calculation

Source Type	Characterization for the Air Dispersion Modeling	Appendix Tab Presenting Details on Methods Used to Calculate Emissions
Handling and transfer of coal, including unloading coal from rail cars, transferring coal on conveyors, piling coal onto storage piles, and loading coal onto ships[a]	Volume	Tab F
Locomotive exhaust emissions that occur during unloading, idling, and switching of rail cars	Line	Tabs H, H2, and H3
Maneuvering and hotel emissions during vessel loading and tug assist maneuvering	Point	Tabs I, I2
Emissions from operations (e.g., loader) and maintenance equipment	Point	Tabs J, J2
Coal dust from coal storage piles	Area	Tabs D and E
Coal dust from moving rail cars	Line	Tab G

Notes:

[a] The on-site coal transfers would occur in enclosed areas (i.e., rotary coal car dump and conveyors), as well as areas that are not enclosed (i.e., coal piles and the unloading of rail cars).

[5] The Sea-Web data is produced by IHS Global Limited. The data is based on Lloyd's Register of Ships Sea-web provided ship characteristics data for ships over 100 gross tons.

Characterizing Emissions for Air Quality Modeling

An air quality modeling impact assessment was conducted to assess the localized air quality impacts from operation of the terminal on air quality and assess the contribution from just terminal emissions, from all on-site activities, and from all activities, including off-site activities.

The air quality modeling methodology follows general EPA protocols used in air quality permitting. The methodology used is similar to the approach used in the *Environmental Report Air Quality Analysis, Appendix L – Air Quality Modeling Analysis* prepared by URS (URS Corporation 2015). One notable exception was the use of the Tier 3 level Ozone Limiting Method (OLM) to estimate NO_2 concentration. The OLM approach accounts for the NO_x to NO_2 conversion,[6] using EPA's default NO_2/NO_x equilibrium ratio of 0.9, an in-stack NO_2 to NO_x of 0.05 for locomotives,[7] an in-stack of NO_2 to NO_x of 0.20 for vessels (Alföldy et al. 2013), and an NO_2 to NO_x of 0.30 for on-site equipment (Wang et al. 2011). The OLM approach also requires the O_3 data. The nearest representative O_3 data available was from the Oregon Department of Environmental Quality's Sauvie Island monitor located in the Columbia River approximately 25 miles to the south-southeast of the project area. However, this site is not a year-round monitor, and other more distant and less representative sites would be needed to complete the analysis using monitored data. Instead, representative background concentrations for the study area were obtained from the Northwest International Air Quality Environmental Science and Technology Consortium (NW AIRQUEST), Washington State University, for the time period of 2009 through 2011.[8] The background ozone concentration for this location was 79 $\mu g/m^3$.

The air quality model requires that emissions be characterized for use in AERMOD as four types of sources: point, volume, area, and line sources.[9] Each emissions source type characteristic is summarized below.

- **Point Sources.** Vessels and tug boat emissions from vented stacks were characterized as point sources. The operating and maintenance equipment were also modeled as point sources spread across the terminal. Exhaust emissions from on-site operations and maintenance equipment were also based on the NONROAD model. Vessel emissions factors came from several sources, including California's Air Resource Board (CARB) *Emission Estimation Methodology for Ocean Going Vessels* (California Air Resource Board 2011), and EPA's *Federal Marine Compression-Ignition Engines, Exhaust Emission Standards* for highest tier engines—auxiliary and Tugs C2; main engine C3 (U.S. Environmental Protection Agency 2012). This analysis assumes that EPA's engine emissions standards are fully implemented by 2016, and that all vessels would be using these types of engines by the time the terminal would become fully operational.
- **Volume sources.** Coal transfer operations were characterized as volume sources, which included eight transfer towers, a rotary rail dump, surge bins work points, and two conveyors to

[6] Atmospheric chemistry changes NO to NO_2; the rate at which this conversion takes place is limited by the available ozone and sunlight.

[7] About 5% of NO_x freshly emitted from locomotives is in the form of NO_2 (Fritz pers. comm.).

[8] The consortium developed background design value estimates for 2009 through 2011, based on model-monitor interpolated products that provide realistic background design value estimates where nearby ambient monitoring data are unavailable. The work is sponsored by EPA Regional 10, Ecology, and others. More information about the NW AIRQUEST tool can be found at http://www.lar.wsu.edu/nw-airquest/lookup.html.

[9] AERMOD User Guide (2004) provides additional information on the definition of these source types.

load coal onto the vessels with emissions rates estimated based on the EPA AP-42, Chapter 13.2.4 approach (U.S. Environmental Protection Agency 1995b).

- **Area sources.** Area sources were used to model low-level ground releases. The four coal storage piles were modeled as area sources with emissions estimated following the EPA AP-42, Chapter 13.2.5 approach (U.S. Environmental Protection Agency 1995c).
- **Line sources.** Exhaust emissions from locomotives unloading operations and coal dust from moving rail cars were modeled as line sources. Coal dust particulate emissions were estimated following EPA's AP-42, Chapter 13.2.5 approach (U.S. Environmental Protection Agency 1995c), and locomotive exhaust emissions were estimated following EPA's NONROAD2008a model[10] (U.S. Environmental Protection Agency 2009).

Table 3 presents a list of emissions source types associated with operations, identifies how the source type is characterized in AERMOD, and lists the appendix where further details are provided on how emissions were calculated.

2.2 Existing Conditions

The existing environmental conditions related to air quality in the study area are described below.

2.2.1 Project Area Air Quality Conditions

The following sections describe the meteorological conditions and background air quality conditions.

2.2.1.1 Prevailing Meteorology/Climate

The project area is located along the Columbia River in southwestern Washington, approximately 50 miles east of the Pacific Ocean. The region is characterized as a mid-latitude, west coast marine-type climate. The Cascade Range to the east has a large influence on the climate in Cowlitz County. The Cascade Range forms a barrier from continental air masses originating over the Columbia River Basin. The Cascades also induce heavy amounts of rainfall; as moist air from the west rises, it is forced to rise up the mountain slopes, which produces heavier rainfall on the western slopes of the Cascades and moderate rainfall amounts in the lower lying areas, such as Longview.

Summers in the region are mild and dry. Winters are cool, but typically wet and cloudy with a small range in daily temperature. The average annual precipitation in Longview is approximately 48 inches, with most precipitation falling during the months of November through March (National Climate Data Center 2011). Average annual rain events, taken as days with measured rain greater than 0.01-inch, are approximately 175 days per year, based on National Climatic Data Center summaries.

Due mostly to its geographical location, temperatures are usually mild. Days with maximum temperatures above 90 degrees Fahrenheit (°F) occur about 7 times per year on average. Days with a minimum temperature below 32°F occur about 57 times per year on average, and below 0°F temperatures occur only very rarely (none recorded between 1931 and 2006). Mean high

[10] Rail emissions were based on the national fleet Class-1 line-haul locomotive fleet.

temperatures range from the high 70s in the summer to mid-40s (°F) in winter, while average lows are generally in the low 50s in summer and mid-30s in winter.

Meteorological data collected by the Weyerhaeuser meteorological tower at the nearby Mint Farm Industrial Park between 2001 and 2003 indicates that the prevailing winds in the vicinity of the project area are from the west-northwest and southeast, following along the alignment of the Columbia River at that location. In the fall and winter months (October through March), the winds are primarily from the southeast and east; the winds are typically from the west-northwest in the spring and summer months (April through September). Figure 3 shows the annual wind rose for the Mint Farm meteorological station for the three-year period from 2001 to 2003 with an average wind speed of 2.25 meters/second.

2.2.1.2 Background Air Quality

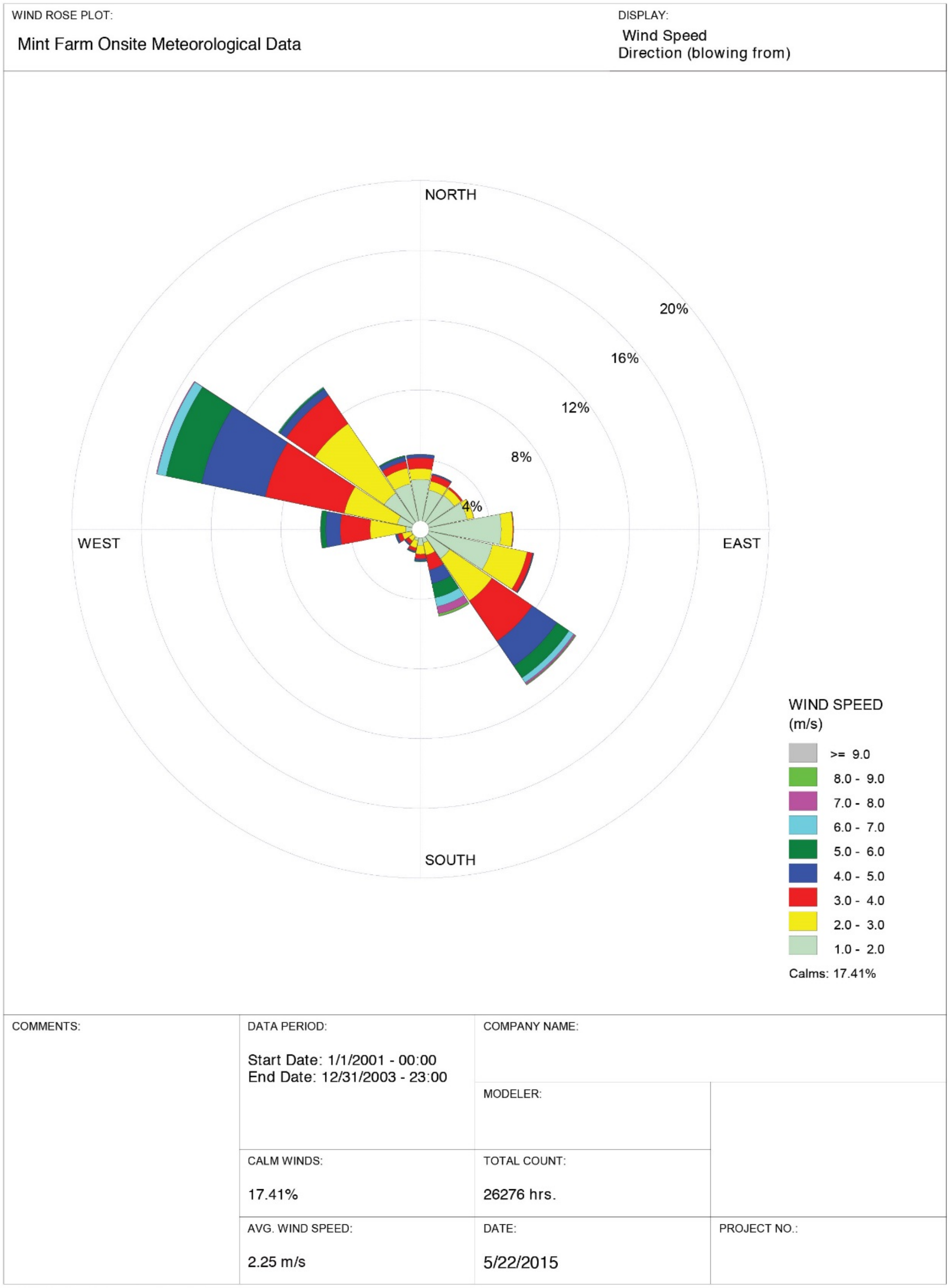
As discussed in Section 1.2.4, *Attainment Status*, Cowlitz County is attainment or unclassified for all criteria pollutants, indicating that air quality in the vicinity of the project area meets the federal and state ambient air quality standards shown in Table 2. The only available local air pollutant monitoring is for PM2.5. The monitor is operated by Ecology and is located at 1234 30th Avenue in Longview (Olympic School), approximately 1.5 miles east of the project area.

Beginning January 1, 2007, hourly data were made available for analysis and download at Ecology's monitoring data site (Washington State Department of Ecology 2015a). The maximum reported daily 24-hour PM2.5 concentration between January 1, 2007 and February 2015 was 28.0 $\mu g/m^3$ reported on November 16, 2014. The second highest 24-hour average was 26.7 $\mu g/m^3$ reported on November 23, 2013. The 3-year average of 98th percentile is 17.8 μg/m3. This 3-year average is well below the 24-hour 98th percentile PM2.5 standard of 35 $\mu g/m^3$. The 3-year annual average PM2.5 concentration has ranged from 4.9 to 6.1 $\mu g/m^3$ over the past 8 years, with the highest concentration occurring from 2012 through 2014. The monitoring shows that PM2.5 levels in the Longview-Kelso area are well within the PM2.5 air quality standards. However this $PM_{2.5}$ monitor is not a Federal Reference Method or Federal Equivalence Method monitor, and thus, cannot be used to make formal designations of attainment status.

Concentrations of other criteria pollutants for the study area also are expected to be well within air quality standards, although no monitoring data are available. Estimated values based on air quality modeling are discussed in Section 3.1.1.2, *Operations*.

In addition, criteria pollutants results from the Longview air toxics study (Southwest Clean Air Agency 2007) showed that measured levels of toxic pollutants were below levels of concern for short-term and long-term exposures. The study found that, of the air toxics that could be directly monitored, the air toxics of most concern for potential health risk in Longview are acetaldehyde, arsenic, benzene, manganese and formaldehyde, while DPM was identified as the most likely contributor to cancer risk in Washington State. No further studies on air toxic monitoring in the Longview-Kelso area has been conducted since that time. Regarding HAPs, the most recent national air toxic assessment (U.S. Environmental Protection Agency 2011) showed that Cowlitz County has an overall inhalation cancer risk of 30 cancers per million, which is slightly lower than the state average of 40 cancers per million and below the national average of 40 cancers per million. A similar pattern emerges when DPM is included in the analysis, but with levels nearly ten times higher (Washington State Department of Ecology 2011).

Figure 3. Wind Data for Mint Farm 2001-2003, Supplemented with Portland International Airport for Missing Hours



2.2.2 Cowlitz County Air Quality Conditions

Cowlitz County is classified as attainment or unclassified for all air pollutants. Of the criteria air pollutants, only PM2.5 is currently being monitored in the county. The PM2.5 monitoring station located at the Olympic Middle School is a neighborhood-scale site, affected primarily by smoke from home heating. It is considered representative of the Longview-Kelso area and is used for curtailment calls during the home heating season. The 24-hour design value in 2014 was 18 $\mu g/m^3$ (Washington State Department of Ecology 2015b). Although it is not a reference instrument, it is considered a strong indicator of the relative air quality for the Longview-Kelso area. Air quality in other locations of Cowlitz County is generally as good as or better than in the Longview-Kelso area. With respect to HAPs, the most recent national air toxic assessment (U.S. Environmental Protection Agency 2011) showed that Cowlitz County has an overall inhalation cancer risk of 30 cancers per million, which is lower than the state average of 40 cancers per million as well as below the national average of 40 cancers per million, not including DPM. A similar pattern emerges when DPM is included but with levels nearly ten times higher.

2.2.3 Washington State Air Quality Conditions

As described in the SEPA Rail Transportation Technical Report (ICF International and Hellerworx 2016), most loaded and empty trains would be expected to travel the same route between the Washington-Idaho State line and Pasco, Washington. West of Pasco, westbound loaded trains would travel to the project area along the Columbia River Gorge route, through Vancouver, to Longview Junction on the BNSF main line, and then along the BNSF Spur and Reynolds Lead to the project area. Empty trains would travel from the project area along the Reynolds Lead and BNSF Spur to Longview Junction, on the BNSF main line to Auburn, over Stampede Pass, then through Yakima and back to Pasco.

Air quality along the loaded portion of the rail route in eastern Washington from the Idaho border to Pasco is generally good. Spokane is a maintenance area for carbon monoxide, but has not had an exceedance of the carbon monoxide standard in over 10 years. Also in this region of the Columbia Plateau from spring through fall, high winds can combine with dry weather conditions to create dust storms, which can lead to extremely high levels of PM10. The state monitors for PM2.5 along this route, but in general the monitoring is below the state's goal to keep concentrations below 20 $\mu g/m^3$, which is well below the PM2.5 NAAQS of 35 $\mu g/m^3$. Air quality through the Columbia Gorge is generally good, with the primary concern focused on visibility impairment and regional haze issues; standards established to protect visibility are much lower than for health effects. The air quality from Vancouver up to Longview is generally good with PM2.5 being the pollutant of most concern; readings are generally below the state's goal to keep PM2.5 concentrations below 20 $\mu g/m^3$. The few days with higher levels mostly occur during the home heating season. Vancouver design values cannot be calculated because of data completeness issues.

Unloaded rail cars would pass from Longview through Tacoma, up to Auburn, and over the Cascades via Stampede Pass. The area east of Auburn experiences some of the highest ozone levels in western Washington, but these levels are below the NAAQS. The ozone monitoring site near Enumclaw has shown exceedances of the 8-hour ozone standard during the past 3 years (Washington State Department of Ecology 2015b).

Air quality from Stampede Pass through Yakima and back to Pasco is generally good but in the Yakima region recent monitoring data in the area has shown higher than usual levels of PM2.5 that contains nitrate. In Yakima, much of the PM2.5 comes from wood burning, with the highest levels occurring during the wintertime as a result of increased wood burning along with stagnant air conditions (Washington State Department of Ecology 2015b); nitrate accounts for up to one-quarter of the wintertime PM2.5 in the Yakima area. High levels of daily PM2.5 are found in Ellensburg for 2 to 3 weeks each year. Unloaded rail cars would then pass along the same route from Pasco back to Spokane with the same air quality as described above.

Vessel traffic would traverse along the Columbia River between the project area and the mouth of the Columbia River. Wahkiakum and Pacific Counties are designated as attainment areas for criteria air pollutants.

With respect to HAPs, the 2005 EPA National-Scale Air Toxics Assessment was adjusted by Ecology to estimate cancer risk (Washington State Department of Ecology 2011). Inhalation cancer risks were highest in the major population centers along the rail route (i.e., Vancouver and Spokane), with a cancer risk of up to 500 cancers per million. For the smaller communities (i.e., Kelso-Longview, Spokane, Yakima, and Pasco), cancer risks were up to 300 cancers per million, although locations along the rail line have cancer risks of less than 75 cancers per million.[11]

[11] EPA released the results from the 2011 National-Scale Air Toxics Assessment in December 2015. The 2011 Ecology study uses the 2005 National-Scale Air Toxics Assessment.

Chapter 3
Impacts and Mitigation

This chapter describes the impacts on air quality that would result from construction and operation of the Proposed Action or the ongoing activities of the No-Action Alternative.

3.1 Impacts

This section describes the impacts on air quality that could result from the Proposed Action and No-Action Alternative.

3.1.1 Proposed Action

Potential impacts on air quality from the Proposed Action are described below.

3.1.1.1 Construction

Maximum annual emission estimates associated with construction of the Proposed Action are presented in Table 4, and maximum daily emission estimates are presented in Table 5. Table 4 provides the maximum annual construction emissions during the peak of the construction period. Table 5 considers the same construction activities presented in Table 4, while looking at the maximum construction emissions occurring during an 8-hour weekday.

As mentioned in Section 1.2.4, *Attainment Status*, the study area is in attainment for all criteria pollutants. Although attainment areas are not subject to federal General Conformity rules (40 CFR 93, subpart B), the rule provides emission *de minimis* levels that could be used for evaluating the potential impact from construction emissions.

As shown in Table 4, the maximum annual construction-related emissions would be well below the *de minimis* levels established by the EPA. This means that although emissions of criteria pollutants would occur, they would not be expected to cause a significant change in air quality and are unlikely to adversely affect sensitive receptors surrounding the project area. Table 5 shows the maximum daily construction emissions. This maximum activity occurs early in the construction schedule with earthwork activity and with the delivery of construction of materials via barge and truck. Since no suitable docking locations are available for the type of barges needed to deliver materials in Cowlitz County, the barge emissions are included as informational since barge emissions would be outside the study area. Haul truck emissions are included for the truck trips needed to make deliveries of construction material to the project area.

The estimated emissions shown in Tables 4 and 5 assume that best management practices would be followed, including reduced idling measures, dust control measures to minimize soil disturbance, and the application of water along access roads to minimize the track-out of soil.

Table 4. Maximum Annual Estimated Construction Emissions

	Construction Emissions (tpy) [maximum per year]								
Source	**NO_x**	**CO**	**VOCs**	**SO_2**	**TSP**	**PM10**	**PM2.5**	**HAPs**	**DPM**
Combustion Sources									
Equipment (project area)	24.60	9.04	2.23	0.95	2.34	1.93	1.93	0.05	2.34
Haul Trucks (project area)	4.06	0.88	0.18	0.01	0.23	0.19	0.13	0.004	0.23
Haul Trucks (study area)[a]	9.37	2.04	0.41	0.03	0.54	0.44	0.31	0.010	0.54
Barges (study area)[b]	59.0	15.68	1.51	0.028	1.29	1.06	1.06	0.03	1.29
Passenger Commute Vehicles/Crossing-Delay (study area)[a]	0.05	7.5	0.13	0.010	0.22	0.22	0.04	0.001	<0.001
Total Combustion Sources (project area)	**28.66**	**9.92**	**2.41**	**0.96**	**2.57**	**2.12**	**2.06**	**0.05**	**2.57**
Total Combustion Sources (all study area)[c]	**38.1**	**19.5**	**2.95**	**1.0**	**3.3**	**2.8**	**2.4**	**0.07**	**3.1**
Fugitive Sources									
Controlled Fugitive Earthwork (project area)	-	-	-	-	12.00	5.87	1.22	-	-
Total Fugitive Sources	**-**	**-**	**-**	**-**	**12.00**	**5.87**	**1.22**	**-**	**-**
Total									
On-site construction emissions sources (project area)	**28.7**	**9.9**	**2.41**	**0.96**	**14.6**	**7.99**	**3.28**	**0.05**	**2.6**
All construction emissions sources[c]	**38.1**	**19.5**	**2.95**	**1.0**	**15.3**	**8.7**	**3.6**	**0.07**	**3.1**
General Conformity *de minimis* levels for ozone maintenance areas (CFR 93.153)	100	100	100	100		100	100		

Source: Combustion and fugitive emissions sources were obtained from various references, as described above under Section 2.1.2.1, *Construction Impact Analysis Approach*.

Notes:

[a] Not in the project area but within Cowlitz County.

[b] Not in project area. Based on barge maneuvering time for docking of 0.5 hour in and 0.5 hour out; does not include transit on the Columbia River.

[c] Rounded. Does not include barge emissions, but does include haul truck emissions to the project area.

"-" = not applicable

tpy = tons per year; NO_x = nitrogen oxide; CO = carbon monoxide; VOCs = volatile organic compounds; SO_2 = sulfur dioxide; TSP = total suspended particles; PM10 = particulate matter less than 10 micrometers in diameter; PM2.5 = particulate matter less than 2.5 micrometers in diameter; HAPs = hazardous air pollutants; DPM = diesel particulate matter

Table 5. Maximum Daily Estimated Construction Emissions

Source	Construction Emissions (lb/day) [maximum daily]								
	NO_x	CO	VOCs	SO_2	TSP	PM10	PM2.5	HAPs	DPM
Combustion Sources									
Equipment (project area)	229.6	82.89	20.4	8.67	21.49	17.66	17.66	0.42	21.5
Haul Trucks (project area)	54.7	14.4	3.1	0.2	6.1	5.0	2.6	0.1	6.12
Haul Trucks (study area)[a]	110.48	24.0	4.81	0.33	6.34	5.21	3.66	0.12	6.34
Barges (study area)[b]	454.7	120.8	11.6	0.21	9.90	8.14	8.14	0.61	9.9
Passenger Commute and Crossing Delay (study area)[a]	1.43	20.0	0.35	0.03	0.58	0.58	0.11	0.01	<0.001
Total Combustion Sources (project area)	**284.3**	**97.29**	**23.5**	**8.87**	**27.59**	**22.66**	**20.26**	**0.52**	**27.62**
Total Combustion Sources (all study area)[c]	**396.2**	**141.29**	**28.7**	**9.23**	**34.5**	**28.5**	**24.0**	**0.65**	**34.0**
Fugitive Sources									
Controlled Fugitive Earthwork	-	-	-	-	66.7	32.6	6.80	-	-
Total Fugitive Sources	-	-	-	-	**66.7**	**32.6**	**6.80**	-	-
Total									
Onsite construction emissions sources (project area)	**284.3**	**97.29**	**23.5**	**8.87**	**94.3**	**55.3**	**27.1**	**0.52**	**27.6**
All construction emissions sources[c]	**396.2**	**141.29**	**28.7**	**9.23**	**101.21**	**61.1**	**30.8**	**0.65**	**34.0**

Notes:

Source: Combustion and fugitive emissions sources were obtained from various references, as described above under Section 2.1.2.1, *Construction Impact Analysis Approach*.

[a] Not in the project area, but within Cowlitz County.

[b] Not in project area. Based on barge maneuvering time for docking of 0.5 hour in and 0.5 hour out; does not include transit on the Columbia River

[c] Rounded. Does not include barge emissions, but does include haul truck emissions to the project area.

"-" = not applicable

lb/day = pounds per day; NO_x = nitrogen oxide; CO = carbon monoxide; VOCs = volatile organic compounds; SO_2 = sulfur dioxide; TSP = total suspended particles; PM10 = particulate matter less than 10 micrometers in diameter; PM2.5 = particulate matter less than 2.5 micrometers in diameter; HAPs = hazardous air pollutants; DPM = diesel particulate matter

3.1.1.2 Operations

Sources of air pollution from the Proposed Action would include fugitive emissions from coal handling and mobile source emissions from maintenance and operation of the terminal, as well as emissions from trains and vessels used in transport. As presented in Table 6, rail and vessel emissions are the largest source of emissions, with the exception of particulate matter where all sources are important contributors. The terminal would produce only small quantities of air pollutants (maintenance/operations); the supporting operations of coal transport from vessels and trains are the dominant source of air emissions.

Table 6. Full Operations Maximum Annual Average Emissions[a]

	Maximum Annual Average Emissions (tpy)								
Source	**NO_x**	**CO**	**VOCs**	**SO_2**	**TSP**	**PM10**	**PM2.5**	**HAPs**	**DPM**
Fugitive Sources									
Coal Transfer (except piles):									
Material Handling	-	-	-	-	5.25	1.84	0.28	-	-
Coal Piles:									
Wind Erosion	-	-	-	-	1.08	0.92	0.14	-	-
Material Handling	-	-	-	-	2.62	0.92	0.14	-	-
Mobile Sources									
Maintenance/Operations Equipment:									
Combustion	4.36	1.42	0.36	0.19	0.38	0.31	0.31	0.01	0.38
Employee Commute\Crossing Delay	0.13	2.05	0.04	0.003	0.008	0.08	0.02	0.01	<0.01
Locomotive:									
Combustion (off-site)[b]	17.5	7.63	0.60	0.027	0.45	0.37	0.36	0.08	0.45
Fugitive Dust (off-site)[b]	-	-	-	-	0.94	0.80	0.12	-	-
Combustion (on-site)	11.6	4.00	0.48	0.01	0.30	0.25	0.24	0.04	0.21
Fugitive Dust (on-site)	-	-	-	-	2.10	1.79	0.27	-	-
Vessels:									
Combustion (off-site)[b]	24.8	37.9	14.1	3.04	2.17	1.78	1.64	0.03	0.00
Combustion (on-site)	23.3	65.9	15.3	4.52	1.27	1.05	1.02	0.08	0.56
Total: All Mobile Sources, On-site and Off-site	81.7	118.9	30.9	7.8	7.6	6.4	4.0	0.3	1.6
Total - On-site Sources	39.3	71.3	16.14	4.72	13.00	7.08	2.40	0.13	1.15
Fugitive Dust Only	-	-	-	-	11.05	5.47	0.83	-	-
Mobile Combustion Sources	39.26	71.32	16.14	4.72	1.95	1.61	1.57	0.13	1.15

Notes:
Source: Combustion and fugitive emissions sources were obtained from various references, as described in Section 2.1.2.2, *Operations Impact Analysis Approach*.
[a] Full operations = Maximum production (44 million metric tons per year).
[b] off-site = Not in the project area.
"-" = Not applicable.
tpy = tons per year; NO_x = nitrogen oxide; CO = carbon monoxide; VOCs = volatile organic compounds; SO_2 = sulfur dioxide; TSP = total suspended particles; PM10 = particulate matter less than 10 micrometers in diameter; PM2.5 = particulate matter less than 2.5 micrometers in diameter; HAPs = hazardous air pollutants; DPM = diesel particulate matter

Air Quality Impact Assessment

A modeling analysis was performed with the AERMOD dispersion model. The results from the modeling are compared with the NAAQS.

Two sets of emissions were developed. The first set was used to model the long-term (annual average concentrations), reflecting emissions over an entire year with train and vessel arrivals spread over the year to simulate the average activity at the terminal. The second set of emissions was used to determine the short-term (24-hour or less concentrations), reflecting peak emissions that could occur during the course of an hour. Peak activity included a coal train unloading at the terminal, a vessel loading with coal, and a second vessel docking at the terminal.

To assess impacts associated with the Proposed Action, the AERMOD model was used to predict the increase in criteria pollutant concentrations. The maximum modeled incremental increases for each pollutant and averaging time were added to applicable background concentrations. With the exception of PM2.5, the background concentrations were obtained from NW AIRQUEST, Washington State University, for the time period 2009 through 2011.[12] These consortium values are typically recommended for use as background concentration by Ecology in air quality analyses when no representative monitoring data is available. The resulting total pollutant concentrations (background plus modeled concentration) were then compared with the appropriate NAAQS.

As described in Section 2.2, *Existing Conditions*, there is a monitoring program for PM2.5 in the Longview-Kelso area and the resulting data were used to estimate the background concentration for PM2.5. The method for comparing modeled impacts with added background concentrations to each NAAQS is dependent on the form of the standard, and thus varies by pollutant and averaging time. The differences are footnoted in the comparison tables (Tables 7, 8, and 9). For example, the 1-hour NO_2 NAAQS is based on the 98^{th} percentile of 1-hour daily maximum concentration (8th highest 1-hour daily maximum for a full year of hourly values) across the 3 meteorological modeling years (2009 through 2011) plus the background concentration.

Table 7 summarizes the maximum predicted criteria pollutant concentrations due to maintenance and operations of the terminal only. This includes the material handling and moving of the coal and coal piles, as well as exhaust emissions from mobile source equipment (e.g., loader). In no case are the terminal-only estimated emissions in combination with the background concentrations anticipated to cause a violation of any NAAQS. The highest incremental impact due to the terminal-only operation is the 24-hour PM10 impact, which is 38% of the respective NAAQS.

[12] The consortium developed background design value estimates for 2009 through 2011, based on model-monitor interpolated products that provide realistic background design value estimates where nearby ambient monitoring data are unavailable. The work is sponsored by EPA Regional 10, Ecology, and others. More information about the NW AIRQUEST tool can be found at http://www.lar.wsu.edu/nw-airquest/lookup.html.

Table 7. AERMOD Modeling Results (Terminal Sources: Maintenance and Operations Equipment)[a]

Pollutant	Averaging Period	Modeled Impact (μg/m³)	Background[b,c] (μg/m³)	Total Predicted Concentration (μg/m³)	NAAQS (μg/m³)
CO	1 hour[d]	10.7	827	838	40,000
	8 hour[d]	4	600	604	10,000
NO_2	1 hour[e,f]	15	56.6	72	188
	Annual[f,g]	0.4	5.3	6	100
PM10	24 hour[h]	57	23	80	150
PM2.5	24 hour[i]	4.8	17.8	22.6	35
	Annual[j]	0.2	6.1	6.3	12
SO_2	1 hour[k]	6.8	14.7	21.5	196
	3 hour[l]	4.5	11.5	16.0	1,300

Notes:

[a] Terminal sources include emissions from handling coal, coal storage piles, and mobile source exhaust emissions from the operation and maintenance of the facility.

[b] Background design value estimates for 2009 through 2011, based on model-monitor interpolated products (except PM2.5) sponsored by EPA Regional 10, Ecology, and others. From NW AIRQUEST tool Washington State University (http://www.lar.wsu.edu/nw-airquest/lookup.html.)

[c] PM2.5 background based on Ecology's Kelso Monitor (2012 through 2014).

[d] Modeled impact is the highest 2nd high for each calendar year over the 3 modeled years..

[e] The NO_2 1-hour modeled impact is the 3-year average of the 98th percentile of 1-hour daily maximum concentrations.

[f] Modeled NO_2 impacts applied the Tier III Ozone Limiting Method (OLM), using an ozone background of 42ppb, as per the NW-AIRQUEST tool. For additional information regarding the modeling methodology, see Section 2.1.2.2, *Operations Impact Analysis Approach*.

[g] The NO_2 annual modeled impact is the maximum annual mean over the 3 modeled years.

[h] The PM10 24-hour modeled impact is 3-year average of the highest 2nd high concentration.

[i] The PM2.5 24-hour modeled impact is the 3-year average of the 98th percentile of 1-hour daily maximum concentrations.

[j] The PM2.5 annual modeled impact is the 3-year average of the annual mean.

[k] The SO_2 1-hour modeled impact is the 3-year average of the 99th percentile of the 1-hour daily maximum concentrations.

[l] The SO_2 3-hour modeled impact is not to be exceeded more than once per year.

μg/m³ = micrograms per cubic meter; NAAQS = National Ambient Air Quality Standards; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM10 = particulate matter less than 10 micrometers in diameter; PM2.5 = particulate matter less than 2.5 micrometers in diameter; SO_2 = sulfur dioxide

Table 8 shows the modeling results for on-site sources (terminal emissions sources, plus cargo vessel and train operations while on-site). Cargo vessel operations are the main source of SO_2 emissions, which has an incremental increase in the 1-hour SO_2 concentration that is 61% of the respective standard. The incremental increase in the 24-hour PM10 is about half the respective standard. The maximum impacts for each pollutant plus the maximum background show total concentrations below the NAAQS for all criteria air pollutants.

Table 8. AERMOD Modeling Results (On-site Sources)[a]

Pollutant	Averaging Period	Modeled Impact (μg/m³)	Background[b,c] (μg/m³)	Total Predicted Concentration (μg/m³)	NAAQS (μg/m³)
CO	1 hour[d]	220	827	1,047	40,000
	8 hour[d]	71	600	671	10,000
NO_2	1 hour[d,e]	100	56.6	157	188
	Annual[f,g]	10.8	5.3	12	100
PM10	24 hour[h]	85	23	108	150
PM2.5	24 hour[i]	12	17.8	29.8	35
	Annual[j]	1.1	6.1	7.2	12
SO_2	1 hour[k]	119	14.7	134	196
	3 hour[l]	84	11.5	96	1,300

Notes:

[a] On-site sources include emissions from handling coal, coal storage piles, and mobile source exhaust emissions from the operation and maintenance of the facility.

[b] Background design value estimates for 2009 through 2011, based on model-monitor interpolated products (except PM2.5) sponsored by EPA Regional 10, Ecology, and others. From NW AIRQUEST tool Washington State University (http://www.lar.wsu.edu/nw-airquest/lookup.html.)

[c] PM2.5 background based on Ecology's Kelso Monitor (2012 through 2014).

[d] Modeled impact is the highest 2nd high for each calendar year over the 3 modeled years.

[e] The NO_2 1-hour modeled impact is the 3-year average of the 98th percentile of 1-hour daily maximum concentrations.

[f] Modeled NO_2 impacts applied the Tier III Ozone Limiting Method (OLM), using an ozone background of 42ppb, as per the NW-AIRQUEST tool. For additional information regarding the modeling methodology, see Section 2.1.2.2, *Operations Impact Analysis Approach*.

[g] The NO_2 annual modeled impact is the maximum annual mean over the 3 modeled years.

[h] The PM10 24-hour modeled impact is 3-year average of the highest 2nd high concentration.

[i] The PM2.5 24-hour modeled impact is the 3-year average of the 98th percentile of 1-hour daily maximum concentrations.

[j] The PM2.5 annual modeled impact is the 3-year average of the annual mean.

[k] The SO_2 1-hour modeled impact is the 3-year average of the 99th percentile of the 1-hour daily maximum concentrations.

[l] The SO_2 3-hour modeled impact is not to be exceeded more than once per year.

μg/m³ = micrograms per cubic meter; NAAQS = National Ambient Air Quality Standards; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM10 = particulate matter less than 10 micrometers in diameter; PM2.5 = particulate matter less than 2.5 micrometers in diameter; SO_2 = sulfur dioxide

Table 9 shows the modeling results for all on-site sources and off-site sources (vessels arriving and departing from the terminal, assist tugs, plus trains arriving and departing from the terminal, to approximately 5 miles out). These results are similar to the on-site sources. The largest increase as a percentage of the NAAQS is the SO_2 concentration due to operation of the tugs and cargo vessels. Again, in all cases the maximum impacts for each pollutant plus the maximum background show total concentrations below the NAAQS for all criteria air pollutants.

Table 9. AERMOD Modeling Results (On-site and Off-site Sources)

Pollutant	Averaging Period	Modeled Impact (µg/m³)	Background[a,b] (µg/m³)	Total Predicted Concentration (µg/m³)	NAAQS (µg/m³)
CO	1 hour[c]	346	827	1,173	40,000
	8 hour[c]	97	600	697	10,000
NO_2	1 hour[c,d]	100	56.6	157	188
	Annual[e,f]	16	5.3	21	100
PM10	24 hour[g]	85	23	108	150
PM2.5	24 hour[h]	12	17.8	29.8	35
	Annual[i]	1.2	6.1	7.3	12
SO_2	1 hour[j]	130	14.7	145	196
	3 hour[k]	127	11.5	138	1,300

Notes:

[a] Background design value estimates for 2009 through 2011, based on model-monitor interpolated products (except PM2.5) sponsored by EPA Regional 10, Ecology, and others. Source: NW AIRQUEST tool Washington State University (http://www.lar.wsu.edu/nw-airquest/lookup.html.)

[b] PM2.5 background based on Ecology's Kelso Monitor (2012 through 2014).

[c] Modeled impact is the highest 2nd high for each calendar year over the 3 modeled years.

[d] The NO_2 1-hour modeled impact is the 3-year average of the 98th percentile of 1-hour daily maximum concentrations.

[e] Modeled NO2 impacts applied the Tier III Ozone Limiting Method (OLM), using an ozone background of 42ppb, as per the NW-AIRQUEST tool. For additional information regarding the modeling methodology, see Section 2.1.2.2, *Operations Impact Analysis Approach*.

[f] The NO_2 annual modeled impact is the maximum annual mean over the 3 modeled years.

[g] The PM10 24-hour modeled impact is 3-year average of the highest 2nd high concentration.

[h] The PM2.5 24-hour modeled impact is the 3-year average of the 98th percentile of 1-hour daily maximum concentrations.

[i] The PM2.5 annual modeled impact is the 3-year average of the annual mean.

[k] The SO_2 1-hour modeled impact is the 3-year average of the 99th percentile of the 1-hour daily maximum concentrations.

[l] The SO_2 3-hour modeled impact is not to be exceeded more than once per year.

µg/m³ = micrograms per cubic meter; NAAQS = National Ambient Air Quality Standards; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM10 = particulate matter less than 10 micrometers in diameter; PM2.5 = particulate matter less than 2.5 micrometers in diameter; SO_2 = sulfur dioxide

Proposed Action and Cowlitz County Emissions Comparison

The pollutant emissions totals within Cowlitz County for the Proposed Action during maximum terminal throughput (Table 6) are shown in Table 10 with the 2011 Cowlitz County emissions inventory totals.

When comparing potential train emissions (a combination of on-site and off-site fugitive dust and combustion emissions) resulting from full operations of the Proposed Action (Table 6) with the 2011 railroad emissions in Cowlitz County (Table 10), railroad-related emissions are estimated to increase by about 6%. The largest emissions increase for a single pollutant associated with rail is for PM10, which is equal to an increase of approximately 15% when compared to the 2011 rail emissions for Cowlitz County.

A similar comparison is made for vessel emissions as shown in Table 10; vessel-related emissions are estimated to increase by about 12%. The largest emissions increase for a single pollutant associated with vessels is for CO and VOC at approximately 69 and 63%, respectively when compared to the 2011 vessel emissions for Cowlitz County. The increase in CO emissions is primarily due to ship hoteling, which would use the auxiliary engines while docked. While this emission increase represents a substantial increase relative to the commercial marine vessel category, overall it represents only a small increase (0.28% and 0.17%) to the total Cowlitz County CO and VOC emissions.

Table 10. Maximum Annual Emissions Estimates in Cowlitz County for Locomotive and Commercial Marine Vessels for the Proposed Action in Comparison with the 2011 Cowlitz County Emissions Inventory

	Maximum Annual Average Emissions (tpy)						
	NO_x	CO	VOCs	SO_2	PM10	PM2.5	DPM
Locomotive							
Proposed Action Emissions	41	16	1.6	0.06	3.5	1.2	0.88
Cowlitz County Emissions	789	137	43	6	23	23	23
Commercial Marine Vessels							
Proposed Action Emissions	48	104	29	7.6	2.8	2.7	0.6
Cowlitz County Emissions	1,109	150	46	199	37	34	34

Notes:

Source: Washington State Department of Ecology 2014.

tpy = tons per year; NO_x = nitrogen oxide; CO = carbon monoxide; VOCs = volatile organic compounds; SO_2 = sulfur dioxide; PM10 = particulate matter less than 10 micrometers in diameter; PM2.5 = particulate matter less than 2.5 micrometers in diameter; DPM = diesel particulate matter

Proposed Action and Washington State Emissions Comparison

The pollutant emissions totals for the Proposed Action during maximum production throughout Cowlitz County combined with statewide emissions associated with the vessel and rail transport are shown in Table 11 in comparison with the 2011 Washington statewide emissions inventory totals for locomotives and commercial marine vessels. The largest increase in locomotive emissions for any one pollutant would be CO at 38%, followed by NO_x with a 15% increase. For commercial marine vessels, the relative increase is smaller with a maximum increase of 12% for VOC and just under 11% for CO.

Table 11. Maximum Annual Emissions Estimates in Washington State for Locomotive and Commercial Marine Vessels for the Proposed Action in Comparison with the 2011 Statewide Emissions Inventory

	Maximum Annual Average Emissions (tpy)						
	NO_x	CO	VOCs	SO_2	PM10	PM2.5	DPM
Locomotive							
Proposed Action Emissions	2,209	963	76	3	47	46	47
Statewide Emissions	15,026	2,536	810	95	N/A	430	428
Commercial Marine Vessels							
Proposed Action Emissions	161	276	93	21	13	11	10
Statewide Emissions	20,486	2,521	782	11,529	N/A	1,213	1,021

Notes:

Source: Washington State Department of Ecology 2014.

tpy = tons per year; NO_x = nitrogen oxide; CO = carbon monoxide; VOCs = volatile organic compounds; SO_2 = sulfur dioxide; PM10 = particulate matter less than 10 micrometers in diameter; PM2.5 = particulate matter less than 2.5 micrometers in diameter; DPM = diesel particulate matter

Locomotive emissions would occur along the rail routes described in Section 2.2.3, *Washington State Air Quality Conditions*.[13] Vessel emissions would occur along the Columbia River between the project area and 3 nautical miles beyond the mouth of the Columbia River.

3.1.2 No-Action Alternative

Under the No Action Alternative, the Applicant would not construct the export terminal and impacts on air quality related to construction and operation of the proposed export terminal would not occur. The Applicant would continue with current and future increased operations in the project area. The project area could be developed for other industrial uses including an expanded bulk product terminal or other industrial uses. The Applicant has indicated that, over the long term, it would expand the existing bulk product terminal and develop new facilities to handle more products such as calcine petroleum coke, coal tar pitch, and cement, as described in the SEPA Alternatives Technical Report (ICF International 2016).

Expanded bulk terminal operations and maintenance would result in emissions of air pollutants. The Applicant has identified planned future rail and vessel operations for the No-Action Alternative. Emissions were estimated assuming that current and future operations would result in two daily trains arriving and departing the facility with an average rail car length of 30 cars carrying bulk product. Each train would be composed of two locomotives with an average of 26 vessels arriving and departing each year. In addition, truck haul emissions associated with the transport to the nearby Weyerhaeuser facility are included. The estimated emissions are shown in Table 12. The largest emissions for any single air pollutant is NO_x at 4.4 tons per year. These emissions are lower than the proposed export terminal which were shown to be less than *de minims*. Therefore, no adverse air quality impacts would be anticipated under the No-Action Alternative.

Table 12. No-Action Alternative Annual Average Emissions from Rail, Vessel and Haul Trucks

	Maximum Annual Average Emissions (tpy)								
Source	**NO_x**	**CO**	**VOCs**	**SO_2**	**TSP**	**PM10**	**PM2.5**	**HAPs**	**DPM**
Locomotive Combustion	3.1	1.4	0.11	0.01	0.08	0.07	0.06	0.01	0.06
Vessel Combustion	1.1	2.6	0.63	0.19	0.08	0.06	0.06	0.003	0.02
Haul Trucks	0.2	0.1	0.02	0.002	0.04	0.04	0.01	0.001	0.04
Total	4.4	4.1	0.76	0.20	0.20	0.17	0.13	0.014	0.12

Notes:
tpy = tons per year; NO_x = nitrogen oxide; CO = carbon monoxide; VOCs = volatile organic compounds; SO_2 = sulfur dioxide; PM10 = particulate matter less than 10 micrometers in diameter; PM2.5 = particulate matter less than 2.5 micrometers in diameter; TSP = total suspended particles; HAPs = hazardous air pollutants; DPM = diesel particulate matter

3.2 Mitigation

Based on the findings in this technical report, the co-lead agencies (Cowlitz County and Washington State Department of Ecology) determined mitigation measures are not required.

[13] For more information on the coal train routes, see the SEPA Rail Transportation Technical Report (ICF International and Hellerworx 2016).

Chapter 4
Required Permits

The following permit would be required in relation to air quality for the Proposed Action.

- **Notice of Construction—Southwest Clean Air Agency.** Businesses and industries that cause, or have the potential to cause, air pollution are required to receive approval from the local air agency prior to beginning construction. These are requirements of Washington's Clean Air Act and apply statewide (Chapter 70.94 RCW). Businesses located in Cowlitz County are regulated by the SWCAA. SWCAA rules generally require an air permit for a stationary sources emitting more than 0.75 ton per year of PM10 or 0.5 ton per year for PM2.5[14]. It is anticipated that these levels will be exceeded and the Applicant would need to file a permit application and receive an approved Notice of Construction air permit prior to constructing, installing, establishing or modifying any equipment or operations that may emit air pollution.

[14] Other criteria pollutants have higher emission threshold levels.

Chapter 5
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5.2 Personal Communications

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Appendix A

Air Quality Data

APPENDIX A1
CONSTRUCTION EMISSIONS

SUMMARY

Source	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2e	CO2	CH4	N2O	DPM
	Construction Emissions (tpy) [Maximum per Year]												
COMBUSTION SOURCES													
Equipment (On-site)	24.6	9.04	2.23	0.95	2.34	1.93	1.93	4.55E-02	5,035	5,025.67	2.47E-01	1.22E-02	2.34
Haul Trucks (Off-site)[1]	9.37	2.04	0.41	0.03	0.54	0.44	0.31	0.010	3,161	3,159	5.91E-02	2.87E-03	0.54
Haul Trucks (On-site)[1]	4.06	0.88	0.18	0.01	0.23	0.19	0.13	0.004	1,369	1,368	2.56E-02	1.24E-03	0.23
Haul Trucks idle (On-site)[2]	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0	0.00E+00	0.00E+00	0.00E+00
Passenger Commute Vehicles (off-site)	0.51	7.38	0.13	0.01	-	0.22	0.04	-	1485.28	1482.77	0.02	0.01	-
Crossing Delay (Off-Site)	0.0126	0.0798	0.0025	0.0001	-	0.0015	0.0006	0.0010	-	-	-	-	-
Barges (Off-site)	59.04	15.68	1.51E+00	2.77E-02	1.29E+00	1.06E+00	1.06E+00	7.90E-02	3,050	3,044	1.49E-01	7.38E-03	1.29
Trains:													
Combustion (Off-site)	18.48	8.06	0.64	2.85E-02	4.79E-01	3.94E-01	3.82E-01	8.57E-02	3,125	3,095	2.42E-01	7.88E-02	4.79E-01
Combustion (On-site)	0.71	3.11E-01	2.45E-02	1.10E-03	1.85E-02	1.52E-02	1.47E-02	3.31E-03	121	119	9.35E-03	3.04E-03	1.85E-02
Highest Combination for Transport (Trucks) - Combustion Onl													
Total - Onsite only	28.6	9.9	2.41	0.97	2.58	2.12	2.06	4.99E-02	6,404	6,393	0.27	1.34E-02	2.58
Total - All Construction Sources in Count	38.5	19.4	2.95	1.00	3.11	2.78	2.41	6.12E-02	11,051	11,035	0.35	2.34E-02	3.11
Total combustin													
FUGITIVE SOURCES													
Controlled Fugitive Earthwork	-	-	-	-	12.00	5.87	1.22	-	-	-	-	-	-
Total Fugitive Sources	-	-	-	-	12.00	5.87	1.22	-	-	-	-	-	-
Highest Combination for Transport (Trucks) - All Source													
Total - Onsite only	28.6	9.9	2.41	0.97	14.58	7.99	3.28	4.99E-02	6,404	6,393	0.27	1.34E-02	2.58
Total - All Construction Sources in Count	38.5	19.4	2.95	1.00	15.11	8.65	3.64	6.12E-02	11,051	11,035	0.35	2.34E-02	3.11
General Conformity *de minimis* levels for ozone mainte	100	100	100	100		100	100						

Note:
[1] For Haul truck TSP & HAPs, use same emission ratio as emission factor ratios for Large Diesel Engines (below): PM_{10} and $PM_{2.5}$ ratio to TSP; HAPs ratio to CO.
[2] See assumptions for surrogate idle/onsite in Tab A4 Material Transfer by Truck

INPUT DATA:

Major Construction Activities and Typical Equipment Fleets

Construction Equipment Type	Rail Infrastructure and Rotary Car Dump Station		Conveyors, Transfer Stations and Surge Bins		Shiploader, Dock, and Trestles	
	Max Qty. per Month	Duration (months)	Max Qty. per Month	Duration (months)	Max Qty. per Month	Duration (months)
Mobile Cranes (25-50t)[1]						
Mobile Cranes (50-150t)[1]						
Mobile Cranes (150-300t)[1]						
Water Trucks[2]	1	12	1	12	0	0
Dump Trucks	3	12	1	12	0	0
Dozers	1	5	0	0	0	0
Excavators[3]	1	9	2	12	1	3
Rollers	2	9	2	12	1	3
Graders	2	9	0	0	1	3
Compactors	2	9	2	12	1	3
Track Laying Machine	1	6	0	0	0	0
Drill Rigs	1	2	2	6	0	0
Impact Piling Rigs	2	6	2	6	2	6
Loaders[4]	1	12	1	12	1	9
River Barge	0	0	0	0	2	18
Generator	2	18	2	18	2	18
Air Compressor	2	18	2	18	2	18

Source: MBTL, *Noise Resource Report*, Appendix D-1 (URS, June 2014)
NOTES:
[1] Mobile cranes to be shared between the 3 areas. - removed here because not all material is onsite so crane work may not start the first year.
[2] Water truck to be shared between the 2 land areas.
[3] Excavators to be shared between the 3 areas.
[4] Loaders to be shared between the 3 areas.

Typical construction fleet may be modified with equivalent items as construction activities demai

Assume entire construction period for all 3 areas is	18	months total
	5	days/week

ONSITE EQUIPMENT (NON-BARGE) EMISSIONS

Note: using NONRoad T/Y as calculated which may assume 24/7, so conservative

Equipment Type	Engine Size (hp)	Fuel	Maximum Units Onsite (per year)	EPA NONROAD SCC Number	EPA NONROAD model combustion emission factor (tons/yr per unit)					
					THC-Exhaust	CO-Exhaust	NOx-Exhaust	CO2-Exhaust	SO2-Exhaust	PM-Exhaust
Crane, 50 ton	165	Diesel	0	2270002045	5.15E-02	1.65E-01	6.50E-01	120.43	2.38E-02	5.04E-02
Crane, 150 ton	280	Diesel	0	2270002045	7.69E-02	2.12E-01	9.99E-01	201.70	3.88E-02	6.33E-02
Crane, 300 ton	450	Diesel	0	2270002045	8.22E-02	3.69E-01	1.44E+00	215.37	4.28E-02	7.47E-02
Water Trucks	350	Diesel	1	2270002051	3.06E-02	9.01E-02	3.12E-01	108.922	1.86E-02	3.49E-02
Dump Trucks	350	Diesel	4	*See Notes*	*3.06E-02*	*9.01E-02*	*3.12E-01*	*108.922*	*1.86E-02*	*3.49E-02*
Dozers	185	Diesel	0.4	2270002069	1.66E-01	8.15E-01	1.96E+00	437.06	8.46E-02	2.35E-01
Excavators	230	Diesel	2	2270002036	3.15E-01	1.24E+00	3.65E+00	977.30	1.79E-01	3.62E-01
Rollers	350	Diesel	3.8	2270002015	4.20E-02	1.70E-01	5.19E-01	110.57	2.12E-02	4.42E-02
Graders	185	Diesel	1.8	2270002048	5.49E-02	2.71E-01	6.48E-01	146.26	2.83E-02	7.85E-02
Compactors	25	Diesel	3.8	2270002009	2.47E-04	1.15E-03	2.15E-03	0.26	5.65E-05	1.78E-04
Track Laying Machine	*See Notes*	Diesel	0.5	*See Notes*	*1.96E-01*	*9.29E-01*	*2.35E+00*	*459.49*	*9.05E-02*	*2.51E-01*
Drill Rigs	*NONROAD Default*	Diesel	1.2	2270002033	4.12E-02	1.48E-01	5.47E-01	62.90	1.27E-02	3.29E-02
Impact Piling Rigs	*NONROAD Default*	Diesel	3	2270002033	*4.12E-02*	*1.48E-01*	*5.47E-01*	*62.90*	*1.27E-02*	*3.29E-02*
Loaders	140	Diesel	1	2270002060	1.96E-01	9.29E-01	2.35E+00	459.49	9.05E-02	2.51E-01
Generator	30	Diesel	6	2270006005	1.10E-01	4.39E-01	1.00E+00	119.95	2.48E-02	8.80E-02
Air Compressor	25	Diesel	6	2270006015	2.27E-04	1.17E-03	2.23E-03	0.29	6.30E-05	1.77E-04

NOTES:
Assume Dump Truck size/emissions same as Water Truck
Assume Track Laying Machine uses 1 diesel locomotive and 1 front end loader engine (Harsco Rail, New Track Construction). Assume full-time locomotive used 4 hrs/day, 5 days/
Horsepower and weight estimates based on capacity ratings and industry specifications, or average ratings per equipment type. Where hp could not be assumed, an average hp rate in NONROAD for the equipment type was us

Emission Rates for Onsite Equipment (tpy

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Crane, 50 ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0	0.0000	0.0000	0
Crane, 150 ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0	0.0000	0.0000	0
Crane, 300 ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0	0.0000	0.0000	0
Water Trucks	0.31	0.09	0.03	0.02	0.03	0.03	0.03	0.000	109	0.0053	0.0003	109
Dump Trucks	1.25	0.36	0.12	0.07	0.14	0.11	0.11	0.002	436	0.0214	0.0011	437
Dozers	0.82	0.34	0.07	0.04	0.10	0.08	0.08	0.002	182	0.0089	0.0004	182
Excavators	7.30	2.48	0.63	0.36	0.72	0.60	0.60	0.012	1955	0.0960	0.0047	1958
Rollers	1.95	0.64	0.16	0.08	0.17	0.14	0.14	0.003	415	0.0204	0.0010	415
Graders	1.13	0.47	0.10	0.05	0.14	0.11	0.11	0.002	256	0.0126	0.0006	256
Compactors	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.000	1	0.0000	0.0000	1
Track Laying Machine	1.17	0.46	0.10	0.05	0.13	0.10	0.10	0.002	230	0.0113	0.0006	230
Drill Rigs	0.64	0.17	0.05	0.01	0.04	0.03	0.03	0.001	73	0.0036	0.0002	74
Impact Piling Rigs	1.64	0.44	0.12	0.04	0.10	0.08	0.08	0.002	189	0.0093	0.0005	189
Loaders	2.35	0.93	0.20	0.09	0.25	0.21	0.21	0.005	459	0.0226	0.0011	460
Generator	6.02	2.63	0.66	0.15	0.53	0.43	0.43	0.013	720	0.0353	0.0017	721
Air Compressor	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.000	2	0.0001	0.0000	2
Total Onsite Construction Equipment (tpy	24.6	9.0	2.23	0.95	2.34	1.93	1.93	0.05	5026	0.25	0.01	5035

Note:
For PM_{10}, $PM_{2.5}$, HAPs, and GHGs (CH_4 and N_2O), use same emission ratio as emission factor ratios for Large Diesel Engines (below): P_{10} and $PM_{2.5}$ ratio to TSP; HAPs ratio to CO, and; GHGs ratio to CO_2.

BARGE EMISSIONS

Barges for Construction	2		
Engine Size (propulsion	3500	hp	
Total Barge Engines	7000	hp	(Maximum # Units per year)
Barge Positioning Time	1	hrs/ship (in-out	(Conservative estimate)
Total Power per "Trip"	7,000	hp-hrs	
Construction Trips	2.90	per day	(assume 2/3 of material imported during first year
	753	per year	
Annual Power	5,271,666	hp-hrs/yr	
Annual Diesel Fuel Use	36,902	MMBtu/yr	
	270,095	gallons/yr	

Emission Factors for Barges

	lb/MMBtu, fuel input											
	NO_x	**CO**	**VOC**	**SO_2**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**HAPS**	**CO2**	**CH4**	**N2O**	**CO2e**
Large Diesel Engines	3.20	0.8500	0.0819	0.002	0.07	0.06	0.06	0.00428	165	0.0081	0.0004	165

Source:

Emission factors from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Assume Sulfur content of 0.0015% by weight (15 ppm). Assume TSP to PM10 ratio from Table 3.4-2, and PM2.5=PM10. Sum of HAPs factors from Table 3.4-3 and 3.4-4.

Global Warming Potentials (GWPs):
CO_2 - 1
CH_4 - 25
N_2O - 298

Emission Rates for Barges (tpy

	NO_x	**CO**	**VOC**	**SO_2**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**HAPS**	**CO2**	**CH4**	**N2O**	**CO2e**
Construction - Barges	59.0	15.68	1.51	0.03	1.29	1.06	1.06	0.08	3044	0.15	0.007	3050

FUGITIVE DUST EMISSIONS

Methodology based on EPA AP-42 Chapter 13.2.3 Heavy Construction Operation

Assumed acreage for groundwork 100 acres
Assumed schedule for groundwork 1 year
12 months

Annual Groundwork Operations 8.33 acres/month

AP-42 Emission Factor 1.2 tons PM/acre/month

Uncontrolled PM Emissions 120.0 tons

Controlled Emissions (assume watering only; no factor included for natural control from precipitation
Control %: 90 *WRAP Fugitive Dust Handbook, Table 9-4, Watering.*

PM_{10} and $PM_{2.5}$ Fractions of Total PM
(CARB Appendix A CEIDARS $PM_{2.5}$ and PM_{10} fractions of TSP; Fugitive Dust - Construction and Demolitio)
(http://www.aqmd.gov/docs/default-source/ceqa/handbook/localized-significance-thresholds/particulate-matter-(pm)-2.5-significance-thresholds-and-calculation-methodology/appendix-a-updated-ceidars-table-with-pm2-5-fractions.doc?sfvrs

PM_{10} Fraction of Total PM 0.489
$PM_{2.5}$ Fraction of Total PM 0.102

Emission Rates for Fugitive Dust (tpy

	NO_x	**CO**	**VOC**	**SO_2**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**HAPS**	**CO2**	**CH4**	**N2O**	**CO2e**
Construction - Fugitive Dus	-	-	-	-	12.00	5.87	1.22	-	-	-	-	-

APPENDIX A2
CONSTRUCTION EMISSIONS

SUMMARY

Source	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2e	CO2	CH4	N2O	DPM
	Construction Emissions (lb/day) [Maximum daily]												
COMBUSTION SOURCES													
Equipment (On-site)	229.6	82.89	20.39	8.67	21.49	17.66	17.66	0.42	45,519	45,431	2.23	0.11	21.49
Haul Trucks (Off-site)[1]	110.48	24.00	4.81	0.33	6.34	5.21	3.66	0.12	37,259	37,232	6.96E-01	3.39E-02	6.34
Haul Trucks (On-site and project study area)[1]	54.7	14.4	3.1	0.2	6.1	5.0	2.6	0.1	18236.0	18,214	0.5	0.0	6.12
Passenger Commute Vehicles (off-site)	1.36	19.60	0.34	0.03	0.57	0.57	0.11	-	3944.46	3,938	0.04	0.02	-
Crossing Delay (Off-Site)[3]	0.07	0.44	0.01	0.00	0.01	0.01	0.003	0.01	-	-	-	-	-
Barges (Off-site)	454.7	120.79	11.64	0.21	9.90	8.14	8.14	0.61	23,492	23,446.50	1.15E+00	5.68E-02	9.90

[1] For Haul truck TSP & HAPs, use same emission ratio as emission factor ratios for Large Diesel Engines (below): PM_{10} and $PM_{2.5}$ ratio to TSP; HAPs ratio to CO.
[2] See assumptions for surrogate idle/onsite in Tab A4 Material Transfer by Truck
[3] Original assumption was 1 min/day for each of the 365 days, so T/Y value was divided bye 365 to get value per day.

INPUT DATA:

Major Construction Activities and Typical Equipment Fleets

Construction Equipment Type	Rail Infrastructure and Rotary Car Dump Station		Conveyors, Transfer Stations and Surge Bins		Shiploader, Dock, and Trestles	
	Max Qty. per Month	Duration (months)	Max Qty. per Month	Duration (months)	Max Qty. per Month	Duration (months)
Mobile Cranes (25-50t)[1]						
Mobile Cranes (50-150t)[1]						
Mobile Cranes (150-300t)[1]						
Water Trucks[2]	1	12	1	12	0	0
Dump Trucks	3	12	1	12	0	0
Dozers	1	5	0	0	0	0
Excavators[3]	1	9	2	12	1	3
Rollers	2	9	2	12	1	3
Graders	2	9	0	0	1	3
Compactors	2	9	2	12	1	3
Track Laying Machine	1	6	0	0	0	0
Drill Rigs	1	2	2	6	0	0
Impact Piling Rigs	2	6	2	6	2	6
Loaders[4]	1	12	1	12	1	9
River Barge	0	0	0	0	2	18
Generator	2	18	2	18	2	18
Air Compressor	2	18	2	18	2	18

Source: MBTL, *Noise Resource Report* , Appendix D-1 (URS, June 2014).
NOTES:
[1] Mobile cranes to be shared between the 3 areas. - removed here because not all material is onsite so crane work may not start the first year.
[2] Water truck to be shared between the 2 land areas.
[3] Excavators to be shared between the 3 areas.
[4] Loaders to be shared between the 3 areas.

Typical construction fleet may be modified with equivalent items as construction activities demand

Assume entire construction period for all 3 areas is: 18 months total
5 days/week

ONSITE EQUIPMENT (NON-BARGE) EMISSIONS

Equipment Type	Engine Size (hp)	Fuel	Maximum Units Onsite (per max	EPA NONROAD SCC Number	EPA NONROAD model combustion emission factor (tons/yr per unit)					
					THC-Exhaust	CO-Exhaust	NOx-Exhaust	CO2-Exhaust	SO2-Exhaust	PM-Exhaust
Crane, 50 ton	165	Diesel	0	2270002045	5.15E-02	1.65E-01	6.50E-01	120.43	2.38E-02	5.04E-02
Crane, 150 ton	280	Diesel	0	2270002045	7.69E-02	2.12E-01	9.99E-01	201.70	3.88E-02	6.33E-02
Crane, 300 ton	450	Diesel	0	2270002045	8.22E-02	3.69E-01	1.44E+00	215.37	4.28E-02	7.47E-02
Water Trucks	350	Diesel	1	2270002051	3.06E-02	9.01E-02	3.12E-01	108.922	1.86E-02	3.49E-02
Dump Trucks	350	Diesel	4	*See Notes*	*3.06E-02*	*9.01E-02*	*3.12E-01*	*108.922*	*1.86E-02*	*3.49E-02*
Dozers	185	Diesel	1.0	2270002069	1.66E-01	8.15E-01	1.96E+00	437.06	8.46E-02	2.35E-01
Excavators	230	Diesel	2	2270002036	3.15E-01	1.24E+00	3.65E+00	977.30	1.79E-01	3.62E-01
Rollers	350	Diesel	5.0	2270002015	4.20E-02	1.70E-01	5.19E-01	110.57	2.12E-02	4.42E-02
Graders	185	Diesel	3.0	2270002048	5.49E-02	2.71E-01	6.48E-01	146.26	2.83E-02	7.85E-02
Compactors	25	Diesel	5.0	2270002009	2.47E-04	1.15E-03	2.15E-03	0.26	5.65E-05	1.78E-04
Track Laying Machine[5]	*See Notes*	Diesel	0.5	*See Notes*	*1.96E-01*	*9.29E-01*	*2.35E+00*	*459.49*	*9.05E-02*	*2.51E-01*
Drill Rigs	*NONROAD Default*	Diesel	3.0	2270002033	4.12E-02	1.48E-01	5.47E-01	62.90	1.27E-02	3.29E-02

Impact Piling Rigs	*NONROAD Default*	Diesel	6	2270002033	*4.12E-02*	*1.48E-01*	*5.47E-01*	*62.90*	*1.27E-02*	*3.29E-02*
Loaders	140	Diesel	1	2270002060	1.96E-01	9.29E-01	2.35E+00	459.49	9.05E-02	2.51E-01
Generator	30	Diesel	6	2270006005	1.10E-01	4.39E-01	1.00E+00	119.95	2.48E-02	8.80E-02
Air Compressor	25	Diesel	6	2270006015	2.27E-04	1.17E-03	2.23E-03	0.29	6.30E-05	1.77E-04

NOTES: 15.07692308

Assume Dump Truck size/emissions same as Water Truck.

[5] Assume Track Laying Machine uses 1 diesel locomotive and 1 front end loader engine (Harsco Rail, New Track Construction). Assume full-time locomotive used 4 hrs/day, 5 days/wk.

If max hour is needed, this should be 1.

Horsepower and weight estimates based on capacity ratings and industry specifications, or average ratings per equipment type. Where hp could not be assumed, an average hp rate in NONROAD for the equipment type was used.

factor to convert to lb/day (2000lb/T)/(5 day/week * 52 week/year) 7.692307692

Emission Rates for Onsite Equipment (lb/day)

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Crane, 50 ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0	0.0000	0.0000	0
Crane, 150 ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0	0.0000	0.0000	0
Crane, 300 ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0	0.0000	0.0000	0
Water Trucks	2.40	0.69	0.24	0.14	0.27	0.22	0.22	0.003	838	0.0411	0.0020	839
Dump Trucks	9.59	2.77	0.94	0.57	1.07	0.88	0.88	0.014	3351	0.1645	0.0081	3358
Dozers	15.10	6.27	1.28	0.65	1.81	1.48	1.48	0.032	3362	0.1650	0.0082	3369
Excavators	56.12	19.09	4.85	2.76	5.58	4.58	4.58	0.096	15035	0.7381	0.0364	15065
Rollers	19.97	6.54	1.61	0.81	1.70	1.40	1.40	0.033	4253	0.2088	0.0103	4261
Graders	14.95	6.25	1.27	0.65	1.81	1.49	1.49	0.031	3375	0.1657	0.0082	3382
Compactors	0.08	0.04	0.01	0.00	0.01	0.01	0.01	0.000	10	0.0005	0.0000	10
Track Laying Machine	9.03	3.57	0.75	0.35	0.96	0.79	0.79	0.018	1767	0.0868	0.0043	1771
Drill Rigs	12.63	3.41	0.95	0.29	0.76	0.63	0.63	0.017	1452	0.0713	0.0035	1454
Impact Piling Rigs	25.27	6.81	1.90	0.59	1.52	1.25	1.25	0.034	2903	0.1425	0.0070	2909
Loaders	18.06	7.14	1.50	0.70	1.93	1.59	1.59	0.036	3535	0.1735	0.0086	3541
Generator	46.27	20.26	5.07	1.14	4.06	3.34	3.34	0.102	5536	0.2718	0.0134	5547
Air Compressor	0.10	0.05	0.01	0.00	0.01	0.01	0.01	0.000	14	0.0007	0.0000	14
Max Onsite Construction Equipment (lb/day)	229.6	82.9	20.39	8.67	21.49	17.66	17.66	0.42	45431	2.23	0.11	45519

Note:
For PM_{10}, $PM_{2.5}$, HAPs, and GHGs (CH_4 and N_2O), use same emission ratio as emission factor ratios for Large Diesel Engines (below): PM_{10} and $PM_{2.5}$ ratio to TSP; HAPs ratio to CO, and; GHGs ratio to CO_2.

BARGE EMISSIONS

Barges for Construction	2		
Engine Size (propulsion)	3500	hp	
Total Barge Engines	7000	hp	(Maximum # Units per year))
Barge Positioning Time	1	hrs/ship (in-out)	(Conservative estimate for emissions at docking site)
Total Power per "Trip"	7,000	hp-hrs	
Construction Trips:	2.9	max per day	(only make deliveries 5 days per week)
Annual Power	20,300	hp-hrs/day	
Annual Diesel Fuel Use	142	MMBtu/day	
	1,040	gallons/day	

Emission Factors for Barges

lb/MMBtu, fuel input

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Large Diesel Engines	3.20	0.85	0.08	0.002	0.07	0.06	0.06	0.004	165	0.0081	0.0004	165

Source:

Emission factors from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Assume Sulfur content of 0.0015% by weight (15 ppm). Assume TSP to PM10 ratio from Table 3.4-2, and PM2.5=PM10. Sum of HAPs factors from Table 3.4-3 and 3.4-4.

Global Warming Potentials (GWPs):
CO_2 - 1
CH_4 - 25
N_2O - 298

Emission Rates for Barges (lb/day)

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Construction - Barges	454.7	120.79	11.64	0.21	9.90	8.14	8.14	0.61	23447	1.15	0.057	23492

FUGITIVE DUST EMISSIONS

Methodology based on EPA AP-42 Chapter 13.2.3 Heavy Construction Operations

Assumed acreage for groundwork	100	acres
Assumed schedule for groundwork	1	year
	12	months
Annual Groundwork Operations	8.33	acres/month

AP-42 Emission Factor 1.2 tons PM/acre/month

Uncontrolled PM Emissions: 666.7 lbs /1 day 10 tons for one month

Controlled Emissions (assume watering only; no factor included for natural control from precipitation):

Control %: 90 *WRAP Fugitive Dust Handbook, Table 9-4, Watering.*

PM_{10} and $PM_{2.5}$ Fractions of Total PM

(CARB Appendix A CEIDARS $PM_{2.5}$ and PM_{10} fractions of TSP; Fugitive Dust - Construction and Demolition)

(http://www.aqmd.gov/docs/default-source/ceqa/handbook/localized-significance-thresholds/particulate-matter-(pm)-2.5-significance-thresholds-and-calculation-methodology/appendix-a-updated-ceidars-table-with-pm2-5-fractions.doc?sfvrsn=2)

PM_{10} Fraction of Total PM 0.489

$PM_{2.5}$ Fraction of Total PM 0.102

Emission Rates for Fugitive Dust (lb/day)

	NO_x	**CO**	**VOC**	**SO_2**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**HAPS**	**CO2**	**CH4**	**N2O**	**CO2e**
Construction - Fugitive Dust	-	-	-	-	66.67	32.60	6.80	-	-	-	-	-

	Operations Commuter Emissions (tpy)												
2018	**NO_x**	**CO**	**VOC**	**SO_2**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**HAPS**	**CO2e**	**CO2**	**CH4**	**N2O**	**DPM**
Passenger Commute Vehicles, Operations (off-site)	7.34E-02	1.06E+00	1.81E-02	1.52E-03	-	3.10E-02	5.90E-03	-	213	212.38	2.24E-03	1.02E-03	-
2028													
Passenger Commute Vehicles - Operations (off-site)	3.66E-02	1.07E+00	1.23E-02	1.97E-03	-	5.40E-02	9.07E-03	-	275	274.24	2.19E-03	1.60E-03	-
Crossing Delay (Off-Site)	9.78E-02	9.73E-01	2.36E-02	1.36E-03	-	2.75E-02	6.58E-03	9.19E-03	-	-	-	-	-
sum	0.13	2.05	0.04	0.0033	-	0.08	0.02	0.01	274.77	274.24	0.0022	0.00160	
2038													
Passenger Commute Vehicles Operations (off-site)	1.71E-02	4.67E-01	4.84E-03	1.05E-03	-	4.06E-02	7.77E-03	-	158	157.88	6.36E-04	9.90E-04	-
Crossing Delay (Off-Site)	2.87E-02	2.91E-01	7.83E-03	5.36E-04	-	1.15E-02	2.38E-03	3.06E-03	-	-	-	-	-

Material Haul Traffic

Assume Peak Year Truck Haul Traffic is 56,000 Round Trips (MTBL Supplementary Traffic Report Construction Traffic Analysis, March 2015)

Peak trips per day is capped at 330 trips (MTBL Supplementary Traffic Report Construction Traffic Analysis, March 2015)

		Number	Miles (RT)[1]	miles/year
Haul Trucks	Freeway @ 55mph	56000	32.8	1836800
	SR432 @ 35mph	56000	14.2	795200
				miles/day
Haul Truck	Freeway @ 55mph	330	32.8	10824
	SR432 @ 35mph	330	14.2	4686

[1]16.4 miles on the I-5 and 7.1 miles on WA-432 to MBTL

Project Year	NOx	PM10	PM2.5	SO2	CO	VOC	CO2	CH4	N2O	CO2eq
2018										
Construction Annual				**T/year**						
Combo Short Haul Truck @ 55mph	9.37	0.44	0.31	0.03	2.04	0.41	3159.07	0.06	0.00	3161.40
Combo Short Haul Truck @ 35mph	4.06	0.19	0.13	0.01	0.88	0.18	1367.65	0.03	0.00	1368.66
Total:	13.43	0.63	0.44	0.04	2.92	0.58	4526.72	0.08	0.00	4530.06
Construction Max Day				**lbs/day**						
Combo Short Haul Truck @55 mph	110	5.2	3.7	0.3	24.0	4.8	37232	0.7	0.0	37259
Combo Short Haul Truck @ 35mph	55	5.0	2.6	0.2	14.4	3.1	18214	0.5	0.0	18236
Total:	165	10.2	6.3	0.5	38.4	7.9	55446	1.2	0.1	55495

Factors:	
453.59	g/lb
2000	lbs/ton
5280	ft/mile
3.78541	l/gal

Global Warming Potentials (GWPs): CO_2 - 1; CH_4 - 25; N_2O - 298

MOVES factors (g/mile) for surrogate idle were based on 2.5 mi/hr travel. So to get g/hr, multiply by 2.5 mi/hr. For onsite/idle, assume 0.25 hr. So factor is 2.5/.25 to get grams/trip

mi/hr	2.5
hr	0.25
factor for 1/2 hr idle/trip	10

Mobile Source - Moves run for Cowlitz County, WY, 2018
Emission factors for Truck Exhaust

Emission factors for Truck Exhaust Emission Factors (gm/mile)												
Project Year	NOx	PM10	PM2.5	SO2	CO	VOC	CO2	CH_4	N_2O	Benzene	Form	CO2eq
2018												
Short Haul Combo - diesel @ 55mph (Rural restricted)	4.63	0.22	0.15	0.01	1.01	0.20	1560.24	0.03	0.00	0.00	0.02	1561.39
Short Haul Combo - diesel @ 35mph (Urban un-restricted)	5.30	0.49	0.26	0.02	1.39	0.30	1763.06	0.05	0.00	0.00	0.03	1765.19
Short Haul Combo - diesel @ idle (Rural unrestricted)	6.00	0.42	0.24	0.02	1.48	0.35	1927.59	0.06	0.00	0.00	0.03	1930.06

APPENDIX A5 Material Transfer by Rail (annual T/year)

LOCOMOTIVE EMISSIONS

	5-year construction schedule (35,000 loaded rail cars)		
Unit Trains (cars/train)	100	cars	=Millennium Coal Export Terminal Longview, Washington Traffic and Transportation, Resource Report, September 2014,URS Corporation'
Unit Trains Required	467	Trains/yr	6 trains per month' 'Millennium Coal Export Terminal Longview, Washington Traffic and Transportation, Resource Report, September 2014,URS Corporation'
	3	Locomotives/Train (full)	
	3	Locomotives/Train (empty)	
Engine Size:	4400	hp/locomotive	*Electro-Motive Diesel, GE Transportation* (http://www.getransportation.com/locomotives/locomotives/ac4400-and-dash-series-locomotives); GE AC4400CW (4400hp) or ElectroMotive Diesel SD70Ace (4300hp). Also consistent with DKS traffic analysis
Locomotive Fuel Use:	20.8	bhp-hr/gal	(conversion for large line-haul locomotive, *Emission Factors for Locomotives, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009*.)
Fuel Use per Train	Full Build-Out		
ON SITE			
Loaded Train:	4.6%	Percent Load	Notch 1 setting and associatedd load @ 6 mph (202 hp) based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	607.2	hp	
	29	gallons/hr	
Idle Train:	0.25%	Percent Load	Idle setting and associated load (11 hp) @idle based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	33	hp	
	2	gallons/hr	
OFF SITE			
Loaded Train:	65.4%	Percent Load	Notch 6 setting and associatedd load @ 40 mph (2876 hp) based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	8628	hp	
	415	gallons/hr	
Empty Train:	65.4%	Percent Load	Assume same notch 6 setting as loaded (conservative)
	8628	hp	
	415	gallons/hr	

Longview Short Line (Longview Switching Company (LSC) Track)			
Offsite			
Distance from Main Rail Line to Site:	7.10	miles	distance from GIS drawings per Danny Stratten (ICF) Feb 2014
Travel Time to Site:	0.71	hrs	DKS travel speed average of 10 mph
Total Power:	5721572	hp-hr/yr	
Total Fuel Use:	275076	gallons/yr	
Onsite			
Onsite loop distance:	8727	ft	Per train average loop distance (Drawings 80552-500-GE-DLP-0020_RevA.pdf and 80552-500-ST-DAL-2019-00-RevA.pdf, WorleyParsons)
Travel Distance:	1.65	miles	(one loop onsite; does not include dump track time which is operated by electric indexing system)
Time per Train:	1.48	hours	time needed to unload the coal from 125 cars scaled from 125 coal cars
Total Power:	220776	hp-hr/yr	
Total Fuel Use:	10614	gallons/yr	
Total Fuel Use (On and Offsite)	285690	gallons/yr	

Emission Factors (2028 full operation)

	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	HAPS	CO2	CH4	N2O	CO2e
2028 National Locomotive Fleet Avera (g/gal)	61	26.6	2.1	0.094	1.58	1.3	1.26	0.28	10217	0.80	0.26	10314

Sources:

[1] NOx, CO, VOC, SO2, PM10, PM2.5 2025 emission factors from: *Emission Factors for Locomotives*, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. Table 5,6,7, Line-Haul Emission Factors. From text: $PM_{2.5}$ = 0.97* PM_{10}.

[2] SO2 emission factor using S content of 15 ppm

[3] TSP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Based on ratio of total particulate to PM10 in diesel engines, as given in Table 3.4-2.

[4] HAP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Total HAPs from Tables 3.4-3 and 3.4-4, sum of HAPs as indicated by footnote b. For diesel fuel: 7000 Btu/hp-hr.

[5] *Direct Emissions from Mobile Combustion Sources*, EPA, Office of Air and Radiation, EPA-430-K-08-004, May 2008. N_2O and CH_4 from Table A-6.

[6] Global Warming Potentials (GWPs): CO_2 - 1, CH_4 - 25, N_2O - 298

Emission Rates (tpy)

Full Build-Out	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Offsite	1.85E+01	8.06E+00	6.36E-01	2.85E-02	4.79E-01	3.94E-01	3.82E-01	8.57E-02	3.10E+03	2.42E-01	7.88E-02	3.12E+03
Onsite	7.13E-01	3.11E-01	2.45E-02	1.10E-03	1.85E-02	1.52E-02	1.47E-02	3.31E-03	1.19E+02	9.35E-03	3.04E-03	1.21E+02
Total	1.92E+01	8.37E+00	6.61E-01	2.96E-02	4.98E-01	4.09E-01	3.97E-01	8.90E-02	3.21E+03	2.52E-01	8.18E-02	3.25E+03

APPENDIX A6 Material Transfer by Rail (Max Day)
LOCOMOTIVE EMISSIONS

5-year construction schedule (35,000 loaded rail cars)

Unit Trains (cars/train) 100 cars =Millennium Coal Export Terminal Longview, Washington Traffic and Transportation, Resource Report, September 2014,URS Corporation'

Unit Trains Required 1.3 Trains/day 6 trains per month' 'Millennium Coal Export Terminal Longview, Washington Traffic and Transportation, Resource Report, September 2014,URS Corporation'
3 Locomotives/Train (full) Constinet with DKS traffic analysis
3 Locomotives/Train (empty) Constinet with DKS traffic analysis

Engine Size: 4400 hp/locomotive *Electro-Motive Diesel, GE Transportation* (http://www.getransportation.com/locomotives/locomotives/ac4400-and-dash-series-locomotives); GE AC4400CW (4400hp) or ElectroMotive Diesel SD70Ace (4300hp). Also consistent with DKS tr
Locomotive Fuel Use: 20.8 bhp-hr/gal (conversion for large line-haul locomotive, *Emission Factors for Locomotives, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009*.)

Fuel Use per Train — Full Build-Out

ON SITE

Loaded Train:	4.6%	Percent Load	Notch 1 setting and associatedd load @ 6 mph (202 hp) based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004
	607.2	hp	
	29	gallons/hr	
Idle Train:	0.25%	Percent Load	Idle setting and associated load (11 hp) @idle based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004
	33	hp	
	2	gallons/hr	

OFF SITE

Loaded Train:	65.4%	Percent Load	Notch 6 setting and associatedd load @ 40 mph (2876 hp) based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004
	8628	hp	
	415	gallons/hr	
Empty Train:	65.4%	Percent Load	Assume same notch 6 setting as loaded (conservative)
	8628	hp	
	415	gallons/hr	

Longview Short Line (Longview Switching Company (LSC) Track)

Offsite

Distance from Main Rail Line to Site:	7.10	miles	distance from GIS drawings per Danny Stratten (ICF) Feb 2014
Travel Time to Site:	0.71	hrs	DKS travel speed average of 10 mph
Total Power:	15927	hp-hr/yr	
Total Fuel Use:	766	gallons/yr	

Onsite

Onsite loop distance:	8727	ft	Per train average loop distance (Drawings 80552-500-GE-DLP-0020_RevA.pdf and 80552-500-ST-DAL-2019-00-RevA.pdf, WorleyParsons
Travel Distance:	1.65	miles	(one loop onsite; does not include dump track time which is operated by electric indexing system)
Time per Train:	1.48	hours	time needed to unload the coal from 125 cars — scaled from 125 coal cars
Total Power:	615	hp-hr/yr	
Total Fuel Use:	30	gallons/yr	

Total Fuel Use (On and Offsite) 795 gallons/yr

Emission Factors (2028 full operation)

	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	HAPS	CO2	CH4	N2O	CO2e
2028 National Locomotive Fleet Avera (g/gal)	61	26.6	2.1	0.094	1.58	1.3	1.26	0.28	10217	0.80	0.26	10314

Sources:
[1] NOx, CO, VOC, SO2, PM10, PM2.5 2025 emission factors from: *Emission Factors for Locomotives*, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. Table 5,6,7, Line-Haul Emission Factors. From text: $PM_{2.5} = 0.97 * PM_{10}$.
[2]SO2 emission factor using S content of 15 ppm
[3]TSP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Based on ratio of total particulate to PM10 in diesel engines, as given in Table 3.4-2.
[4]HAP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Total HAPs from Tables 3.4-3 and 3.4-4, sum of HAPs as indicated by footnote b. For diesel fuel: 7000 Btu/hp-hr.
[5]*Direct Emissions from Mobile Combustion Sources*, EPA, Office of Air and Radiation, EPA-430-K-08-004, May 2008. N_2O and CH_4 from Table A-6.
[6]Global Warming Potentials (GWPs):
CO_2 - 1
CH_4 - 25
N_2O - 298

Emission Rates (tpy)

Full Build-Out	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Offsite	5.14E-02	2.24E-02	1.77E-03	7.93E-05	1.33E-03	1.10E-03	1.06E-03	2.39E-04	8.62E+00	6.75E-04	2.19E-04	8.70E+00
Onsite	1.98E-03	8.66E-04	6.83E-05	3.06E-06	5.15E-05	4.23E-05	4.10E-05	9.21E-06	3.32E-01	2.60E-05	8.46E-06	3.36E-01
Total	5.34E-02	2.33E-02	1.84E-03	8.23E-05	1.39E-03	1.14E-03	1.10E-03	2.48E-04	8.95E+00	7.01E-04	2.28E-04	9.03E+00

APPENDIX B
CONSTRUCTION - 'NONROAD' MODEL EMISSIONS

EPA`s NONROAD Emissions Model
Core Model ver 2008a, 07/06/09
Jul 25 11:58:30: 2014
MBTL
2014
Options file used: C:\NONROAD\Projects\MBTL.OPT
Total for year: 2014
Tons/Year

Cnty	Sub	SCC	HP	Population	THC-Exhaust	CO-Exhaust	NOx-Exhaust	CO2-Exhaust	SO2-Exhaust	PM-Exhaust	Crankcase	Hot-Soaks	Diurnal	Displacement	Spillage	RunLoss	TankPerm	HosePerm	FuelCons.	Activity	LF	HPAvg
53015		2265003070	40	1.70E-03	1.53E-05	5.51E-04	4.18E-05	2.96E-02	6.10E-06	3.06E-06	0.00E+00	1.67E-07	7.96E-07	1.12E-05	6.70E-07	3.74E-07	0.00E+00	0.00E+00	3.01E+00	1.41E+00	7.80E-01	3.50E+01
53015		2265003070	75	6.63E-02	1.04E-03	3.81E-02	2.83E-03	1.92E+00	3.95E-04	1.96E-04	0.00E+00	6.50E-06	8.20E-05	7.25E-04	2.20E-05	1.78E-05	0.00E+00	0.00E+00	1.95E+02	5.49E+01	7.80E-01	5.82E+01
53015		2265003070	100	3.06E-02	8.13E-04	2.98E-02	2.22E-03	1.50E+00	3.09E-04	1.53E-04	0.00E+00	3.00E-06	3.79E-05	5.67E-04	1.72E-05	8.23E-06	0.00E+00	0.00E+00	1.53E+02	2.53E+01	7.80E-01	9.86E+01
53015		2265003070	175	1.19E-01	3.66E-03	1.34E-01	9.98E-03	6.76E+00	1.39E-03	6.90E-04	0.00E+00	1.17E-05	2.43E-04	2.55E-03	4.69E-05	3.20E-05	0.00E+00	0.00E+00	6.88E+02	9.85E+01	7.80E-01	1.14E+02
53015		2265003070	300	1.70E-03	1.14E-04	4.20E-03	3.12E-04	2.11E-01	4.36E-05	2.16E-05	0.00E+00	1.67E-07	7.61E-06	7.99E-05	6.70E-07	4.57E-07	0.00E+00	0.00E+00	2.15E+01	1.41E+00	7.80E-01	2.50E+02
53015		2267002057	40	3.32E-02	5.20E-05	1.84E-03	2.95E-04	1.52E-01	2.95E-06	1.60E-05	6.96E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.26E+01	1.37E+01	6.30E-01	2.90E+01
53015		2267002057	50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015		2267002057	75	2.23E-01	3.06E-03	8.60E-02	1.35E-02	2.40E+00	4.67E-05	2.42E-04	5.99E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.58E+02	9.20E+01	6.30E-01	6.59E+01
53015		2267002057	100	1.33E-03	2.21E-05	6.22E-04	9.74E-05	1.74E-02	3.38E-07	1.75E-06	4.33E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.58E+00	5.48E-01	6.30E-01	8.00E+01
53015		2267002057	175	2.65E-02	6.26E-04	1.76E-02	2.76E-03	4.92E-01	9.56E-06	4.94E-05	1.23E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.32E+01	1.10E+01	6.30E-01	1.13E+02
53015		2270002009	6	3.82E+00	2.92E-03	1.94E-02	2.14E-02	2.54E+00	5.47E-04	2.21E-03	3.10E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E+02	1.85E+03	4.30E-01	4.94E+00
53015		2270002009	11	1.71E+00	2.26E-03	1.50E-02	1.66E-02	1.97E+00	4.24E-04	1.71E-03	2.40E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E+02	8.26E+02	4.30E-01	8.55E+00
53015		2270002009	16	1.04E+00	1.87E-03	8.73E-03	1.63E-02	1.99E+00	4.28E-04	1.35E-03	2.03E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E+02	5.02E+02	4.30E-01	1.42E+01
53015		2270002009	25	9.57E-02	2.47E-04	1.15E-03	2.15E-03	2.63E-01	5.65E-05	1.78E-04	2.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.33E+01	4.63E+01	4.30E-01	2.04E+01
53015		2270002015	6	4.11E-01	6.24E-04	5.13E-03	4.78E-03	6.57E-01	1.41E-04	4.31E-04	9.20E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.82E+01	3.13E+02	5.90E-01	5.44E+00
53015		2270002015	11	7.72E-01	1.87E-03	1.54E-02	1.43E-02	1.97E+00	4.24E-04	1.29E-03	2.76E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E+02	5.87E+02	5.90E-01	8.69E+00
53015		2270002015	16	9.24E-01	2.79E-03	1.51E-02	2.76E-02	3.68E+00	7.91E-04	2.26E-03	4.08E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.26E+02	7.02E+02	5.90E-01	1.36E+01
53015		2270002015	25	1.66E+00	7.28E-03	3.95E-02	7.19E-02	9.60E+00	2.06E-03	5.88E-03	1.06E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.49E+02	1.26E+03	5.90E-01	1.97E+01
53015		2270002015	40	2.37E+00	8.94E-03	4.83E-02	1.58E-01	2.26E+01	4.40E-03	9.69E-03	1.54E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E+03	1.80E+03	5.90E-01	3.25E+01
53015		2270002015	50	2.19E+00	1.17E-02	6.31E-02	2.06E-01	2.95E+01	5.74E-03	1.26E-02	2.01E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E+03	1.67E+03	5.90E-01	4.58E+01
53015		2270002015	75	2.22E+00	1.88E-02	1.78E-01	2.48E-01	3.97E+01	8.05E-03	2.30E-02	2.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.51E+03	1.69E+03	5.90E-01	6.07E+01
53015		2270002015	100	6.07E+00	7.16E-02	7.40E-01	8.22E-01	1.51E+02	2.98E-02	1.10E-01	1.24E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E+04	4.62E+03	5.90E-01	8.48E+01
53015		2270002015	175	5.63E+00	8.40E-02	3.99E-01	1.01E+00	1.97E+02	3.89E-02	1.08E-01	1.40E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.74E+04	4.28E+03	5.90E-01	1.32E+02
53015		2270002015	300	1.92E+00	4.20E-02	1.70E-01	5.19E-01	1.11E+02	2.12E-02	4.42E-02	6.31E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.78E+03	1.46E+03	5.90E-01	2.17E+02
53015		2270002015	600	5.70E-01	2.34E-02	1.59E-01	3.93E-01	6.35E+01	1.26E-02	2.72E-02	3.82E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.61E+03	4.33E+02	5.90E-01	4.21E+02
53015		2270002033	11	1.78E-02	2.15E-05	1.41E-04	1.57E-04	1.85E-02	3.97E-06	1.63E-05	2.37E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.64E+00	8.28E+00	4.30E-01	8.00E+00
53015		2270002033	16	2.73E-02	4.94E-05	2.28E-04	4.24E-04	5.15E-02	1.11E-05	3.53E-05	5.57E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.56E+00	1.27E+01	4.30E-01	1.45E+01
53015		2270002033	25	6.15E-02	1.80E-04	8.32E-04	1.54E-03	1.88E-01	4.04E-05	1.29E-04	2.03E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.66E+01	2.87E+01	4.30E-01	2.35E+01
53015		2270002033	40	1.05E+00	2.69E-03	1.22E-02	3.37E-02	4.29E+00	8.78E-04	2.61E-03	3.47E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E+02	4.88E+02	4.30E-01	3.15E+01
53015		2270002033	50	1.07E+00	3.91E-03	1.78E-02	4.89E-02	6.24E+00	1.28E-03	3.79E-03	5.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.52E+02	4.97E+02	4.30E-01	4.49E+01
53015		2270002033	75	1.73E+00	1.23E-02	6.46E-02	1.23E-01	1.39E+01	2.90E-03	1.19E-02	2.19E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E+03	8.06E+02	4.30E-01	6.18E+01
53015		2270002033	100	1.76E+00	1.71E-02	8.67E-02	1.63E-01	1.95E+01	4.00E-03	1.71E-02	3.29E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E+03	8.19E+02	4.30E-01	8.51E+01
53015		2270002033	175	2.58E+00	2.85E-02	1.07E-01	3.64E-01	3.99E+01	8.19E-03	2.41E-02	5.39E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.53E+03	1.20E+03	4.30E-01	1.32E+02
53015		2270002033	300	2.25E+00	4.12E-02	1.48E-01	5.47E-01	6.29E+01	1.27E-02	3.29E-02	7.60E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.57E+03	1.05E+03	4.30E-01	2.39E+02
53015		2270002033	600	1.29E+00	4.05E-02	1.88E-01	6.15E-01	6.77E+01	1.38E-02	3.33E-02	7.45E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.99E+03	6.03E+02	4.30E-01	4.47E+02
53015		2270002033	750	3.03E-01	1.42E-02	7.74E-02	2.22E-01	2.45E+01	4.98E-03	1.23E-02	2.60E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.17E+03	1.41E+02	4.30E-01	6.91E+02
53015		2270002033	1000	1.65E-01	1.39E-02	5.50E-02	1.93E-01	1.68E+01	3.42E-03	9.71E-03	2.43E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E+03	7.71E+01	4.30E-01	8.69E+02
53015		2270002033	1200	2.73E-03	2.78E-04	1.10E-03	3.85E-03	3.36E-01	6.82E-05	1.94E-04	4.86E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.97E+01	1.27E+00	4.30E-01	1.05E+03
53015		2270002033	2000	5.47E-03	7.93E-04	3.14E-03	1.10E-02	9.59E-01	1.95E-04	5.54E-04	1.39E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.49E+01	2.55E+00	4.30E-01	1.50E+03
53015		2270002036	6	2.05E-02	4.89E-05	3.97E-04	3.77E-04	5.19E-02	1.12E-05	3.22E-05	8.72E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.60E+00	2.24E+01	5.90E-01	6.00E+00
53015		2270002036	11	1.13E-01	3.59E-04	2.91E-03	2.77E-03	3.81E-01	8.20E-05	2.37E-04	6.41E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.38E+01	1.24E+02	5.90E-01	7.97E+00
53015		2270002036	16	2.34E-01	9.77E-04	5.20E-03	9.73E-03	1.30E+00	2.79E-04	7.97E-04	1.73E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E+02	2.55E+02	5.90E-01	1.31E+01
53015		2270002036	25	1.04E+00	7.14E-03	3.80E-02	7.11E-02	9.47E+00	2.04E-03	5.83E-03	1.26E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.39E+02	1.14E+03	5.90E-01	2.15E+01
53015		2270002036	40	2.16E+00	1.08E-02	5.30E-02	2.00E-01	3.01E+01	5.62E-03	1.15E-02	2.53E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E+03	2.35E+03	5.90E-01	3.30E+01
53015		2270002036	50	1.15E+00	8.01E-03	3.92E-02	1.47E-01	2.23E+01	4.15E-03	8.47E-03	1.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.97E+03	1.26E+03	5.90E-01	4.58E+01
53015		2270002036	75	8.92E-01	8.53E-03	8.81E-02	1.30E-01	2.31E+01	4.59E-03	1.10E-02	6.66E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E+03	9.74E+02	5.90E-01	6.13E+01
53015		2270002036	100	4.03E+00	5.70E-02	6.74E-01	7.03E-01	1.56E+02	2.98E-02	1.06E-01	8.68E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E+04	4.40E+03	5.90E-01	9.17E+01
53015		2270002036	175	1.50E+01	2.76E-01	1.39E+00	3.22E+00	7.88E+02	1.50E-01	4.20E-01	3.99E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.97E+04	1.64E+04	5.90E-01	1.38E+02
53015		2270002036	300	1.10E+01	3.15E-01	1.24E+00	3.65E+00	9.77E+02	1.79E-01	3.62E-01	3.84E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.64E+04	1.20E+04	5.90E-01	2.33E+02
53015		2270002036	600	2.91E+00	1.39E-01	8.58E-01	2.18E+00	4.56E+02	8.75E-02	1.73E-01	1.95E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.03E+04	3.18E+03	5.90E-01	4.11E+02
53015		2270002036	750	9.29E-02	7.56E-03	7.04E-02	1.22E-01	2.55E+01	4.89E-03	9.85E-03	1.05E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E+03	1.01E+02	5.90E-01	7.19E+02
53015		2270002036	1000	1.08E-01	1.83E-02	9.27E-02	2.72E-01	3.63E+01	6.98E-03	1.58E-02	2.22E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.21E+03	1.18E+02	5.90E-01	8.84E+02
53015		2270002036	1200	4.10E-03	9.42E-04	4.78E-03	1.40E-02	1.87E+00	3.60E-04	8.15E-04	1.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.66E+02	4.48E+00	5.90E-01	1.20E+03
53015		2270002036	2000	4.10E-02	1.39E-02	7.04E-02	2.07E-01	2.76E+01	5.30E-03	1.20E-02	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.44E+03	4.48E+01	5.90E-01	1.77E+03
53015		2270002036	3000	1.37E-03	6.15E-04	3.12E-03	9.16E-03	1.22E+00	2.35E-04	5.32E-04	7.47E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E+02	1.49E+00	5.90E-01	2.35E+03
53015		2270002045	25	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015		2270002045	40	1.72E-01	7.55E-04	3.82E-03	1.33E-02	1.88E+00	3.66E-04	7.96E-04	1.53E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.66E+02	1.70E+02	4.30E-01	3.94E+01
53015		2270002045	50	2.73E-03	1.27E-05	6.42E-05	2.24E-04	3.15E-02	6.15E-06	1.34E-05	2.57E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E+00	2.71E+00	4.30E-01	4.17E+01
53015		2270002045	75	9.16E-02	7.91E-04	5.87E-03	1.07E-02	1.62E+00	3.30E-04	8.59E-04	1.04E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E+02	9.06E+01	4.30E-01	6.40E+01
53015		2270002045	100	8.85E-01	1.04E-02	7.08E-02	1.24E-01	2.16E+01	4.27E-03	1.25E-02	1.80E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E+03	8.77E+02	4.30E-01	8.81E+01
53015		2270002045	175	3.33E+00	5.15E-02	1.65E-01	6.50E-01	1.20E+02	2.38E-02	5.04E-02	8.61E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E+04	3.30E+03	4.30E-01	1.45E+02
53015		2270002045	300	3.41E+00	7.69E-02	2.12E-01	9.99E-01	2.02E+02	3.88E-02	6.33E-02	1.17E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E+04	3.38E+03	4.30E-01	2.38E+02
53015		2270002045	600	2.10E+00	8.22E-02	3.69E-01	1.44E+00	2.15E+02	4.28E-02	7.47E-02	1.36E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E+04	2.08E+03	4.30E-01	4.12E+02
53015		2270002045	750	9.02E-02	5.44E-03	3.35E-02	1.01E-01	1.50E+01	2.98E-03	5.42E-03	8.90E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E+03	8.93E+01	4.30E-01	6.69E+02
53015		2270002045	1000	2.60E-02	3.56E-03	1.27E-02	5.47E-02	5.70E+00	1.13E-03	2.53E-03	5.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.04E+02	2.57E+01	4.30E-01	8.83E+02
53015		2270002045	1200	1.37E-03	2.27E-04	8.08E-04	3.49E-03	3.64E-01	7.23E-05	1.62E-04	3.51E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.22E+01	1.35E+00	4.30E-01	1.07E+03
53015		2270002048	40	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015		2270002048	50	5.47E-03	3.69E-05	1.88E-04	6.67E-04	9.84E-02	1.87E-05	3.90E-05	2.15E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.70E+00	5.26E+00	5.90E-01	4.83E+01
53015		2270002048	75	3.96E-02	3.54E-04	3.56E-03	5.14E-03	8.79E-01	1.76E-04	4.47E-04	3.46E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.77E+01	3.81E+01	5.90E-01	5.95E+01
53015		2270002048	100	3.03E-01	3.80E-03	4.30E-02	4.59E-02	9.52E+00	1.84E-03	6.55E-03	6.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.41E+02	2.92E+02	5.90E-01	8.42E+01
53015		2270002048	175	3.10E+00	5.49E-02	2.71E-01	6.48E-01	1.46E+02	2.83E-02	7.85E-02	8.43E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E+04	2.98E+03	5.90E-01	1.41E+02
53015		2270002048	300	5.19E+00	1.36E-01	5.51E-01	1.62E+00	4.02E+02	7.51E-02	1.54E-01	1.80E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.56E+04	4.99E+03	5.90E-01	2.31E+02
53015		2270002048	600	5.93E-01	2.19E-02	1.40E-01	3.57E-01	6.80E+01	1.32E-02	2.66E-02	3.27E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.01E+03	5.71E+02	5.90E-01	3.42E+02
53015		2270002048	750	3.55E-02	2.78E-03	2.63E-02	4.68E-02	8.94E+00	1.74E-03	3.57E-03	4.09E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.90E+02	3.42E+01	5.90E-01	7.50E+02
53015		2270002051	175	8.20E-03	2.28E-04	1.04E-03	2.45E-03	7.53E-01	1.36E-04	3.56E-04	2.48E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.66E+01	1.35E+01	5.90E-01	1.61E+02
53015		2270002051	300	7.79E-01	3.06E-02	9.01E-02	3.12E-01	1.09E+02	1.86E-02	3.49E-02	2.22E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.63E+03	1.28E+03	5.90E-01	2.44E+02
53015		2270002051	600	1.65E+00	1.13E-01	5.80E-01	1.45E+00	3.97E+02	7.29E-02	1.44E-01	1.25E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.51E+04	2.71E+03	5.90E-01	4.20E+02
53015		2270002051	750	9.35E-01	1.04E-01	8.34E-01	1.35E+00	3.68E+02	6.76E-02	1.34E-01	1.15E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.25E+04	1.53E+03	5.90E-01	6.88E+02
53015		2270002051	1000	4.54E-01	1.03E-01	5.26E-01	1.41E+00	2.25E+02	4.13E-02	9.12E-02	8.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E+04	7.44E+02	5.90E-01	8.68E+02

53015	2270002051	1200	1.43E-01	4.34E-02	2.21E-01	5.93E-01	9.46E+01	1.74E-02	3.83E-02	3.53E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.37E+03	2.35E+02	5.90E-01	1.15E+03
53015	2270002051	2000	7.27E-01	3.41E-01	1.73E+00	4.66E+00	7.43E+02	1.36E-01	3.01E-01	2.77E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.57E+04	1.19E+03	5.90E-01	1.79E+03
53015	2270002051	3000	1.78E-01	1.13E-01	5.75E-01	1.54E+00	2.46E+02	4.52E-02	9.97E-02	9.19E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E+04	2.92E+02	5.90E-01	2.42E+03
53015	2270002057	16	5.47E-03	1.44E-05	7.92E-05	1.42E-04	1.89E-02	4.06E-06	1.16E-05	3.31E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E+00	3.62E+00	5.90E-01	1.35E+01
53015	2270002057	25	6.15E-02	2.70E-04	1.48E-03	2.65E-03	3.53E-01	7.60E-05	2.18E-04	6.20E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.13E+01	4.07E+01	5.90E-01	2.25E+01
53015	2270002057	40	1.42E+00	4.98E-03	2.78E-02	8.61E-02	1.22E+01	2.39E-03	5.50E-03	1.35E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E+03	9.42E+02	5.90E-01	3.34E+01
53015	2270002057	50	1.58E+00	7.50E-03	4.18E-02	1.29E-01	1.83E+01	3.60E-03	8.27E-03	2.03E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E+03	1.05E+03	5.90E-01	4.51E+01
53015	2270002057	75	3.14E+00	2.62E-02	2.34E-01	3.24E-01	4.94E+01	1.01E-02	3.18E-02	3.70E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.37E+03	2.08E+03	5.90E-01	6.14E+01
53015	2270002057	100	1.80E+01	2.08E-01	2.01E+00	2.28E+00	3.94E+02	7.84E-02	3.05E-01	3.70E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.49E+04	1.19E+04	5.90E-01	8.56E+01
53015	2270002057	175	9.23E+00	1.23E-01	5.82E-01	1.49E+00	2.68E+02	5.34E-02	1.49E-01	2.11E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.37E+04	6.11E+03	5.90E-01	1.26E+02
53015	2270002057	300	4.78E-01	1.04E-02	4.25E-02	1.30E-01	2.53E+01	4.90E-03	1.05E-02	1.64E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.24E+03	3.17E+02	5.90E-01	2.29E+02
53015	2270002057	600	6.30E-01	2.12E-02	1.47E-01	3.40E-01	5.03E+01	1.01E-02	2.41E-02	3.62E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.45E+03	4.17E+02	5.90E-01	3.46E+02
53015	2270002060	11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015	2270002060	16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015	2270002060	25	1.37E-02	6.97E-05	3.78E-04	6.88E-04	9.18E-02	1.98E-05	5.63E-05	1.00E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.13E+00	1.04E+01	5.90E-01	2.28E+01
53015	2270002060	40	7.20E-01	2.88E-03	1.56E-02	5.08E-02	7.30E+00	1.42E-03	3.12E-03	4.92E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.45E+02	5.48E+02	5.90E-01	3.44E+01
53015	2270002060	50	8.27E-01	4.37E-03	2.36E-02	7.72E-02	1.11E+01	2.15E-03	4.73E-03	7.46E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.79E+02	6.29E+02	5.90E-01	4.54E+01
53015	2270002060	75	1.17E+00	1.01E-02	9.51E-02	1.33E-01	2.12E+01	4.31E-03	1.23E-02	1.28E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E+03	8.89E+02	5.90E-01	6.17E+01
53015	2270002060	100	5.02E+00	5.98E-02	6.18E-01	6.86E-01	1.27E+02	2.49E-02	9.20E-02	1.03E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E+04	3.82E+03	5.90E-01	8.55E+01
53015	2270002060	175	1.27E+01	1.96E-01	9.29E-01	2.35E+00	4.59E+02	9.05E-02	2.51E-01	3.25E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.06E+04	9.67E+03	5.90E-01	1.36E+02
53015	2270002060	300	1.21E+01	2.81E-01	1.14E+00	3.47E+00	7.40E+02	1.42E-01	2.96E-01	4.22E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.55E+04	9.23E+03	5.90E-01	2.30E+02
53015	2270002060	600	8.90E+00	3.63E-01	2.47E+00	6.14E+00	9.91E+02	1.96E-01	4.24E-01	5.92E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.76E+04	6.77E+03	5.90E-01	4.19E+02
53015	2270002060	750	6.72E-01	4.28E-02	4.07E-01	7.67E-01	1.24E+02	2.45E-02	5.47E-02	6.88E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E+04	5.12E+02	5.90E-01	6.92E+02
53015	2270002060	1000	3.28E-01	4.54E-02	2.40E-01	6.64E-01	7.53E+01	1.49E-02	3.85E-02	6.86E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.67E+03	2.50E+02	5.90E-01	8.66E+02
53015	2270002060	1200	6.83E-02	1.18E-02	6.25E-02	1.73E-01	1.96E+01	3.88E-03	1.00E-02	1.79E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E+03	5.20E+01	5.90E-01	1.08E+03
53015	2270002060	2000	4.02E-01	1.20E-01	6.34E-01	1.75E+00	1.99E+02	3.94E-02	1.02E-01	1.81E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E+04	3.06E+02	5.90E-01	1.87E+03
53015	2270002060	3000	1.50E-02	5.38E-03	2.85E-02	7.88E-02	8.94E+00	1.77E-03	4.57E-03	8.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.91E+02	1.14E+01	5.90E-01	2.24E+03
53015	2270002069	40	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015	2270002069	50	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015	2270002069	75	1.52E-01	1.30E-03	1.30E-02	1.87E-02	3.19E+00	6.39E-04	1.64E-03	1.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.82E+02	1.42E+02	5.90E-01	5.80E+01
53015	2270002069	100	4.35E+00	5.62E-02	6.31E-01	6.77E-01	1.39E+02	2.68E-02	9.57E-02	9.10E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E+04	4.07E+03	5.90E-01	8.79E+01
53015	2270002069	175	9.84E+00	1.66E-01	8.15E-01	1.96E+00	4.37E+02	8.46E-02	2.35E-01	2.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.86E+04	9.21E+03	5.90E-01	1.36E+02
53015	2270002069	300	8.52E+00	2.23E-01	9.06E-01	2.67E+00	6.55E+02	1.23E-01	2.51E-01	2.99E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.79E+04	7.97E+03	5.90E-01	2.36E+02
53015	2270002069	600	4.31E+00	1.96E-01	1.26E+00	3.19E+00	5.99E+02	1.17E-01	2.35E-01	2.95E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.29E+04	4.04E+03	5.90E-01	4.25E+02
53015	2270002069	750	1.70E+00	1.23E-01	1.17E+00	2.09E+00	3.93E+02	7.65E-02	1.58E-01	1.83E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.47E+04	1.59E+03	5.90E-01	7.07E+02
53015	2270002069	1000	3.53E-01	5.68E-02	2.90E-01	8.52E-01	1.06E+02	2.07E-02	4.84E-02	7.67E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.39E+03	3.30E+02	5.90E-01	9.23E+02
53015	2270002069	1200	6.12E-01	1.14E-01	5.81E-01	1.71E+00	2.13E+02	4.14E-02	9.70E-02	1.54E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E+04	5.73E+02	5.90E-01	1.07E+03
53015	2270002069	2000	2.73E-03	7.03E-04	3.58E-03	1.05E-02	1.31E+00	2.56E-04	5.99E-04	9.49E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.16E+02	2.56E+00	5.90E-01	1.47E+03
53015	2270006005	6	1.90E+01	1.32E-02	7.54E-02	9.35E-02	9.55E+00	2.05E-03	1.01E-02	1.84E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.47E+02	6.41E+03	4.30E-01	5.35E+00
53015	2270006005	11	1.89E+01	2.07E-02	1.18E-01	1.47E-01	1.50E+01	3.23E-03	1.58E-02	2.89E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E+03	6.40E+03	4.30E-01	8.42E+00
53015	2270006005	16	1.46E+01	2.30E-02	9.59E-02	1.70E-01	1.86E+01	4.01E-03	1.58E-02	3.36E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.65E+03	4.93E+03	4.30E-01	1.36E+01
53015	2270006005	25	2.30E+01	5.70E-02	2.37E-01	4.20E-01	4.61E+01	9.91E-03	3.90E-02	8.31E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.09E+03	7.77E+03	4.30E-01	2.13E+01
53015	2270006005	40	3.80E+01	1.10E-01	4.39E-01	1.00E+00	1.20E+02	2.48E-02	8.80E-02	1.77E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E+04	1.29E+04	4.30E-01	3.34E+01
53015	2270006005	50	5.20E+00	2.03E-02	8.10E-02	1.85E-01	2.21E+01	4.58E-03	1.62E-02	3.27E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.96E+03	1.76E+03	4.30E-01	4.52E+01
53015	2270006005	75	1.92E+01	9.86E-02	5.03E-01	9.35E-01	1.08E+02	2.26E-02	8.99E-02	1.77E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.60E+03	6.48E+03	4.30E-01	6.00E+01
53015	2270006005	100	2.33E+01	1.72E-01	8.48E-01	1.55E+00	1.90E+02	3.91E-02	1.62E-01	3.31E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E+04	7.88E+03	4.30E-01	8.64E+01
53015	2270006005	175	7.96E+00	6.81E-02	2.53E-01	8.19E-01	9.17E+01	1.89E-02	5.46E-02	1.29E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.12E+03	2.69E+03	4.30E-01	1.36E+02
53015	2270006005	300	4.43E+00	6.13E-02	2.17E-01	7.61E-01	8.95E+01	1.81E-02	4.66E-02	1.14E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.92E+03	1.50E+03	4.30E-01	2.38E+02
53015	2270006005	600	2.30E+00	4.83E-02	2.15E-01	6.95E-01	8.19E+01	1.66E-02	3.70E-02	8.83E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.24E+03	7.77E+02	4.30E-01	4.19E+02
53015	2270006005	750	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015	2270006005	1000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015	2270006005	1200	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015	2270006005	2000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015	2270006005	3000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015	2270006015	6	1.11E-01	1.36E-04	1.06E-03	1.05E-03	1.40E-01	3.01E-05	9.69E-05	4.97E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E+01	9.02E+01	4.30E-01	5.57E+00
53015	2270006015	11	2.71E-01	5.68E-04	4.42E-03	4.35E-03	5.84E-01	1.26E-04	4.03E-04	2.07E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.17E+01	2.21E+02	4.30E-01	9.47E+00
53015	2270006015	16	3.69E-02	8.67E-05	4.49E-04	8.54E-04	1.12E-01	2.41E-05	6.77E-05	3.09E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.91E+00	3.01E+01	4.30E-01	1.33E+01
53015	2270006015	25	5.68E-02	2.27E-04	1.17E-03	2.23E-03	2.93E-01	6.30E-05	1.77E-04	8.09E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.59E+01	4.63E+01	4.30E-01	2.27E+01
53015	2270006015	40	2.09E+00	6.72E-03	3.45E-02	1.16E-01	1.59E+01	3.15E-03	7.31E-03	2.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E+03	1.70E+03	4.30E-01	3.35E+01
53015	2270006015	50	1.44E+00	6.14E-03	3.15E-02	1.06E-01	1.46E+01	2.88E-03	6.69E-03	2.59E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E+03	1.18E+03	4.30E-01	4.43E+01
53015	2270006015	75	9.25E+00	7.19E-02	4.81E-01	9.03E-01	1.28E+02	2.62E-02	7.58E-02	1.06E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E+04	7.54E+03	4.30E-01	6.08E+01
53015	2270006015	100	1.20E+01	1.28E-01	7.97E-01	1.45E+00	2.30E+02	4.60E-02	1.46E-01	2.30E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E+04	9.82E+03	4.30E-01	8.39E+01
53015	2270006015	175	1.38E+00	1.73E-02	5.52E-02	2.25E-01	3.66E+01	7.31E-03	1.60E-02	3.01E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.23E+03	1.13E+03	4.30E-01	1.29E+02
53015	2270006015	300	1.24E+00	2.61E-02	7.35E-02	3.54E-01	6.18E+01	1.21E-02	2.09E-02	4.24E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E+03	1.01E+03	4.30E-01	2.43E+02
53015	2270006015	600	3.55E-01	1.43E-02	6.63E-02	2.31E-01	3.11E+01	6.23E-03	1.26E-02	2.49E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E+03	2.89E+02	4.30E-01	4.27E+02
53015	2270006015	750	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

APPENDIX C
SUMMARY OF EMISSIONS

Based on:

1 metric tonne = 1.1023 ton (short ton)

Facility Material Handling System Rating

Materials Handling System/Train Unload:	7500 metric tonnes/hr	8267 tons/hr
Reclaim and Vessel Loading:	6500 metric tonnes/hr	7165 tons/hr

Projected Operation

Operating hours	365	days/yr
	Full Build-Out	
Coal Throughput	44	MM metric tons per year
	49	MM tpy
Unit Trains	8	trains/day
Cars per Unit Train	125	cars/train
Coal per Car	122.1	tons/car
Onsite Tracks	8	number of tracks
	840	ships/yr
tons of coal per ship	57,740	tons/vessel
Hours to Unload one unit train	1.85	hours

Latest assumption on number of cargo ships Handymax size to move the coal (also see URS resrouce report on rail and transport Dec 2014

Source	Full Build-Out Pollutant Emissions (tpy) NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	DPM
FUGITIVE SOURCES									
Coal Transfer (except piles):									
Material Handling	-	-	-	-	5.25	1.84	0.28	-	-
Coal Piles:									
Wind Erosion	-	-	-	-	1.08	0.92	0.14	-	-
Material Handling	-	-	-	-	2.62	0.92	0.14	-	-
MOBILE SOURCES									
Maintenance/Operations Equipment:									
Combustion	4.36	1.42	0.36	0.19	0.38	0.31	0.31	0.01	0.38
Trains:									
Combustion (Off-site)	17.5	7.63	0.60	0.027	0.45	0.37	0.36	0.08	0.45
Fugitive (Off-site)	-	-	-	-	0.94	0.80	0.12	-	-
Conbustion (on-site)	11.57	4.00	0.48	0.01	0.30	0.25	0.24	0.04	0.21
Combustion unloading trani (On-site)	5.57	2.43	0.19	8.59E-03	0.14	0.12	0.12	2.58E-02	0.14
Combustion Idle (On-site)	1.56	0.68	5.36E-02	2.40E-03	4.03E-02	3.32E-02	3.22E-02	7.22E-03	4.03E-02
Combustion Switching (On-site)	4.44	0.90	0.23	3.17E-03	0.11	9.43E-02	9.15E-02	9.53E-03	2.69E-02
Fugitive (On-site)	-	-	-	-	2.10	1.79	0.27	-	-
Ships:									
Combustion (Off-site)	24.8	37.9	14.10	3.04	2.17	1.78	1.64	0.03	0.00
Combustion (On-site)	23.3	65.9	15.32	4.52	1.27	1.05	1.02	0.08	0.56
Total - All Sources, Onsite and Offsite	81.5	117	30.9	7.79	16.6	10.0	4.53	0.24	1.61
Total - Onsite Sources	39.2	71.4	16.15	4.72	13.01	7.07	2.40	0.13	1.16
Fugitives Only	-	-	-	-	11.05	5.46	0.83	-	-
Facility Equipment Combusion Only	4.36	1.42	0.36	0.19	0.38	0.31	0.31	0.01	0.38
Mobile Combustion Sources Only	39.20	71.36	16.15	4.72	1.96	1.61	1.57	0.13	1.16

PM From Combustion (tpy):	TSP	PM_{10}	$PM_{2.5}$
Total - Offsite Combustion	2.62	2.16	2.01
Total - Onsite Combustion	1.80	1.48	1.45
Total - Combustion	4.42	3.64	3.45

Washington State Emissions in tons per year
2011 Emissions Inventory for Cowlitz County

Select Sources (full summary in separate worksheet)	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	DPM
Point Sources	3,616	2,507	671	791	-	182	172	-	-
Non-Road Mobile (Land-based, non-locomotive)	389	3,718	592	1	-	48	46	-	24
Railroad	789	137	43	6	-	23	23	-	23
Ships (commercial marine vessels)	1,109	150	46	199	-	37	34	-	34
Total All Source Categories	10,382	36,142	16,919	1,020	-	1,872	971	-	164

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	DPM
Trains (Cowlitz County Total)	40.6	15.6	1.56	0.06	4.09	3.45	1.23	0.17	0.88
Vessels (Cowlitz County total)	48.1	103.9	29.4	7.56	3.44	2.83	2.66	0.11	0.56

	Full Build-Out Pollutant Emissions (tpy) NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	DPM
Trains (WA State except Cowlitz)	2,209	963	76.1	3.40	57.3	47.1	45.7	10.25	57.3
Ships (WA State except Cowlitz)	113	172	64.0	13.8	9.84	8.09	7.46	0.147	9.84

APPENDIX C
SUMMARY OF EMISSIONS

Based on:

1 metric tonne = 1.1023 ton (short ton)

Facility Material Handling System Rating

Materials Handling System/Train Unload:	7500	metric tonnes/hr	8267	tons/hr
Reclaim and Vessel Loading:	6500	metric tonnes/hr	7165	tons/hr

Projected Operation

Operating hours	365	days/yr
	Full Build-Out	
Coal Throughput	44	MM metric tons per year
	49	MM tpy
Unit Trains	8	trains/day
Cars per Unit Train	125	cars/train
Coal per Car	100	tons/car
Onsite Tracks	8	number of tracks
	840	ships/yr
tons of coal per ship	57,740	tons/vessel
Hours to Unload one unit train	1.85	hours

Latest assumption on number of cargo ships Handymax size to move the coal (also see URS resrouce report on rail and transport Dec 2014

Source	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2e
				Full Build-Out Pollutant Emissions (tpy)					
FUGITIVE SOURCES									
Coal Transfer (except piles):									
Material Handling	-	-	-	-	5.25	1.84	0.28	-	-
Coal Piles:									
Wind Erosion	-	-	-	-	1.08	0.92	0.14	-	-
Material Handling	-	-	-	-	2.62	0.92	0.14	-	-
					3.71	1.84	0.28		
MOBILE SOURCES									
Maintenance/Operations Equipment:									
Combustion	4.36	1.40	0.36	0.19	0.38	0.31	0.31	0.01	995
Trains:									
Combustion (Off-site)	17.5	7.63	0.60	0.03	0.45	0.37	0.36	0.08	2,959
Fugitive (Off-site)	-	-	-	-	0.94	0.80	0.12	-	-
Combustion (On-site)	5.57	2.43	0.19	8.59E-03	1.44E-01	0.12	0.12	2.58E-02	942
Combustion Idle (On-site)	1.56	0.68	5.36E-02	2.40E-03	4.03E-02	3.32E-02	3.22E-02	7.22E-03	263
Combustion Switching (On-site)	4.44	0.90	0.23	3.17E-03	0.11	9.43E-02	9.15E-02	9.53E-03	344
Fugitive (On-site)	-	-	-	-	2.10	1.79	0.27	-	-
Ships: (for diesel PM this only includes tugs)									
Combustion (Off-site)	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0
Combustion (On-site)	14	39	1.46	3.08	0.56	0.46	0.46	3.30E-02	5,335
Total - All Sources, Onsite and Offsite	47	52	3	3.31	17	9	2.61	0.16	10,839
Total - Onsite Sources	29.8	43.9	2.30	3.28	16.00	8.32	2.13	0.08	7,880
Fugitives Only	-	-	-	-	11.05	5.46	0.83	-	-
Facility Equipment Combustion Only	4.36	1.40	0.36	0.19	0.38	0.31	0.31	0.01	995
Mobile Combustion Sources Only	19.44	40.96	1.66	3.09	0.71	0.58	0.58	0.06	6,277.61
PM From Combustion (tpy):					**TSP**	**PM_{10}**	**$PM_{2.5}$**		
Total - Offsite Combustion					0.45	0.37	0.36		

Total - Onsite Combustion	1.09	0.90	0.89
Total - Combustion	1.54	1.27	1.25

Washington State Emissions in tons per year
2011 Emissions Inventory for Cowlitz County

Select Sources (full summary in separate worksheet)	**NO_x**	**CO**	**VOC**	**SO_2**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**HAPS**	**CO2e**	**DPM**
Point Sources	3,616	2,507	671	791	-	182	172	-	-	-
Non-Road Mobile (Land-based, non-locomotive)	389	3,718	592	1	-	48	46	-	-	24
Railroad	789	137	43	6	-	23	23	-	-	23
Ships (commercial marine vessels)	1,109	150	46	199	-	37	34	-	-	34
Total All Source Categories	10,382	36,142	16,919	1,020	-	1,872	971	-	-	164

APPENDIX D
PILE INFORMATION

Bulk Density of Coal:	817	kg/m3	min	(PRB coal; source Description of Facilites, September 2011)
	929	kg/m3	max	

Pile Dimensions:

	average L (ft)	Sfc W (ft)	Sfc Acres	Peak H (ft)	Mean H (ft)
Pile 1	2350	233	12.57	85	25
Pile 2	2350	233	12.57	85	25
Pile 3	2350	233	12.57	85	25
Pile 4	2350	233	12.57	85	25

From Millennium Coal Export Terminal, Applicant's Purpose and Need Description, Dec 2013

Coal pads vary between 2200 to 2500 ft in length

85 approximate coal stack height

	metric tonne	ton	
Pile 1	367,000	404,548	*(Stage 1 and 2)*
Pile 2	394,000	434,311	*(Stage 1 and 2)*
Pile 3	375,000	413,367	*(Full Build-Out Only)*
Pile 4	368,000	405,651	*(Full Build-Out Only)*

1,504,000 metric tonnes, total storage capacity

	Full Build-Out	
Annual Coal Throughput:	48,501,697	tpy
Average Pile Turnovers/yr:	29	

Pile Throughput:

Pile 1	11,835,188	tpy
Pile 2	12,705,897	tpy
Pile 3	12,093,176	tpy
Pile 4	11,867,437	tpy

APPENDIX E
PILE - WIND EROSION

(Methodology from AP-24, Section 13.2.5 and WRAP Fugitive Dust Handbook, Section 9.3)
Industrial Wind Erosion

Wind Erosion (emissions from pile activity are covered in Materials Handling (MH) section)
(Equation based on Western Regional Air Partnership [WRAP] Fugitive Dust Handbook, Section 9.3)

$$E(lb\,TSP/acre/yr) = 1.7 * \frac{s}{1.5} * \frac{365*(365-p)}{235} * \frac{f}{15} * r$$

Where:

s=	2.2	Silt Content, weight %. *(Mean value from EPA AP-42, Section 13.2.4, Table 13.2.4-1, Coal-fired Power Plants (as received).)*
p=	175	Number of Days with >= 0.01 inches of precipitation per year. (NCDC Climate Summary for Longview, 1931-2006.)
f=	8.78	Percentage of Time that the unobstructed wind speed exceeds 12 mph at mean pile height. *(Calculated from Weyerhaeuser Mint Farm Met Station Data, 2001-2003 (wind speed monitor at 10 meter height; mean pile height (by exposed area) ~ 25 ft (7.6 m).)*
r=		Particulate Matter Size Ratios (WRAP Fugitive Dust Handbook, Section 9.3).
	1	TSP
	0.85	PM10
	0.13	PM2.5

Uncontrolled Emission Rates:

TSP	431	lb/acre/yr
PM10	366	lb/acre/yr
PM2.5	56	lb/acre/yr

Controlled Emissions:

Control %: 90 *WRAP Fugitive Dust Handbook, Table 9-4, Watering.*

Exposed Pile Area	Acres
Pile 1	12.57
Pile 2	12.57
Pile 3	12.57
Pile 4	12.57

	Full Build-Out	
Total Area	50.28	acres

Total Controlled Emissions:

Pollutant	Full Build-Out	
TSP	1.08	tpy
PM10	0.92	tpy
PM2.5	0.14	tpy

APPENDIX F
MATERIAL HANDLING

Transfer Operations (Pile Construction, Pile Removal)

(Methodology from AP-24, Section 13.2.4)
Aggregate Handling and Storage Piles

$$E\,(lb\,/\,ton\,) = k * 0.0032 * \left\{ \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right\}$$

Where:

k=		Aerodynamic Particle Size Multiplier. *(EPA AP-42 Section 13.2.4.)*
	1	TSP
	0.35	PM10
	0.053	PM2.5
U=	5.04	Mean Wind Speed, mph. *(Calculated from Weyerhaeuser Mint Farm Met Station Data, 2001-2003 (wind speed monitor at 10 meter height).)*
M=	4.5	Material Moisture Content, percent. (Mean value from EPA AP-42, Section 13.2.4, Table 13.2.4-1, Coal-fired Power Plants (as received). This value fits range given in Description of Facilities, September 2011 (1-6% surface; 13-18% total).)

Uncontrolled Emission Rates:

TSP	1.04E-03	lb/ton
PM10	3.64E-04	lb/ton
PM2.5	5.51E-05	lb/ton

Controlled Emissions:

Control %: 90 *WRAP Fugitive Dust Handbook, Table 9-4, Watering.*

Natural Precipitation Mitigation Factor: (365-P)/365 *EPA AP-42, Section 13.2.2*

P= 175 Number of Days with >= 0.01 inches of precipitation per year. *(NCDC Climate Summary for Longview, 1931-2006.)*

	Full Build-Out	
Annual Coal Throughput:	48501697	tpy
Annual Coal Throughput x2 (pile construct and reclaim):	97003394	tpy

Total Controlled Emissions:

Pollutant	Full Build-Out	
TSP	2.62	tpy
PM10	0.92	tpy
PM2.5	0.14	tpy

All Other Coal Handling Operations (Transfers, Conveyors)

All enclosed operations with dry fogging. Equipment is cleaned using a wet scraping technique; assumed cleaning particulate emissions are zero.

Uncontrolled Emission Rates (same methodology as above):

TSP	1.04E-03	lb/ton
PM10	3.64E-04	lb/ton
PM2.5	5.51E-05	lb/ton

Controlled Emissions:

Control %: 95

Changed from 99%. (ICF) This reduced efficiency is consistent with a similar proposed facility in Boardman, OR and the efficiency from watering alone is 90% and since the enclosure doesn't have negative pressure the additional benefit is small, so 95% is a more reasonable conservative assumption.

Natural Precipitation Mitigation Factor: (365-P)/365 *EPA AP-42, Section 13.2.2*

P= 175 Number of Days with >= 0.01 inches of precipitation per year. (NCDC Climate Summary for Longview, 1931-2006.)

	Full Build-Out	
Annual Coal Throughput:	48501697	tpy

Emission/Transfer Points:

Rail Dump	1
Transfer Tower 1	1
Transfer Towers 2-4	1
Transfer Towers 5-7	1
Surge Bin (WP9)	1
Surge Bin (WP10)	1
Transfer Tower 8	1
Conveyor to Ship	1

Total Controlled Emissions:

Pollutant	Full Build-Out	
TSP	5.25	tpy
PM10	1.84	tpy
PM2.5	0.28	tpy

APPENDIX G
COAL CAR FUGITIVE EMISSIONS

(Methodology from AP-24, Section 13.2.5 and WRAP Fugitive Dust Handbook, Section 9.3)
Industrial Wind Erosion

Wind-related losses from Train Transport of Open Coal Cars
(Equation based on WRAP Fugitive Dust Handbook, Section 9.3))

$$E(lb TSP/acre/yr) = 1.7 * \frac{s}{1.5} * \frac{365*(365-p)}{235} * \frac{f}{15} * r$$

Where:

s=	2.2	Silt Content, weight %. *(Mean value from EPA AP-42, Section 13.2.4, Table 13.2.4-1, Coal-fired Power Plants (as received).)*
p=	175	Number of Days with >= 0.01 inches of precipitation per year. *(Calculated from Weyerhaeuser Mint Farm Met Station Data, 2001-2003. (Note: AP-42 Figure 13.2.2-1 shows 180 days, and NCDC Climate data indicates ~ 177 days.))*
f (moving train)=	100	Percentage of Time that the unobstructed wind speed exceeds 12 mph at mean pile height. *(Assumed 100% of time for moving train.)*
f (sitting train)=	8.78	Percentage of Time that the unobstructed wind speed exceeds 12 mph at mean 'pile' height. *(Calculated from Weyerhaeuser Mint Farm Met Station Data, 2001-2003 (wind speed monitor at 10 meter height; train car height with coal load = ~15 ft (4.6 m).)*
r=		Particulate Matter Size Ratios (WRAP Fugitive Dust Handbook, Section 9.3).
	1	TSP
	0.85	PM10
	0.13	PM2.5

Uncontrolled Emission Rates for Moving Trains:

TSP	4905	lb/acre/yr
PM10	4170	lb/acre/yr
PM2.5	638	lb/acre/yr

Uncontrolled Emission Rates for Sitting Trains:

TSP	431	lb/acre/yr
PM10	366	lb/acre/yr
PM2.5	56	lb/acre/yr

Train car exposed surface area:	518	ft2
Area/coal amount (by 1 car):	4.24	ft2/ton coal

	Full Build-Out	
Annual Coal Throughput:	48501697	tpy
Coal/car:	122.1	tons
Cars/train:	125	cars
Total Exposed Area:	4720	acres

Off-site		Full Build-Out	
Distance from main rail line to site:		0.71	miles
Time Moving Car Exposed:		0.71	hrs

Offsite Emissions:

Pollutant		Full Build-Out	
TSP		0.94	tpy
PM10		0.80	tpy
PM2.5		0.12	tpy

On-site		Full Build-Out		
Onsite loop distance:		0.00	miles	
Dumper facility loop:		13236	ft	Drawing 80552-500-ST-DAL-2019-00-RevA.pdf, WorleyParsons
		2.51	miles	
Total onsite distance for transport:		2.51	miles	Includes only loaded travel; assumes full cars for complete staging loop and dump loop distances.
Train Speed:		2	mph	
Time Moving Car Exposed:		1.36	hrs	
Waiting Time:		1.36	hrs	Heyl & Patterson, Martin Engineering (coal dumper and chute mnftrs), BNSF Railway [total time]; apply a conservative estimate for time waiting to unload.
Unloading Time:		2.60	hrs	
Time Sitting Car Exposed:		2.66	hrs	Assume time of exposure during unloading is only 1/2 of total unloading time.

Onsite Emissions:

Pollutant		Full Build-Out	
TSP		2.10	tpy
PM10		1.79	tpy
PM2.5		0.27	tpy

APPENDIX H
LOCOMOTIVE EMISSIONS (Appendix H)

	Full Build-Out		
Coal Throughput	48501697	tons/yr	='D:\Documents\millineum\URS Air Qualty Studies for Millineum Coal Terminal\January 2015 appx L\[4 - Air Quality Appendix L-Mod ICF.xlsx]Operations Summary (ICF)'!C17*1000000
Coal/car	122.1	tons	'='D:\Documents\millineum\URS Air Qualty Studies for Millineum Coal Terminal\January 2015 appx L\[4 - Air Quality Appendix L-Mod ICF.xlsx]Operations Summary (ICF)'!C20
Unit Trains (cars/train)	125	cars	'='D:\Documents\millineum\URS Air Qualty Studies for Millineum Coal Terminal\January 2015 appx L\[4 - Air Quality Appendix L-Mod ICF.xlsx]Operations Summary (ICF)'!C19
Unit Trains Required	2920	Trains/yr	
	3	Locomotives/Train (full)	
	3	Locomotives/Train (empty)	
Engine Size:	4400	hp/locomotive	*Electro-Motive Diesel, GE Transportation* (http://www.getransportation.com/locomotives/locomotives/ac4400-and-dash-series-locomotives); GE AC4400CW (4400hp) or ElectroMotive Diesel SD70Ace (4300hp). Also consistent with DKS tra
Locomotive Fuel Use:	20.8	bhp-hr/gal	(conversion for large line-haul locomotive, *Emission Factors for Locomotives, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 200*9.)

Fuel Use per Train	Full Build-Out		
ON SITE			
Loaded Train:	4.6%	Percent Load	Notch 1 setting and associatedd load @ 6 mph (202 hp) based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	607.2	hp	
	29	gallons/hr	
Idle Train:	0.25%	Percent Load	Idle setting and associated load (11 hp) @idle based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	33	hp	
	2	gallons/hr	
OFF SITE			
Loaded Train:	9.9%	Percent Load	Notch 2 setting and associatedd load @ 12 mph (435 hp) based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	1306.8	hp	
	63	gallons/hr	
Empty Train:	9.9%	Percent Load	Assume same notch 2 setting as loaded (conservative)
	1306.8	hp	
	63	gallons/hr	

Longview Short Line (Longview Switching Company (LSC) Track)

Offsite			
Distance from Main Rail Line to Site:	7.10	miles	distance from GIS drawings per Danny Stratten (ICF) Feb 2014
Travel Time to Site:	0.71	hrs	DKS travel speed average of 10 mph
Total Power:	5418516	hp-hr/yr	
Total Fuel Use:	260506	gallons/yr	
Onsite			
Onsite loop distance:	8727	ft	Per train average loop distance (Drawings 80552-500-GE-DLP-0020_RevA.pdf and 80552-500-ST-DAL-2019-00-RevA.pdf, WorleyParsons)
Travel Distance:	1.65	miles	(one loop onsite; does not include dump track time which is operated by electric indexing system)
Time per Train:	1.85	hours	time needed to unload the coal from 125 cars
Total Power:	1725554	hp-hr/yr	
Total Fuel Use:	82959	gallons/yr	
Total Fuel Use (On and Offsite)	343465	gallons/yr	

Emission Factors (2028 full operation)

	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	**HAPS**	**CO2**	**CH4**	**N2O**	**CO2e**
2028 National Locomotive Fleet Avera((g/gal)	61	26.6	2.1	0.094	1.58	1.3	1.26	0.28	10217	0.80	0.26	10314

Sources:

[1] NOx, CO, VOC, SO2, PM10, PM2.5 2025 emission factors from: *Emission Factors for Locomotives*, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. Table 5,6,7, Line-Haul Emission Factors. From text: $PM_{2.5} = 0.97* PM_{10}$.

[2] SO2 emission factor using S content of 15 ppm

[3] TSP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Based on ratio of total particulate to PM10 in diesel engines, as given in Table 3.4-2.

[4] HAP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Total HAPs from Tables 3.4-3 and 3.4-4, sum of HAPs as indicated by footnote b. For diesel fuel: 7000 Btu/hp-hr.

[5] *Direct Emissions from Mobile Combustion Sources*, EPA, Office of Air and Radiation, EPA-430-K-08-004, May 2008. N_2O and CH_4 from Table A-6.

[6] Global Warming Potentials (GWPs):
CO_2 - 1
CH_4 - 25
N_2O - 298

Emission Rates (tpy)

Full Build-Out	**NO_x**	**CO**	**VOC**	**SO_2**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**HAPS**	**CO2**	**CH4**	**N2O**	**CO2e**
Offsite	18	7.6	0.60	0.03	0.45	0.37	0.36	0.08	2931	0.23	0.07	2959
Onsite	6	2.4	0.19	0.01	0.14	0.12	0.12	0.03	933	0.07	0.02	942
Total	23	10.1	0.79	0.04	0.60	0.49	0.48	0.11	3865	0.30	0.10	3902

APPENDIX H2

LOCOMOTIVE EMISSIONS (Appendix H2) - Trains waiting to leave (on-site) 5 hours

	Full Build-Out		
Coal Throughput	48501697	tons/yr	='D:\Documents\millineum\URS Air Qualty Studies for Millineum Coal Terminal\January 2015 appx L\[4 - Air Quality Appendix L-Mod ICF.xlsx]Operations Summary (ICF)'!C17*1000000
Coal/car	122.1	tons	'='D:\Documents\millineum\URS Air Qualty Studies for Millineum Coal Terminal\January 2015 appx L\[4 - Air Quality Appendix L-Mod ICF.xlsx]Operations Summary (ICF)'!C20
Unit Trains (cars/train)	125	cars	'='D:\Documents\millineum\URS Air Qualty Studies for Millineum Coal Terminal\January 2015 appx L\[4 - Air Quality Appendix L-Mod ICF.xlsx]Operations Summary (ICF)'!C19
Unit Trains Required	2920	Trains/yr	
	3	Locomotives/Train (full)	
	3	Locomotives/Train (empty)	
Engine Size:	4400	hp/locomotive	*Electro-Motive Diesel, GE Transportation* (http://www.getransportation.com/locomotives/locomotives/ac4400-and-dash-series-locomotives); GE AC4400CW (4400hp) or ElectroMotive Diesel SD70Ace (4300hp). Also consistent with DKS traffic analysis
Locomotive Fuel Use:	20.8	bhp-hr/gal	(conversion for large line-haul locomotive, *Emission Factors for Locomotives, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009*.)

Fuel Use per Train	Full Build-Out		
ON SITE			
Idle Train:	0.25%	Percent Load	Idle setting and associated load (11 hp) @idle based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	33	hp	
	2	gallons/hr	
Onsite			
Time per Train:	5.00	hours	time idling
Total Power:	481800	hp-hr/yr	
Total Fuel Use:	23163	gallons/yr	
Total Fuel Use (Onsite, idle)	23163	gallons/yr	

Emission Factors (2028 full operation)

	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	HAPS	CO2	CH4	N2O	CO2e
2028 National Locomotive Fleet Avera (g/gal)	61	26.6	2.1	0.094	1.58	1.3	1.26	0.28	10217	0.80	0.26	10314

Sources:

[1] NOx, CO, VOC, SO2, PM10, PM2.5 2025 emission factors from: *Emission Factors for Locomotives*, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. Table 5,6,7, Line-Haul Emission Factors. From text: $PM_{2.5}$ = 0.97* PM_{10}.

[2] SO2 emission factor using S content of 15 ppm

[3] TSP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Based on ratio of total particulate to PM10 in diesel engines, as given in Table 3.4-2.

[4] HAP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Total HAPs from Tables 3.4-3 and 3.4-4, sum of HAPs as indicated by footnote b. For diesel fuel: 7000 Btu/hp-hr.

[5] *Direct Emissions from Mobile Combustion Sources*, EPA, Office of Air and Radiation, EPA-430-K-08-004, May 2008. N_2O and CH_4 from Table A-6.

[6] Global Warming Potentials (GWPs):
CO_2 - 1
CH_4 - 25
N_2O - 298

Emission Rates (tpy)

Full Build-Out	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Onsite	2	0.7	0.05	0.00	0.04	0.03	0.03	0.01	261	0.02	0.01	263
Total	2	0.7	0.05	0.00	0.04	0.03	0.03	0.01	261	0.02	0.01	263

APPENDIX H3
SWITCH LOCOMOTIVE EMISSIONS (Appendix H3)

	Full Build-Out	
Days/year	365	Trains/yr
Hours/day	8	hours
	1	Locomotives/Train (empty)

Engine Size:	4400	hp/locomotive	*Electro-Motive Diesel, GE Transportation* (http://www.getransportation.com/locomotives/locomotives/ac4400-and-dash-series-locomotives); GE AC4400CW (4400hp) or ElectroMotive Diesel SD70Ace (4300hp). Also consistent with DKS traffic analysis
Locomotive Fuel Use:	20.8	bhp-hr/gal	(conversion for large line-haul locomotive, *Emission Factors for Locomotives, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009* .)

Fuel Use per Train	Full Build-Out		
ON SITE			
Loaded Train:	4.6%	Percent Load	Notch 1 setting and associatedd load @ 6 mph (202 hp) based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	1619.2	hp	
	78	gallons/hr	
Idle Train:	0.25%	Percent Load	Idle setting and associated load (11 hp) @idle based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	11	hp	
	1	gallons/hr	
Empty Train:	9.9%	Percent Load	Assume same notch 2 setting as loaded (conservative)
	435.6	hp	
	21	gallons/hr	

Emission Factors (2028 full operation) — g/gal

	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	HAPS	CO2	CH4	N2O	CO2e
2028 National Locomotive Fleet Avera (g/gal)	61	26.6	2.1	0.094	1.58	1.3	1.26	0.28	10217	0.80	0.26	10314
2028 Large Switch (g/gal)	132	26.6	6.9	0.094	3.41	2.8	2.72	0.28	10217	0.80	0.26	10314

Sources:
[1] NOx, CO, VOC, SO2, PM10, PM2.5 2028 emission factors from: *Emission Factors for Locomotives* , EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. Table 5,6,7, Line-Haul Emission Factors. From text: $PM_{2.5}$ = 0.97* PM_{10}.
[2] SO2 emission factor using S content of 15 ppm
[3] TSP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Based on ratio of total particulate to PM10 in diesel engines, as given in Table 3.4-2.
[4] HAP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Total HAPs from Tables 3.4-3 and 3.4-4, sum of HAPs as indicated by footnote b. For diesel fuel: 7000 Btu/hp-hr.
[5] *Direct Emissions from Mobile Combustion Sources* , EPA, Office of Air and Radiation, EPA-430-K-08-004, May 2008. N_2O and CH_4 from Table A-6.
[6] Global Warming Potentials (GWPs): CO_2 - 1; CH_4 - 25; N_2O - 298

Emission Rates (tpy)

Full Build-Out	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Switch - Move (50%)	0.11	2.26E-02	5.87E-03	7.99E-05	2.90E-03	2.38E-03	2.31E-03	2.41E-04	8.69	6.80E-04	2.21E-04	8.77
Switch - Idle (50%)	4.44	0.90	0.23	3.17E-03	0.11	9.43E-02	9.15E-02	9.53E-03	344.04	2.69E-02	8.76E-03	347.33
Total	4.56	0.92	0.24	3.25E-03	0.12	9.67E-02	9.38E-02	9.77E-03	353	2.76E-02	8.98E-03	356

APPENDIX H

LOCOMOTIVE EMISSIONS (Appendix H) Emissions in Washington State Except Cowlitz Coun

Locomotive Fuel Use 20.8 bhp-hr/gal (conversion for large line-haul locomotive *Emission Factors for Locomotives, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009*.)

	Fuel Consumption			
	31,470,397	gallons	2028 fully operational (consistent with GHG analysis	**for total train fuel consumption within state (diesel) other than in Cowlitz county per GHG report/analysis based on 402 miles inbound and 490.2 miles outbou**
	1,386,221	gallons		**additional fuel consumption within Cowlitz County main line (17.9 miles in bound to Longview Jct; 21.4 miles outbound from Longview Jct to north county li**
total	32,856,619	gallons		
	Factors			
	453.6	grams per lb		
	2000	lb per ton		

Emission Factors (2028 full operation

	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	**HAPS**	**CO2**	**CH4**	**N2O**	**CO2e**
2028 National Locomotive Fleet Avera (g/gal)	61	26.6	2.1	0.094	1.58	1.3	1.26	0.28	10217	0.80	0.26	10314

Sources:

[1] NOx, CO, VOC, SO2, PM10, PM2.5 2025 emission factors from: *Emission Factors for Locomotives*, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. Table 5,6,7, Line-Haul Emission Factors. From text: $PM_{2.5} = 0.97 * PM_{10}$.

[2] SO2 emission factor using S content of 15 ppm

[3] TSP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Based on ratio of total particulate to PM10 in diesel engines, as given in Table 3.4-2.

[4] HAP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Total HAPs from Tables 3.4-3 and 3.4-4, sum of HAPs as indicated by footnote b. For diesel fuel: 7000 Btu/hp-hr.

[5] *Direct Emissions from Mobile Combustion Sources*, EPA, Office of Air and Radiation, EPA-430-K-08-004, May 2008. N_2O and CH_4 from Table A-6.

[6] Global Warming Potentials (GWPs): CO_2 - 1; CH_4 - 25; N_2O - 298

Emission Rates (tpy)

Full Build-Out	**NO_x**	**CO**	**VOC**	**SO_2**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**HAPS**	**CO2**	**CH4**	**N2O**	**CO2e**
Offsite	2,209	963	76	3	57	47	45.7	10.25	370035	29.0	9	373,565.85

APPENDIX H
LOCOMOTIVE EMISSIONS (No Action Alternative)

	Full Build-Out		
Coal Moved	2,673,990	tons/yr	
Coal/car	122.1	tons	'='D:\Documents\millineum\URS Air Qualty Studies for Millineum Coal Terminal\January 2015 appx L\[4 - Air Quality Appendix L-Mod ICF.xlsx]Operations Summary (ICF)'!C20
Unit Trains (cars/train)	30	cars	Same assumption as Noise Study
30-car Trains Required	730	Trains/yr	
	2	Locomotives/Train (full)	
	2	Locomotives/Train (empty)	
Engine Size:	4400	hp/locomotive	*Electro-Motive Diesel, GE Transportation* (http://www.getransportation.com/locomotives/locomotives/ac4400-and-dash-series-locomotives); GE AC4400CW (4400hp) or ElectroMotive Diesel SD70Ace (4300hp). Also consistent with DKS traffic anal
Locomotive Fuel Use:	20.8	bhp-hr/gal	(conversion for large line-haul locomotive, *Emission Factors for Locomotives, EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009* .)

Fuel Use per Train	Full Build-Out		
ON SITE			
Loaded Train:	4.6%	Percent Load	Notch 1 setting and associatedd load @ 6 mph (202 hp) based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	404.8	hp	
	19	gallons/hr	
Idle Train:	0.25%	Percent Load	Idle setting and associated load (11 hp) @idle based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	22	hp	
	1.1	gallons/hr	
OFF SITE			
Loaded Train:	9.9%	Percent Load	Notch 2 setting and associatedd load @ 12 mph (435 hp) based on data from CARB Roseville Railyard Study for 4300 HP loco engine (October, 2004)
	871.2	hp	
	42	gallons/hr	
Empty Train:	9.9%	Percent Load	Assume same notch 2 setting as loaded (conservative)
	871.2	hp	
	42	gallons/hr	

Longview Short Line (Longview Switching Company (LSC) Track)

Offsite			
Distance from Main Rail Line to Site:	7.10	miles	distance from GIS drawings per Danny Stratten (ICF) Feb 2014
Travel Time to Site:	0.71	hrs	DKS travel speed average of 10 mph
Total Power:	903086	hp-hr/yr	
Total Fuel Use:	43418	gallons/yr	
Onsite			
Time per Train:	0.44	hours	time needed to unload the coal from 125 cars under action is 1.85 hours, assume 30/125 *1.85 = 0.444 hours to unload No Action coal train
Total Power:	68544	hp-hr/yr	
Total Fuel Use:	3295	gallons/yr	
Total Fuel Use (On and Offsite)	46713	gallons/yr	

Emission Factors (2028 full operation)

	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	**HAPS**	**CO2**	**CH4**	**N2O**	**CO2e**
2028 National Locomotive Fleet Avera (g/gal)	61	26.6	2.1	0.094	1.58	1.3	1.26	0.28	10217	0.80	0.26	10314

Sources:
[1] NOx, CO, VOC, SO2, PM10, PM2.5 2025 emission factors from: *Emission Factors for Locomotives* , EPA, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. Table 5,6,7, Line-Haul Emission Factors. From text: $PM_{2.5}$ = 0.97* PM_{10}.
[2] SO2 emission factor using S content of 15 ppm
[3] TSP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Based on ratio of total particulate to PM10 in diesel engines, as given in Table 3.4-2.
[4] HAP emission factor from: *EPA AP-42, Section 3.4 Large Stationary Diesel and All Stationary Duel-fuel Engines* (10/96). Total HAPs from Tables 3.4-3 and 3.4-4, sum of HAPs as indicated by footnote b. For diesel fuel: 7000 Btu/hp-hr.
[5] *Direct Emissions from Mobile Combustion Sources* , EPA, Office of Air and Radiation, EPA-430-K-08-004, May 2008. N_2O and CH_4 from Table A-6.
[6] Global Warming Potentials (GWPs): CO_2 - 1
CH_4 - 25
N_2O - 298

Emission Rates (tpy)

Full Build-Out	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Offsite	3	1.3	0.10	0.004	0.08	0.06	0.06	0.01	489	0.04	0.01	493
Onsite	0	0.1	0.01	0.000	0.01	0.00	0.00	0.00	37	0.00	0.00	37
Total	3.14	1.4	0.11	0.005	0.08	0.07	0.06	0.01	526	0.04	0.01	531

APPENDIX I
CARGO VESSEL EMISSIONS

Tugs/Ship	3		(Conservative estimate)
Tug Engine Size (propulsion)	4000	hp	
Tug Positioning Time	3	hrs/ship (in-out)	(Conservative estimate)
Tug Load Factor (Manuvering)	31%	Percent Load	(Engine load factor for Assist Tugs, from Port of Long Beach Air Emissions Inventory - 2011 (POLB, July 2012).)
Panamax Size Engine	16368	hp	
Handymax Size Engine	10153	hp	
Panamax auxillary engine size	3039	hp	
Handymax Auxilliary Engine Size	1885	hp	
Main Engine Load (loaded in transit)	37%	Percent Load	
Main Engine Load (unloaded in transit)	37%	Percent Load	
Auxillary Engine Load (transit)	17%	Percent Load	

Main Engine Load (manuvering)	2%	Percent Load*
Auxillary Engine Load (manuvering)	45%	Percent Load
Auxillary Engine Load (hoteling)	10%	Percent Load

* Need to apply low load adjustment factor to main engine manuvering
Low load adjustment factor for low load manuvering

Table II-5: OGV Auxiliary Engine Load Characteristics (percent load)
Bulk Carrier/General Cargo

Load Factor (%)	
Hoteling	10%
Maneuvering	45%
Transit	17%

ARB, 2011a. Initial Statement of Reasons for Proposed Rulemaking, Proposed Amendments the Regulations "Fuel Sulfur and Other Operational Requirements for Ocean-Goir Vessels within California Waters and 24 Nautical Miles of the California Baseline Appendix D, Emission Estimation Methodology for Ocean Going Vessels, May 201 Data http://www.arb.ca.gov/msei/categories.htm#ogv_categor

Load Factors for Main Engine based on Propeller Law Equation assuming 11 knots transit in river and 4 knots manuvering

Engine	Cruise	Transit	Maneuver
Propulsion	83%	37%	2%

At full cruise engines run at 83% of capacity with maximum speed of 15.3 knots
Propeller equation $LF = (AS/MS)^3$
where **LF** = Load Factor (percent)
AS = Actual Speed (knots)
MS = Maximum Speed (knots)

Number of ship call in 2028	840	
Percent of calls by Panamax	80	percent
Percent of call by Handymax	20	percent
Ship Berth Time ((Hoteling)	13	hrs
Main Ship (Manuvering)	1.0	hrs
Trannsit Time within Cowlitz county	0.90	hrs

Lower bound speeds in the open reaches of the Columbia River Channel are 12 knots, somewhat slower speeds when fully loaded (assumed 10 knots). See: Marine Traffic Technical Report, Feb 2015 , pages 37 and page 49.

Classification	DWT Range	Main Engine (kW)	Auxiliary Engine (kW)	Main Engine (hp)	Auxiliary Engine (kW)
HandyMax	40,000 - 60,000	7577	1407	10153.18	1885.38
PanaMax	60,000 - 100,000	12215	2268	16368.1	3039.12

Source: Sea-Web (http://www.sea-web.com)
The sea-web data is produced by IHS Global Limited, headquartered in Bracknell, England. The data is based on Lloyd's Register of Ships Sea-ewb provided shi characteristics data for shios over 100 gross to
Based on the ships currently in service (2014) that have stopped at US ports.

On-site		Full Operation (2028)		
Coal Throughput		48,501,697	tons/yr	
Ships/yr (Panamax)		672	number	
	Annual Power (aux eng)	3,574,005	hp-hrs/yr	0.1 %S Marine Distillate Fuel (2015 onward)
	Annual Power (main eng)	219,987	hp-hrs/yr	0.1 %S Marine Distillate Fuel
Ships/yr (Handymax)		168	number	
	Annual Power (aux eng)	554,302	hp-hrs/yr	0.1 %S Marine Distillate Fuel
	Annual Power (main eng)	34,115	hp-hrs/yr	0.1 %S Marine Distillate Fuel (or 1000 ppm)
Tugs/yr		2,520	number	
	Annual Power	9,374,400	hp-hrs/yr	diesel low sulfur (15 ppm S)
Off-site				
Ships/yr (Panamax)				
	Annual Power (main)	7,363,914	hp-hrs/yr	0.1 %S Marine Distillate Fuel
	(aux)	628,211		
Ships/yr (Handymax)				
	Annual Power (main)	1,141,964	hp-hrs/yr	0.1 %S Marine Distillate Fuel (or 1000 ppm)
	(aux)	97,431		

Low Speed Adjustment for Main Engine During Ship Manuvering
Based on the Propeller law used to estimate shps propulsion loads, based on law that the propulsion pov varies by the cube of the speed. Transit speed was assumed to average 11 knots and maneuver speed 4 knot

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2
2% load	54.8	41.9	23.6			2.34			2853.6
20% load	11.9	4.2	0.7			0.32			869.1
Adjustment Ratio Increase	4.6	10	31.6	1	7.29	7.29	7.29	31.62	3.28

Pollutant	Exponent (x)	Intercept (b)	Coefficient (a)
PM	1.5	0.2551	0.0059
NOx	1.5	10.4496	0.1255
CO	1	0	0.8378
HC	1.5	0	0.0667
SO2			2.3735 only applies to fuel sulfur flow no adjustment for low loads
CO2	1	648.6	44.1

Slow speed adjustment Ratio of emision rates at 20% load to manuvering Load 2%
emission rate (g/kW-hr) = a (fractional load)^-x + b

Source: USEPA, 2000. US Environmental Protection Agency, Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data, February, 2000, EPA420-R-00-002.

Emission Factors

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Maine Engine Manuvering (g/KW-hr)	3.4	5.0	2.0	0.40	0.3041	0.25	0.23	0.00428	588	0.07	0.0004	590
Maine Engine Manuvering (lb/hp-hr))	0.006	0.00822	0.003	0.001	0.000500	0.000411	0.000378	0.000007	0.967	0.0001151	0.0000007	0.970
Aux Engine T4 Transit, Manuver , Hotel (g/KW-hr)	1.8	5.0	0.19	0.40	0.073	0.060	0.060	0.004	690.0	0.09	0.0004	692
Aux Engine T4 Transit, Manuver , Hotel (lb/hp-hr)	0.0030	0.0082	0.0003	0.0007	0.0001	0.0001	0.0001	0.00001	1.13	0.00015	0.00000	1.14
Main Engine Transit Mode (g/KW-hr)	3.4	5.0	2.0	0.40	0.3041	0.25	0.23	0.00428	588	0.07	0.0004	590
Main Engine Transit Mode (lb/hp-hr)	0.006	0.00822	0.00329	0.00066	0.00050	0.00041	0.00038	0.00001	0.967	0.000115	0.000001	0.970
Tug (Tier 4 compliant post 2016) (g/kW-hr)	1.8	5.0	0.19	0.40	0.073	0.060	0.060	0.004	690.0	0.09	0.0004	692
Tug (Tier 4 compliant post 2016) (lb/bhp-hr)	0.003	0.00822	0.00031	0.00066	0.00012	0.00010	0.00010	0.000007	1.13	0.00015	0.00000	1.14

g/kW-hr conversion to lb/hpr-hr 0.001644

Source:
ARB, 2011a. Initial Statement of Reasons for Proposed Rulemaking, Proposed Amendments to the Regulations "Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline"
Appendix D, Emission Estimation Methodology for Ocean Going Vessels, May 2011. Tables II-6, II-7 (main engines) and Table II-8 Auxilary Engine only for PM10, PM2.5 and C
Other Emissions Factros from USEPA Marine Compression Ignition Exhaust Emission Standards for highest Tier engines (auxillary and Tugs C2; main engine C3) all standars fully impletemented by 2016 assume all engines by 2028 comply with these star
For C3 engines assume lowest engine speed which corresponds with highest emission rat See: http://www.epa.gov/otaq/standards/nonroad/marineci.htm

HAP Emission factors from: *EPA AP-42, Section 3.4;* Sum of HAPs factors from Table 3.4-3 and 3.4-4.
Global Warming Potentials (GWPs): CO_2 - 1
CH_4 - 25
N_2O - 298

Travel Distance:

Ship Miles	11.35 miles	Travel distance from berth site in Longview, west along Columbia River to Cowlitz County line (one-way)

Emission Rates (tpy)

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
2028 Operational Emissions Marine Vessels												
Ships (Cargo and Tugs) - (Onsite)	23	66	15.3	4.5	1.3	1.0	1.0	0.08	8062	1.0	0.0047	8089
Ships (cargo transit) - (Offsite)	25	38	14.1	3.0	2.2	1.8	1.6	0.03	4523	0.5	0.0030	4537
Total	48	104	29.4	7.6	3.4	2.8	2.7	0.11	12584	1.6	0.01	12627

APPENDIX I
CARGO VESSEL EMISSIONS

Tugs/Ship	3		(Conservative estimate)
Tug Engine Size (propulsion)	4000	hp	
Tug Positioning Time	3	hrs/ship (in-out)	(Conservative estimate)
Tug Load Factor (Manuvering)	31%	Percent Load	(Engine load factor for Assist Tugs, from Port of Long Beach Air Emissions Inventory - 2011 (POLB, July 2012).)
Panamax Size Engine		hp	
Handymax Size Engine		hp	
Panamax auxillary engine size		hp	
Handymax Auxilliary Engine Size		hp	
Main Engine Load (loaded in transit)		Percent Load	Main Engine Load (manuvering) 2% Percent Load*
Main Engine Load (unloaded in transit)		Percent Load	
Auxillary Engine Load (transit)	17%	Percent Load	Auxillary Engine Load (manuvering) 45% Percent Load
Number of ship call in 2028	840		
Percent of calls by Panamax	80	percent	
Percent of call by Handymax	20	percent	
Ship Berth Time ((Hoteling)	13	hrs	
Main Ship (Manuvering)	1.0	hrs	
Trannsit Time within Cowlitz county	0.90	hrs	Lower bound speeds in the open reaches of the Columbia River Channel are 12 knots, somewhat slower speeds when fully loaded (assumed 10 knots). See: Marine Traffic Technical Report, Feb 2015 , pages 37 and page 49.

* Need to apply low load adjustment factor to main engine manuvering
Low load adjustment factor for low load manuvering

Auxillary Engine Load (hoteling) 10% Percent Load

On-site		Full Operation (2028)		
Coal Throughput		48,501,697	tons/yr	
Ships/yr (Panamax)			number	
	Annual Power (aux eng)		hp-hrs/yr	0.1 %S Marine Distillate Fuel (2015 onward)
	Annual Power (main eng)		hp-hrs/yr	0.1 %S Marine Distillate Fuel
Ships/yr (Handymax)			number	
	Annual Power (aux eng)		hp-hrs/yr	0.1 %S Marine Distillate Fuel
	Annual Power (main eng)		hp-hrs/yr	0.1 %S Marine Distillate Fuel (or 1000 ppm)
Tugs/yr		2,520	number	
	Annual Power	9,374,400	hp-hrs/yr	diesel low sulfur (15 ppm S)
Off-site				
Ships/yr (Panamax)				
	Annual Power (main)	-	hp-hrs/yr	0.1 %S Marine Distillate Fuel
	(aux)	-		
Ships/yr (Handymax)				
	Annual Power (main)	-	hp-hrs/yr	0.1 %S Marine Distillate Fuel (or 1000 ppm)
	(aux)	-		

Table II-5: OGV Auxiliary Engine Load Characteristics (percent load)
Bulk Carrier/General Cargo
Load Factor (%)

Hoteling	10%
Maneuvering	45%
Transit	17%

ARB, 2011a. Initial Statement of Reasons for Proposed Rulemaking, Proposed Amendments to the Regulations "Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline"
Appendix D, Emission Estimation Methodology for Ocean Going Vessels, May 2011.
Data http://www.arb.ca.gov/msei/categories.htm#ogv_category

Load Factors for Main Engine based on Propeller Law Equation assuming 11 knots transit in river and 4 knots manuvering

Engine	Cruise	Transit	Maneuver
Propulsion	83%	37%	2%

At full cruise engines run at 83% of capacity with maximum speed of 15.3 knots
Propeller equation **LF = (AS/MS)**^{3}
where **LF** = Load Factor (percent)
AS = Actual Speed (knots)
MS = Maximum Speed (knots)

Classification	DWT Range	Main Engine (kW)	Auxiliary Engine (kW)	Main Engine (hp)	Auxiliary Engine (kW)
HandyMax	40,000 - 60,000	7577	1407	10153.18	1885.38
PanaMax	60,000 - 100,000	12215	2268	16368.1	3039.12

Source: Sea-Web (http://www.sea-web.com)
The sea-web data is produced by IHS Global Limited, headquartered in Bracknell, England. The data is based on Lloyd's Register of Ships Sea-ewb provided shi characteristics data for shios over 100 gross tons
Based on the ships currently in service (2014) that have stopped at US ports.

Low Speed Adjustment for Main Engine During Ship Manuvering
Based on the Propeller law used to estimate shps propulsion loads, based on law that the propulsion power varies by the cube of the speed. Transit speed was assumed to average 11 knots and maneuver speed 4 knots.

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2
2% load	54.8	41.9	23.6			2.34			2853.6
20% load	11.9	4.2	0.7			0.32			869.1
Adjustment Ratio Increase	4.6	10	31.6	1	7.29	7.29	7.29	31.62	3.28

Pollutant	Exponent (x)	Intercept (b)	Coefficient (a)	
PM	1.5	0.2551	0.0059	
NOx	1.5	10.4496	0.1255	
CO	1	0	0.8378	
HC	1.5	0	0.0667	
SO2			2.3735	only applies to fuel sulfur flow no adjustment for low loads
CO2	1	648.6	44.1	

Slow speed adjustment Ratio of emision rates at 20% load to manuvering Load 2%
emission rate (g/kW-hr) = a (fractional load)^-x + b

Source: USEPA, 2000. US Environmental Protection Agency, Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data, February, 2000, EPA420-R-00-002

Emission Factors

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e	
Maine Engine Manuvering (g/KW-hr)	3.4	5.0	2.0	0.40	0.3041	0.25	0.23	0.00428	588	0.07	0.0004	590	g/kW-hr
Maine Engine Manuvering (lb/hp-hr)	0.006	0.008	0.003	0.001	0.000500	0.000411	0.000378	0.000007	0.967	0.0001151	0.0000007	0.970	
Aux Engine T4 Transit, Manuver , Hotel (g/KW-hr)	1.8	5.0	0.19	0.40	0.073	0.060	0.060	0.004	690.0	0.09	0.0004	692	
Aux Engine T4 Transit, Manuver , Hotel (lb/hp-hr)	0.0030	0.0082	0.0003	0.0007	0.0001	0.0001	0.0001	0.00001	1.13	0.00015	0.00000	1.14	
Main Engine Transit Mode (g/KW-hr)	3.4	5.0	2.0	0.40	0.3041	0.25	0.23	0.00428	588	0.07	0.0004	590	
Main Engine Transit Mode (lb/hp-hr)	0.006	0.00822	0.00329	0.00066	0.00050	0.00041	0.00038	0.00001	0.967	0.000115	0.000001	0.970	
Tug (Tier 4 compliant post 2016) (g/kW-hr)	1.8	5.0	0.19	0.40	0.073	0.060	0.060	0.004	690.0	0.09	0.0004	692	
Tug (Tier 4 compliant post 2016) (lb/bhp-hr)	0.003	0.00822	0.00031	0.00066	0.00012	0.00010	0.00010	0.000007	1.13	0.00015	0.00000	1.14	

conversion to lb/hpr-hr 0.001644

Source:
ARB, 2011a. Initial Statement of Reasons for Proposed Rulemaking, Proposed Amendments to the Regulations "Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline"
Appendix D, Emission Estimation Methodology for Ocean Going Vessels, May 2011. Tables II-6, II-7 (main engines) and Table II-8 Auxilary Engine only for PM10, PM2.5 and CO2;
Other Emissions Factros from USEPA Marine Compression Ignition Exhaust Emission Standards for highest Tier engines (auxillary and Tugs C2; main engine C3) all standards fully impletemented by 2016 assume all engines by 2028 comply with these standards

APPENDIX I

CARGO VESSEL EMISSIONS (CAP emissions within State of WA except Cowlitz County)

Table II-5: OGV Auxiliary Engine Load Characteristics (percent load)
Bulk Carrier/General Cargo
Load Factor (%)

Hoteling	10%
Maneuvering	45%
Transit	17%

ARB, 2011a. Initial Statement of Reasons for Proposed Rulemaking, Proposed Amendments to the Regulations "Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline"
Appendix D, Emission Estimation Methodology for Ocean Going Vessels, May 2011.
Data http://www.arb.ca.gov/msei/categories.htm#ogv_category

Panamax Size Engine	16368	hp				
Handymax Size Engine	10153	hp				
Panamax auxillary engine size	3039	hp				
Handymax Auxilliary Engine Size	1885	hp				
Main Engine Load (loaded in transit)	37%	Percent Load	Main Engine Load (manuvering)	2%	Percent Load*	
Main Engine Load (unloaded in transit)	37%	Percent Load				
Auxillary Engine Load (transit)	17%	Percent Load	Auxillary Engine Load (manuvering)	45%	Percent Load	Auxillary Engine Load (hoteling) 10% Percent Load

* Need to apply low load adjustment factor to main engine manuvering
Low load adjustment factor for low load manuvering

Load Factors for Main Engine based on Propeller Law Equation assuming 11 knots transit in river and 4 knots manuvering

Engine	Cruise	Transit	Maneuver
Propulsion	83%	37%	2%

At full cruise engines run at 83% of capacity with maximum speed of 15.3 knots

Propeller equation $LF = (AS/MS)^3$

where **LF** = Load Factor (percent)
AS = Actual Speed (knots)
MS = Maximum Speed (knots)

Number of ship call in 2028	840	
Percent of calls by Panamax	80	percent
Percent of call by Handymax	20	percent
Ship Berth Time ((Hoteling)	13	hrs
Main Ship (Manuvering)	1.0	hrs
Trannsit Time round trip Cowlitz county line to 3 nm	4.10	hrs

Lower bound speeds in the open reaches of the Columbia River Channel are 12 knots, somewhat slower speeds when moving upriver (assumed 10 knots). See: Marine Traffic Technical Report, Feb 2015 , pages 37 and page 49.

Classification	DWT Range	Main Engine (kW)	Auxiliary Engine (kW)	Main Engine (hp)	Auxiliary Engine (kW)
HandyMax	40,000 - 60,000	7577	1407	10153.18	1885.38
PanaMax	60,000 - 100,000	12215	2268	16368.1	3039.12

Source: Sea-Web (http://www.sea-web.com)
The sea-web data is produced by IHS Global Limited, headquartered in Bracknell, England. The data is based on Lloyd's Register of Ships Sea-ewb provided shi characteristics data for shios over 100 gross tons.
Based on the ships currently in service (2014) that have stopped at US ports.

On-site Full Operation (2028)

Ships/yr (Panamax)	672	number
Ships/yr (Handymax)	168	number

Low Speed Adjustment for Main Engine During Ship Manuvering

Based on the Propeller law used to estimate shps propulsion loads, based on law that the propulsion power varies by the cube of the speed. Transit speed was assumed to average 11 knots and maneuver speed 4 knots.

		NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2
	2% load	54.8	41.9	23.6			2.34			2853.6
	20% load	11.9	4.2	0.7			0.32			869.1
Adjustment	Ratio Increase	4.6	10	31.6	1	7.29	7.29	7.29	31.62	3.28

Pollutant	Exponent (x)	Intercept (b)	Coefficient (a)	
PM	1.5	0.2551	0.0059	
NOx	1.5	10.4496	0.1255	
CO	1	0	0.8378	
HC	1.5	0	0.0667	
SO2			2.3735	only applies to fuel sulfur flow no adjustment for low loads
CO2	1	648.6	44.1	

Slow speed adjustment Ratio of emision rates at 20% load to manuvering Load 2%
emission rate (g/kW-hr) = a (fractional load)^-x + b

Source: USEPA, 2000. US Environmental Protection Agency, Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data, February, 2000, EPA420-R-00-002.

Off-site

Ships/yr (Panamax)						
	Annual Power (main)	33,406,867	hp-hrs/yr	0.1 %S Marine Distillate Fuel		
	(aux)	2,849,919				
Ships/yr (Handymax)						
	Annual Power (main)	5,180,594	hp-hrs/yr	0.1 %S Marine Distillate Fuel	(or 1000 ppm)	
	(aux)	442,001				

Emission Factors

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e			
Maine Engine Manuvering (g/KW-hr)	3.4	5.0	2.0	0.40	0.3041	0.25	0.23	0.00428	588	0.07	0.0004	590	g/kW-hr	conversion	
Maine Engine Manuvering (lb/hp-hr))	0.006	0.008	0.003	0.001	0.000500	0.000411	0.000378	0.000007	0.967	0.0001151	0.0000007	0.970		to lb/hpr-hr	0.001644
Aux Engine T4 Transit, Manuver , Hotel (g/KW-hr)	1.8	5.0	0.19	0.40	0.073	0.060	0.060	0.004	690.0	0.09	0.0004	692			
Aux Engine T4 Transit, Manuver , Hotel (lb/hp-hr))	0.0030	0.0082	0.0003	0.0007	0.0001	0.0001	0.0001	0.00001	1.13	0.00015	0.00000	1.14			
Main Engine Transit Mode (g/KW-hr)	3.4	5.0	2.0	0.40	0.3041	0.25	0.23	0.00428	588	0.07	0.0004	590			
Main Engine Transit Mode (lb/hp-hr)	0.006	0.00822	0.00329	0.00066	0.00050	0.00041	0.00038	0.00001	0.967	0.000115	0.000001	0.970			
Tug (Tier 4 compliant post 2016) (g/kW-hr)	1.8	5.0	0.19	0.40	0.073	0.060	0.060	0.004	690.0	0.09	0.0004	692			
Tug (Tier 4 compliant post 2016) (lb/bhp-hr)	0.003	0.00822	0.00031	0.00066	0.00012	0.00010	0.00010	0.000007	1.13	0.00015	0.00000	1.14			

Source:
ARB, 2011a. Initial Statement of Reasons for Proposed Rulemaking, Proposed Amendments to the Regulations "Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline"
Appendix D, Emission Estimation Methodology for Ocean Going Vessels, May 2011. Tables II-6, II-7 (main engines) and Table II-8 Auxilary Engine only for PM10, PM2.5 and CO2;

For C3 engines assume lowest engine speed which corresponds with highest emission rate See: http://www.epa.gov/otaq/standards/nonroad/marineci.htm

HAP Emission factors from: *EPA AP-42, Section 3.4;* Sum of HAPs factors from Table 3.4-3 and 3.4-4.
Global Warming Potentials (GWPs): CO_2 - 1
CH_4 - 25
N_2O - 298

Travel Distance:

Ship Miles	51.49	miles	Travel distance from Cowlitz County line to 3 nautical miles beyond the mouth of the Columbia River (one-way)

Emission Rates (tpy)

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
2028 Operational Emissions Marine Vessels												
Ships (cargo transit) - (Offsite)	113	172	64.0	13.8	9.8	8.1	7.5	0.15	20518	2.5	0.0138	20584
Total	113	172	64.0	13.8	9.8	8.1	7.5	0.15	20518	2.5	0.01	20584

APPENDIX I
CARGO VESSEL EMISSIONS

Tugs/Ship	3		(Conservative estimate)
Tug Engine Size (propulsion)	4000	hp	
Tug Positioning Time	3	hrs/ship (in-out)	(Conservative estimate)
Tug Load Factor (Manuvering)	31%	Percent Load	(Engine load factor for Assist Tugs, from Port of Long Beach Air Emissions Inventory - 2011 (POLB, July 2012).)
Panamax Size Engine	16368	hp	
Handymax Size Engine	10153	hp	
Panamax auxillary engine size	3039	hp	
Handymax Auxilliary Engine Size	1885	hp	
Main Engine Load (loaded in transit)	37%	Percent Load	Main Engine Load (manuvering) 2% Percent Load*
Main Engine Load (unloaded in transit)	37%	Percent Load	
Auxillary Engine Load (transit)	17%	Percent Load	Auxillary Engine Load (manuvering) 45% Percent Load; Auxillary Engine Load (hoteling) 10% Percent Load

* Need to apply low load adjustment factor to main engine manuvering
Low load adjustment factor for low load manuvering

Table II-5: OGV Auxiliary Engine Load Characteristics (percent load)
Bulk Carrier/General Cargo

Load Factor (%)	
Hoteling	10%
Maneuvering	45%
Transit	17%

ARB, 2011a. Initial Statement of Reasons for Proposed Rulemaking, Proposed Amendments to the Regulations "Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline"
Appendix D, Emission Estimation Methodology for Ocean Going Vessels, May 2011.
Data http://www.arb.ca.gov/msei/categories.htm#ogv_category

Load Factors for Main Engine based on Propeller Law Equation assuming 11 knots transit in river and 4 knots manuvering

Engine	Cruise	Transit	Maneuver
Propulsion	83%	37%	2%

At full cruise engines run at 83% of capacity with maximum speed of 15.3 knots

Propeller equation **$LF = (AS/MS)^3$**
where **LF** = Load Factor (percent)
AS = Actual Speed (knots)
MS = Maximum Speed (knots)

Number of ship call in 2028	26	
Percent of calls by Panamax	0	percent
Percent of call by Handymax	100	percent
Ship Berth Time ((Hoteling)	13	hrs
Main Ship (Manuvering)	1.0	hrs
Trannsit Time within Cowlitz county	0.90	hrs

Lower bound speeds in the open reaches of the Columbia River Channel are 12 knots, somewhat slower speeds when fully loaded (assumed 10 knots). See: Marine Traffic Technical Report, Feb 2015 , pages 37 and page 49.

Classification	DWT Range	Main Engine (kW)	Auxiliary Engine (kW)	Main Engine (hp)	Auxiliary Engine (kW)
HandyMax	40,000 - 60,000	7577	1407	10153.18	1885.38
PanaMax	60,000 - 100,000	12215	2268	16368.1	3039.12

Source: Sea-Web (http://www.sea-web.com)
The sea-web data is produced by IHS Global Limited, headquartered in Bracknell, England. The data is based on Lloyd's Register of Ships Sea-ewb provided shi characteristics data for shios over 100 gross tons.
Based on the ships currently in service (2014) that have stopped at US ports.

On-site		Full Operation (2028)		
Coal Throughput		48,501,697	tons/yr	
Ships/yr (Panamax)		0	number	
	Annual Power (aux eng)	-	hp-hrs/yr	0.1 %S Marine Distillate Fuel (2015 onward)
	Annual Power (main eng)	-	hp-hrs/yr	0.1 %S Marine Distillate Fuel
Ships/yr (Handymax)		26	number	
	Annual Power (aux eng)	85,785	hp-hrs/yr	0.1 %S Marine Distillate Fuel
	Annual Power (main eng)	5,280	hp-hrs/yr	0.1 %S Marine Distillate Fuel (or 1000 ppm)
Tugs/yr		78	number	
	Annual Power	290,160	hp-hrs/yr	diesel low sulfur (15 ppm S)
Off-site				
Ships/yr (Panamax)				
	Annual Power (main)	-	hp-hrs/yr	0.1 %S Marine Distillate Fuel
	(aux)	-		
Ships/yr (Handymax)				
	Annual Power (main)	176,733	hp-hrs/yr	0.1 %S Marine Distillate Fuel (or 1000 ppm)
	(aux)	15,079		

Low Speed Adjustment for Main Engine During Ship Manuvering
Based on the Propeller law used to estimate shps propulsion loads, based on law that the propulsion power varies by the cube of the speed. Transit speed was assumed to average 11 knots and maneuver speed 4 knots.

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2
2% load	54.8	41.9	23.6			2.34			2853.6
20% load	11.9	4.2	0.7			0.32			869.1
Adjustment Ratio Increase	4.6	10	31.6	1	7.29	7.29	7.29	31.62	3.28

Pollutant	Exponent (x)	Intercept (b)	Coefficient (a)	
PM	1.5	0.2551	0.0059	
NOx	1.5	10.4496	0.1255	
CO	1	0	0.8378	
HC	1.5	0	0.0667	
SO2			2.3735	only applies to fuel sulfur flow no adjustment for low loads
CO2	1	648.6	44.1	

Slow speed adjustment Ratio of emision rates at 20% load to manuvering Load 2%
emission rate (g/kW-hr) = a (fractional load)^-x + b

Source: USEPA, 2000. US Environmental Protection Agency, Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data, February, 2000, EPA420-R-00-002.

<u>Emission Factors</u>

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
Marine Engine Manuvering (g/KW-hr)	3.4	5.0	2.0	0.40	0.3041	0.25	0.23	0.00428	588	0.07	0.0004	590
Marine Engine Manuvering (lb/hp-hr))	0.006	0.00822	0.003	0.001	0.000000	0.000411	0.000378	0.000007	0.967	0.0001151	0.0000007	0.970
Aux Engine T4 Transit, Manuver , Hotel (g/KW-hr)	1.8	5.0	0.19	0.40	0.073	0.060	0.060	0.004	690.0	0.09	0.0004	692
Aux Engine T4 Transit, Manuver , Hotel (lb/hp-hr))	0.0030	0.0082	0.0003	0.0007	0.0001	0.0001	0.0001	0.00001	1.13	0.00015	0.00000	1.14
Main Engine Transit Mode (g/KW-hr)	3.4	5.0	2.0	0.40	0.3041	0.25	0.23	0.00428	588	0.07	0.0004	590
Main Engine Transit Mode (lb/hp-hr)	0.006	0.00822	0.00329	0.00066	0.00050	0.00041	0.00038	0.00001	0.967	0.000115	0.000001	0.970
Tug (Tier 4 compliant post 2016) (g/kW-hr)	1.8	5.0	0.19	0.40	0.073	0.060	0.060	0.004	690.0	0.09	0.0004	692
Tug (Tier 4 compliant post 2016) (lb/bhp-hr)	0.003	0.00822	0.00031	0.00066	0.00012	0.00010	0.00010	0.000007	1.13	0.00015	0.00000	1.14

g/kW-hr conversion to lb/hpr-hr 0.001644

Source:
ARB, 2011a. Initial Statement of Reasons for Proposed Rulemaking, Proposed Amendments to the Regulations "Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline"
Appendix D, Emission Estimation Methodology for Ocean Going Vessels, May 2011. Tables II-6, II-7 (main engines) and Table II-8 Auxilary Engine only for PM10, PM2.5 and CO2;
Other Emissions Factros from USEPA Marine Compression Ignition Exhaust Emission Standards for highest Tier engines (auxillary and Tugs C2; main engine C3) all standars fully impletemented by 2016 assume all engines by 2028 comply with these standards
For C3 engines assume lowest engine speed which corresponds with highest emission rate See: http://www.epa.gov/otaq/standards/nonroad/marineci.htm

HAP Emission factors from: *EPA AP-42, Section 3.4;* Sum of HAPs factors from Table 3.4-3 and 3.4-4.
Global Warming Potentials (GWPs): CO_2 - 1
CH_4 - 25
N_2O - 298

Travel Distance:
Ship Miles 11.35 miles Travel distance from berth site in Longview, west along Columbia River to Cowlitz County line (one-way)

<u>Emission Rates (tpy)</u>

	NO_x	CO	VOC	SO_2	TSP	PM_{10}	$PM_{2.5}$	HAPS	CO2	CH4	N2O	CO2e
2028 Operational Emissions Marine Vessels												
Ships (Cargo and Tugs) - (Onsite)	0.6	1.8	0.3	0.1	0.02	0.03	0.03	0.00	221.61	0.03	0.00	222.4
Ships (cargo transit) - (Offsite)	0.5	0.8	0.3	0.1	0.05	0.04	0.03	0.00	93.97	0.01	0.00	94.3
Total	1.1	2.6	0.63	0.19	0.07	0.06	0.06	0.003	315.6	0.04	0.0002	316.6

Material Haul Traffic MTBL to Weyerhauser

		Number	Miles (RT)[1]	miles/year
Haul Trucks				
	SR432 @ 35mph	104,862	2.0	209,725

	Full Build-Out		
Coal Moved	2,673,990	tons/yr	
Carrying Capacity of Haul Truck	51000	lbs/load	Based on 77,000 lb GVWR for a 26,000 lb curb weight haul truck Large Capacity Dump Truck
Loads per year	104,862	trips per year	
	287	trips per day	
Round trip distance	2.0	miles	Weyerhauser to Milleneum

Project Year	NOx	PM10	PM2.5	SO2	CO	VOC	CO2	CH4	N2O	CO2eq	HAP	
2028												
Construction Annual				**T/year**								
Combo Short Haul Truck @ 35mph	0.23	0.04	0.01	0.00	0.10	0.02	237.87	0.01	0.00	238.41		0.001
Total:	0.23	0.04	0.01	0.002	0.10	0.02	237.87	0.01	0.00	238.41		

Factors:	
453.59	g/lb
2000	lbs/ton
5280	ft/mile
3.78541	l/gal
Global Warming Potentials (GWPs):	CO_2 - 1
	CH_4 - 25
	N_2O - 298

MOVES factors (g/mile) for surrogate idle were based on 2.5 mi/hr travel. So to get g/hr, multiply by 2.5 mi/hr. For onsite/idle, assume 0.25 hr. So factor is 2.5/.25 to get grams/trip.

mi/hr	2.5
hr	0.25
factor for 1/2 hr idle/trip	10

Mobile Source - Moves run for Cowlitz County, WY, 2028
Emission factors for Truck Exhaust

Emission factors for Truck Exhaust Emission Factors (gm/mile)												
Project Year	**NOx**	**PM10**	**PM2.5**	**SO2**	**CO**	**VOC**	**CO2**	**CH_4**	**N_2O**	**Benzene**	**Form**	**CO2eq**
2018												
Short Haul Combo - diesel @ 35mph (Urban un-restricted)	9.82E-01	1.71E-01	4.41E-02	8.86E-03	4.38E-01	9.24E-02	1.03E+03	6.01E-02	2.77E-03	9.16E-04	1.41E-02	1.03E+03
Short Haul Combo - diesel @ idle (Rural unrestricted)	6.00	0.42	0.24	0.02	1.48	0.35	1927.59	0.06	0.00	0.00	0.03	1930.06

APPENDIX J
OPERATIONS AND MAINTENANCE EQUIPMENT

Equipment Information

Equipment Type	Estimated Engine Size (hp)	Fuel	Number of Units Full Build-Out	EPA SCC Number	EPA NONROAD model combustion emission factor (tons/yr per unit) THC-Exhaust	CO-Exhaust	NOx-Exhaust	CO2-Exhaust	SO2-Exhaust	PM-Exhaust
Loader (miscellaneous use)	300	Diesel	1	2270002060	2.81E-01	1.14E+00	3.47E+00	7.40E+02	1.42E-01	2.96E-01
Bobcat (sump cleaning)	50	Diesel	2	2270002057	7.50E-03	4.18E-02	1.29E-01	1.83E+01	3.60E-03	8.27E-03
10-Ton Truck (sump cleaning)	300	Diesel	2	2270002051	3.06E-02	9.01E-02	3.12E-01	1.09E+02	1.86E-02	3.49E-02
Crane (miscellaneous use)	50	Diesel	1	2270002045	1.27E-05	6.42E-05	2.24E-04	3.15E-02	6.15E-06	1.34E-05
Forklift (miscellaneous use)	40	Propane	1	2267002057	5.20E-05	1.84E-03	2.95E-04	1.52E-01	2.95E-06	1.60E-05
Maintenance Trucks (eg. Ford F150)	300	Gasoline	4	2265003070	1.14E-04	4.20E-03	3.12E-04	2.11E-01	4.36E-05	2.16E-05

Note:
For PM_{10}, $PM_{2.5}$, and HAPs, use same emission ratio as emission factor ratios for Large Diesel Engines (see Construction worksheet): PM_{10} and $PM_{2.5}$ ratio to TSP, and; HAPs ratio to CO.

Annual Emissions (tpy)

Full Build-Out (tpy)	NO_x	CO	VOC	SO_2	TSP	PM10	PM2.5	HAPS	CO2e
Loader (miscellaneous use)	3.47	1.14	0.28	0.14	0.30	0.24	0.24	0.01	740
Bobcat (sump cleaning)	0.26	0.08	0.01	0.01	0.02	0.01	0.01	0.00	37
10-Ton Truck (sump cleaning)	0.62	0.18	0.06	0.04	0.07	0.06	0.06	0.00	218
Crane (miscellaneous use)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Forklift (miscellaneous use)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Maintenance Trucks (eg. Ford F150)	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	1
Full Build-Out Total (tpy)	4.36	1.42	0.36	0.19	0.38	0.31	0.31	0.01	996

APPENDIX J
OPERATIONS AND MAINTENANCE EQUIPMENT

Equipment Information

Equipment Type	Estimated Engine Size (hp)	Fuel	Number of Units Full Build-Out	EPA SCC Number	EPA NONROAD model combustion emission factor (tons/yr per unit) THC-Exhaust	CO-Exhaust	NOx-Exhaust	CO2-Exhaust	SO2-Exhaust	PM-Exhaust
Loader (miscellaneous use)	300	Diesel	1	2270002060	2.81E-01	1.14E+00	3.47E+00	7.40E+02	1.42E-01	2.96E-01
Bobcat (sump cleaning)	50	Diesel	2	2270002057	7.50E-03	4.18E-02	1.29E-01	1.83E+01	3.60E-03	8.27E-03
10-Ton Truck (sump cleaning)	300	Diesel	2	2270002051	3.06E-02	9.01E-02	3.12E-01	1.09E+02	1.86E-02	3.49E-02
Crane (miscellaneous use)	50	Diesel	1	2270002045	1.27E-05	6.42E-05	2.24E-04	3.15E-02	6.15E-06	1.34E-05
Forklift (miscellaneous use)	40	Propane	0	2267002057	5.20E-05	1.84E-03	2.95E-04	1.52E-01	2.95E-06	1.60E-05
Maintenance Trucks (eg. Ford F150)	300	Gasoline	0	2265003070	1.14E-04	4.20E-03	3.12E-04	2.11E-01	4.36E-05	2.16E-05

Note:
For PM_{10}, $PM_{2.5}$, and HAPs, use same emission ratio as emission factor ratios for Large Diesel Engines (see Construction worksheet): PM_{10} and $PM_{2.5}$ ratio to TSP, and; HAPs ratio to CO.

Annual Emissions (tpy)

Full Build-Out (tpy)	NO_x	CO	VOC	SO_2	TSP	PM10	PM2.5	HAPS	CO2e
Loader (miscellaneous use)	3.47	1.14	0.28	0.14	0.30	0.24	0.24	0.01	740
Bobcat (sump cleaning)	0.26	0.08	0.01	0.01	0.02	0.01	0.01	0.00	37
10-Ton Truck (sump cleaning)	0.62	0.18	0.06	0.04	0.07	0.06	0.06	0.00	218
Crane (miscellaneous use)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Forklift (miscellaneous use)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Maintenance Trucks (eg. Ford F150)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Full Build-Out Total (tpy)	4.36	1.40	0.36	0.19	0.38	0.31	0.31	0.01	995

APPENDIX K

Washington State Emissions in tons per year

2011 Emissions Inventory

COWLITZ COUNTY EMISSIONS							
Category	**CO**	**NOx**	**PM10**	**PM2.5**	**DSPM2.5**	**SO2**	**VOC**
AIR	125	2	3	2		0	4
BOAT	887	74	5	5	0	0	298
CONS							549
CONST			523	55			
F_COMM	6	2	5	5		0	0
F_RES	5	13	0	0	0	3	1
FERT							
FIRE	68	1	7	6		1	16
FOOD	14		35	33			5
GAS_TRANS							696
GASSTN							138
LIVE							
MISC	8	1	2	2		0	2
NAT	3,361	59					11,443
NRM	3,718	389	48	46	24	1	592
OB_nonRES	117	6	24	21		0	7
OB_Res	162	8	38	33		1	22
ORM	22,852	4,281	157	130	83	13	1,649
POTW							2
PT	2,507	3,616	182	172	0	791	671
ROADS			381	93			
RR	137	789	23	23	23	6	43
RWC	2,026	31	290	290		5	346
SHIP	150	1,109	37	34	34	199	46
SOLV							390
TILL_HARV			109	22			
Total	**36,142**	**10,382**	**1,872**	**971**	**164**	**1,020**	**16,919**

Source: Compiled from data in Ecology's *Washington State 2011 County Emissions Inventory* (April 25, 2014)
(http://www.ecy.wa.gov/programs/air/EmissionInventory/AirEmissionInventory.htm

NOTES:

1) Source Category Abbreviations

Abbreviation	**Source Category Description**
AIR	Aircraft: military, commercial, general aviation
BOAT	Recreational boats
CONS	Commercial and consumer solvents
CONST	Construction
F_COMM	Commercial fuel use: natural gas, oil, LPG
F_RES	Residential fuel use: natural gas, oil, LPG
FERT	Fertilizer application
FIRE	Wildfires
FOOD	Food and Kindred Products
GAS_TRANS	Aviation gas storage and transport, petroleum gas cans, bulk plants, and truck transport
GASSTN	Gasoline stations
LIVE	Livestock wastes
MISC	Structure and motor vehicle fires, Cremation, Dental alloy production, Bench scale reagents, Fluorescent lamps
NAT	Natural emissions from soil and vegetation
NRM	Nonroad mobile except locomotives
OB_nonRES	Agricultural and silvicultural burning
OB_Res	Residential outdoor burning: yard waste, trash
ORM	Onroad mobile sources
POTW	Publicly owned treatment works
PT	Point sources
ROADS	Paved and unpaved road dust
RR	Locomotives

RWC	Woodstoves, fireplaces, inserts
SHIP	Commercial marine vessels
SOLV	Dry cleaning, graphic arts, surface coating: industrial
TILL_HARV	Agricultural tilling and harvesting

2) Pollutant Abbreviations

Abbreviation	Pollutant Name
PM10	particulate matter less than or equal to 10 microns in diameter
PM2.5	particulate matter less than or equal to 2.5 microns in diameter
DSPM 2.5	particulate matter less than or equal to 2.5 microns in diameter from diesel combustion
SO2	sulfur dioxide
NOx	nitrogen oxides
VOC	volatile organic hydrocarbons
CO	carbon monoxide

Sum of emisRate - 55 mph				Pollutant
				PM2.5 Tirewear
RoadType	yearID	FuelType	SourceType	g/mi
Rural Restricted Access	2018	Diesel Fuel	Combination Long-haul Truck	3.90E-03
			Combination Short-haul Truck	3.51E-03
			Intercity Bus	3.09E-03
			Passenger Car	1.03E-03
			Passenger Truck	1.29E-03
			School Bus	1.88E-03
			Single Unit Long-haul Truck	2.21E-03
			Single Unit Short-haul Truck	2.00E-03
			Transit Bus	2.06E-03
			Motor Home	1.67E-03
			Refuse Truck	3.75E-03
			Light Commercial Truck	1.25E-03
		Gasoline	Combination Short-haul Truck	1.92E-03
			Motorcycle	5.15E-04
			Passenger Car	1.03E-03
			Passenger Truck	1.04E-03
			School Bus	1.88E-03
			Single Unit Long-haul Truck	1.52E-03
			Single Unit Short-haul Truck	1.52E-03
			Transit Bus	3.02E-03
			Motor Home	1.67E-03
			Refuse Truck	1.52E-03
			Light Commercial Truck	1.05E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.06E-03
		Ethanol (E-85)	Passenger Car	1.03E-03
			Passenger Truck	1.03E-03
			Light Commercial Truck	1.03E-03
Rural Unrestricted Acces	2018	Diesel Fuel	Combination Long-haul Truck	4.26E-03
			Combination Short-haul Truck	3.83E-03
			Intercity Bus	3.51E-03
			Passenger Car	1.17E-03
			Passenger Truck	1.46E-03
			School Bus	2.13E-03
			Single Unit Long-haul Truck	2.51E-03
			Single Unit Short-haul Truck	2.27E-03
			Transit Bus	2.34E-03
			Motor Home	1.90E-03
			Refuse Truck	4.26E-03
			Light Commercial Truck	1.42E-03
		Gasoline	Combination Short-haul Truck	2.10E-03
			Motorcycle	5.85E-04
			Passenger Car	1.17E-03

			Passenger Truck	1.18E-03
			School Bus	2.13E-03
			Single Unit Long-haul Truck	1.73E-03
			Single Unit Short-haul Truck	1.73E-03
			Transit Bus	3.43E-03
			Motor Home	1.90E-03
			Refuse Truck	1.73E-03
			Light Commercial Truck	1.20E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.34E-03
		Ethanol (E-85)	Passenger Car	1.17E-03
			Passenger Truck	1.17E-03
			Light Commercial Truck	1.17E-03
Urban Restricted Access	2018	Diesel Fuel	Combination Long-haul Truck	4.13E-03
			Combination Short-haul Truck	3.71E-03
			Intercity Bus	3.28E-03
			Passenger Car	1.09E-03
			Passenger Truck	1.37E-03
			School Bus	1.99E-03
			Single Unit Long-haul Truck	2.34E-03
			Single Unit Short-haul Truck	2.12E-03
			Transit Bus	2.19E-03
			Motor Home	1.77E-03
			Refuse Truck	3.99E-03
			Light Commercial Truck	1.33E-03
		Gasoline	Combination Short-haul Truck	2.03E-03
			Motorcycle	5.47E-04
			Passenger Car	1.09E-03
			Passenger Truck	1.10E-03
			School Bus	1.99E-03
			Single Unit Long-haul Truck	1.62E-03
			Single Unit Short-haul Truck	1.61E-03
			Transit Bus	3.21E-03
			Motor Home	1.77E-03
			Refuse Truck	1.62E-03
			Light Commercial Truck	1.12E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.19E-03
		Ethanol (E-85)	Passenger Car	1.09E-03
			Passenger Truck	1.09E-03
			Light Commercial Truck	1.09E-03
Urban Unrestricted Acces	2018	Diesel Fuel	Combination Long-haul Truck	4.61E-03
			Combination Short-haul Truck	4.14E-03
			Intercity Bus	3.80E-03
			Passenger Car	1.27E-03
			Passenger Truck	1.58E-03
			School Bus	2.31E-03

	Single Unit Long-haul Truck	2.71E-03
	Single Unit Short-haul Truck	2.46E-03
	Transit Bus	2.53E-03
	Motor Home	2.05E-03
	Refuse Truck	4.61E-03
	Light Commercial Truck	1.54E-03
Gasoline	Combination Short-haul Truck	2.27E-03
	Motorcycle	6.33E-04
	Passenger Car	1.27E-03
	Passenger Truck	1.27E-03
	School Bus	2.30E-03
	Single Unit Long-haul Truck	1.87E-03
	Single Unit Short-haul Truck	1.87E-03
	Transit Bus	3.72E-03
	Motor Home	2.05E-03
	Refuse Truck	1.87E-03
	Light Commercial Truck	1.30E-03
Compressed Natural Gas (CNG)	Transit Bus	2.53E-03
Ethanol (E-85)	Passenger Car	1.27E-03
	Passenger Truck	1.27E-03
	Light Commercial Truck	1.27E-03

RateUnit

PM2.5 Brakewear	PM10 Tirewear	PM10 Brakewear	PM10 Total Exh	VOC	SO2	NOx
g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi
4.90E-03	2.60E-02	3.92E-02	2.15E-01	2.52E-01	1.44E-02	5.75E+00
4.65E-03	2.34E-02	3.72E-02	1.58E-01	2.02E-01	1.36E-02	4.63E+00
4.08E-03	2.06E-02	3.26E-02	3.44E-01	4.29E-01	1.44E-02	9.54E+00
7.37E-04	6.86E-03	5.89E-03	3.82E-03	1.98E-02	2.49E-03	1.10E-01
1.13E-03	8.58E-03	9.04E-03	3.71E-02	1.18E-01	5.04E-03	9.23E-01
4.17E-03	1.25E-02	3.34E-02	2.65E-01	5.10E-01	9.18E-03	5.52E+00
4.35E-03	1.47E-02	3.48E-02	8.92E-02	1.85E-01	7.25E-03	1.85E+00
3.87E-03	1.33E-02	3.10E-02	1.07E-01	2.09E-01	7.81E-03	2.26E+00
2.61E-03	1.37E-02	2.09E-02	3.06E-01	4.38E-01	1.31E-02	7.76E+00
3.11E-03	1.11E-02	2.49E-02	1.75E-01	3.57E-01	8.84E-03	3.63E+00
4.49E-03	2.50E-02	3.59E-02	1.68E-01	2.03E-01	1.40E-02	4.63E+00
1.19E-03	8.33E-03	9.55E-03	4.39E-02	1.36E-01	4.72E-03	9.54E-01
3.24E-03	1.28E-02	2.59E-02	3.61E-01	2.47E+00	9.98E-03	1.10E+01
5.67E-05	3.43E-03	4.54E-04	3.59E-02	5.46E-01	2.63E-03	8.78E-01
7.37E-04	6.86E-03	5.89E-03	6.87E-03	3.39E-02	1.92E-03	1.89E-01
1.18E-03	6.91E-03	9.48E-03	9.46E-03	7.07E-02	2.56E-03	3.77E-01
4.17E-03	1.25E-02	3.33E-02	1.96E-01	1.28E+00	6.89E-03	5.86E+00
2.97E-03	1.02E-02	2.37E-02	2.09E-01	7.73E-01	6.08E-03	4.63E+00
2.91E-03	1.01E-02	2.32E-02	4.58E-02	1.95E-01	6.25E-03	1.07E+00
4.21E-03	2.02E-02	3.37E-02	6.01E-02	3.61E-01	9.13E-03	1.50E+00
3.11E-03	1.11E-02	2.49E-02	1.09E-01	5.31E-01	6.77E-03	2.49E+00
1.93E-03	1.01E-02	1.54E-02	2.33E-01	8.36E-01	9.93E-03	5.16E+00
1.24E-03	7.03E-03	9.92E-03	8.41E-03	5.84E-02	2.50E-03	3.36E-01
2.61E-03	1.37E-02	2.09E-02	6.65E-02	4.35E-01	7.16E-03	4.23E+00
7.37E-04	6.86E-03	5.89E-03	2.85E-03	1.96E-02	2.17E-03	7.68E-02
1.19E-03	6.86E-03	9.49E-03	3.93E-03	3.09E-02	2.77E-03	1.29E-01
1.25E-03	6.86E-03	9.96E-03	3.57E-03	2.86E-02	2.69E-03	1.20E-01
7.50E-03	2.84E-02	6.00E-02	2.21E-01	2.77E-01	1.42E-02	5.78E+00
7.03E-03	2.55E-02	5.63E-02	1.60E-01	2.20E-01	1.33E-02	4.58E+00
6.81E-03	2.34E-02	5.45E-02	3.54E-01	4.85E-01	1.36E-02	9.09E+00
1.30E-03	7.80E-03	1.04E-02	2.82E-03	1.54E-02	2.42E-03	9.03E-02
2.01E-03	9.74E-03	1.61E-02	3.76E-02	1.24E-01	4.95E-03	9.00E-01
5.95E-03	1.42E-02	4.76E-02	2.70E-01	5.54E-01	7.50E-03	4.50E+00
6.29E-03	1.67E-02	5.03E-02	9.30E-02	2.12E-01	6.32E-03	1.69E+00
5.63E-03	1.51E-02	4.50E-02	1.13E-01	2.41E-01	6.88E-03	2.08E+00
4.28E-03	1.56E-02	3.42E-02	2.86E-01	4.54E-01	1.14E-02	6.85E+00
4.62E-03	1.27E-02	3.69E-02	1.89E-01	4.12E-01	7.30E-03	3.07E+00
7.54E-03	2.84E-02	6.03E-02	1.67E-01	2.25E-01	1.30E-02	4.41E+00
2.04E-03	9.47E-03	1.63E-02	4.52E-02	1.46E-01	4.71E-03	9.40E-01
4.70E-03	1.40E-02	3.76E-02	2.41E-01	2.43E+00	9.70E-03	1.06E+01
1.07E-04	3.90E-03	8.58E-04	2.45E-02	5.69E-01	2.54E-03	8.85E-01
1.30E-03	7.80E-03	1.04E-02	4.60E-03	2.95E-02	1.87E-03	1.65E-01

2.10E-03	7.85E-03	1.68E-02	5.66E-03	6.15E-02	2.47E-03	3.21E-01
5.95E-03	1.42E-02	4.76E-02	6.57E-02	1.07E+00	5.69E-03	4.79E+00
4.11E-03	1.15E-02	3.29E-02	2.36E-02	6.60E-01	5.31E-03	4.18E+00
4.10E-03	1.15E-02	3.28E-02	1.08E-02	1.71E-01	5.55E-03	9.75E-01
6.79E-03	2.29E-02	5.44E-02	2.83E-02	3.35E-01	8.01E-03	1.31E+00
4.62E-03	1.27E-02	3.69E-02	2.28E-02	4.40E-01	5.73E-03	2.17E+00
3.07E-03	1.15E-02	2.46E-02	1.01E-01	8.31E-01	9.33E-03	4.92E+00
2.11E-03	7.98E-03	1.69E-02	5.44E-03	5.23E-02	2.47E-03	2.96E-01
4.28E-03	1.56E-02	3.42E-02	4.72E-02	4.01E-01	6.28E-03	3.70E+00
1.30E-03	7.80E-03	1.04E-02	2.02E-03	1.62E-02	2.12E-03	6.38E-02
2.11E-03	7.80E-03	1.69E-02	2.48E-03	2.44E-02	2.68E-03	9.86E-02
2.12E-03	7.80E-03	1.70E-02	2.44E-03	2.35E-02	2.65E-03	9.46E-02
7.21E-03	2.75E-02	5.77E-02	2.27E-01	2.66E-01	1.44E-02	5.77E+00
6.76E-03	2.47E-02	5.40E-02	1.66E-01	2.13E-01	1.36E-02	4.61E+00
5.73E-03	2.19E-02	4.58E-02	3.59E-01	4.55E-01	1.42E-02	9.39E+00
1.03E-03	7.29E-03	8.21E-03	3.78E-03	1.88E-02	2.49E-03	1.03E-01
1.58E-03	9.11E-03	1.26E-02	3.80E-02	1.22E-01	5.03E-03	9.23E-01
5.33E-03	1.33E-02	4.26E-02	2.81E-01	5.48E-01	9.02E-03	5.36E+00
5.42E-03	1.56E-02	4.33E-02	9.48E-02	1.98E-01	7.42E-03	1.90E+00
4.84E-03	1.42E-02	3.87E-02	1.14E-01	2.25E-01	7.93E-03	2.30E+00
3.68E-03	1.46E-02	2.95E-02	3.17E-01	4.59E-01	1.29E-02	7.62E+00
3.93E-03	1.18E-02	3.15E-02	1.86E-01	3.85E-01	8.70E-03	3.56E+00
6.43E-03	2.66E-02	5.14E-02	1.76E-01	2.14E-01	1.38E-02	4.58E+00
1.65E-03	8.85E-03	1.32E-02	4.51E-02	1.42E-01	4.72E-03	9.54E-01
4.48E-03	1.35E-02	3.59E-02	3.47E-01	2.58E+00	1.00E-02	1.08E+01
8.12E-05	3.65E-03	6.50E-04	3.67E-02	5.62E-01	2.60E-03	8.75E-01
1.03E-03	7.29E-03	8.21E-03	6.87E-03	3.32E-02	1.92E-03	1.81E-01
1.66E-03	7.35E-03	1.33E-02	9.43E-03	6.84E-02	2.53E-03	3.57E-01
5.33E-03	1.33E-02	4.26E-02	1.86E-01	1.32E+00	6.90E-03	5.81E+00
3.58E-03	1.08E-02	2.87E-02	2.14E-01	8.40E-01	6.24E-03	4.72E+00
3.55E-03	1.08E-02	2.84E-02	4.64E-02	2.11E-01	6.39E-03	1.09E+00
5.87E-03	2.14E-02	4.70E-02	5.84E-02	3.76E-01	9.08E-03	1.49E+00
3.93E-03	1.18E-02	3.15E-02	1.10E-01	5.57E-01	6.78E-03	2.49E+00
2.61E-03	1.08E-02	2.09E-02	2.32E-01	8.97E-01	9.92E-03	5.17E+00
1.72E-03	7.46E-03	1.37E-02	8.26E-03	5.66E-02	2.49E-03	3.18E-01
3.68E-03	1.46E-02	2.95E-02	6.61E-02	4.50E-01	7.12E-03	4.20E+00
1.03E-03	7.29E-03	8.21E-03	2.83E-03	1.89E-02	2.17E-03	7.25E-02
1.66E-03	7.29E-03	1.33E-02	3.91E-03	2.91E-02	2.75E-03	1.18E-01
1.72E-03	7.29E-03	1.38E-02	3.50E-03	2.69E-02	2.67E-03	1.09E-01
1.40E-02	3.07E-02	1.12E-01	2.54E-01	3.17E-01	1.47E-02	6.07E+00
1.28E-02	2.76E-02	1.03E-01	1.83E-01	2.52E-01	1.38E-02	4.78E+00
1.21E-02	2.53E-02	9.68E-02	4.05E-01	5.55E-01	1.42E-02	9.43E+00
2.01E-03	8.43E-03	1.61E-02	2.89E-03	1.54E-02	2.54E-03	8.58E-02
3.13E-03	1.05E-02	2.51E-02	4.03E-02	1.39E-01	5.13E-03	9.59E-01
8.19E-03	1.54E-02	6.55E-02	3.01E-01	6.23E-01	7.74E-03	4.68E+00

9.74E-03	1.81E-02	7.79E-02	1.07E-01	2.47E-01	7.11E-03	1.92E+00
8.67E-03	1.64E-02	6.94E-02	1.30E-01	2.81E-01	7.68E-03	2.34E+00
6.72E-03	1.69E-02	5.37E-02	3.13E-01	4.96E-01	1.14E-02	7.03E+00
6.92E-03	1.37E-02	5.53E-02	2.16E-01	4.82E-01	7.97E-03	3.37E+00
1.30E-02	3.08E-02	1.04E-01	1.92E-01	2.55E-01	1.35E-02	4.62E+00
3.19E-03	1.02E-02	2.55E-02	4.87E-02	1.64E-01	4.88E-03	1.00E+00
7.97E-03	1.51E-02	6.38E-02	2.41E-01	2.80E+00	1.02E-02	1.08E+01
1.72E-04	4.22E-03	1.37E-03	2.35E-02	6.17E-01	2.50E-03	8.45E-01
2.01E-03	8.43E-03	1.61E-02	4.67E-03	3.12E-02	1.97E-03	1.61E-01
3.30E-03	8.50E-03	2.64E-02	5.46E-03	6.40E-02	2.56E-03	3.07E-01
8.19E-03	1.54E-02	6.55E-02	6.23E-02	1.23E+00	5.84E-03	4.71E+00
6.02E-03	1.25E-02	4.82E-02	2.43E-02	8.46E-01	5.74E-03	4.32E+00
6.05E-03	1.25E-02	4.84E-02	1.06E-02	2.18E-01	6.01E-03	1.01E+00
1.05E-02	2.48E-02	8.42E-02	2.76E-02	3.82E-01	8.14E-03	1.31E+00
6.92E-03	1.37E-02	5.53E-02	2.18E-02	5.40E-01	6.11E-03	2.23E+00
4.84E-03	1.25E-02	3.87E-02	1.03E-01	1.04E+00	9.81E-03	5.07E+00
3.32E-03	8.63E-03	2.65E-02	5.23E-03	5.49E-02	2.56E-03	2.83E-01
6.72E-03	1.69E-02	5.37E-02	4.56E-02	4.51E-01	6.39E-03	3.68E+00
2.01E-03	8.43E-03	1.61E-02	2.07E-03	1.64E-02	2.22E-03	6.08E-02
3.30E-03	8.43E-03	2.64E-02	2.40E-03	2.41E-02	2.78E-03	9.10E-02
3.33E-03	8.43E-03	2.67E-02	2.35E-03	2.31E-02	2.75E-03	8.72E-02

CO g/mi	Methane (CH4) g/mi	N2O g/mi	Benzene g/mi	Formaldehyde g/mi	CO2 Equivalent g/mi	PM2.5 Total Exh g/mi	NOx
1.27E+00	2.77E-02	1.42E-03	1.90E-03	2.12E-02	1.64E+03	1.98E-01	5.75E+00
1.01E+00	2.92E-02	1.42E-03	1.53E-03	1.76E-02	1.56E+03	1.45E-01	4.63E+00
1.96E+00	2.04E-02	1.36E-03	3.25E-03	3.41E-02	1.61E+03	3.17E-01	9.54E+00
1.85E+00	8.79E-03	2.77E-04	1.78E-04	2.49E-03	2.87E+02	3.52E-03	1.10E-01
1.76E+00	1.99E-02	1.04E-03	9.80E-04	1.14E-02	5.78E+02	3.41E-02	9.23E-01
1.55E+00	2.30E-02	1.36E-03	3.97E-03	4.14E-02	1.03E+03	2.44E-01	5.52E+00
6.85E-01	3.03E-02	1.36E-03	1.51E-03	1.75E-02	8.34E+02	8.21E-02	1.85E+00
7.94E-01	3.01E-02	1.36E-03	1.70E-03	1.94E-02	8.95E+02	9.84E-02	2.26E+00
2.46E+00	2.46E-02	1.36E-03	3.36E-03	3.55E-02	1.49E+03	2.82E-01	7.76E+00
1.16E+00	2.65E-02	1.36E-03	2.80E-03	3.01E-02	1.00E+03	1.61E-01	3.63E+00
9.91E-01	2.75E-02	1.36E-03	1.52E-03	1.74E-02	1.60E+03	1.55E-01	4.63E+00
1.91E+00	1.81E-02	9.49E-04	1.12E-03	1.26E-02	5.39E+02	4.04E-02	9.54E-01
1.27E+02	1.33E-01	1.34E-02	8.09E-02	3.10E-02	1.51E+03	3.19E-01	1.10E+01
1.32E+01	2.33E-02	1.41E-03	2.34E-02	8.41E-03	3.96E+02	3.18E-02	8.78E-01
2.53E+00	3.39E-03	8.62E-04	1.17E-03	4.33E-04	2.89E+02	6.08E-03	1.89E-01
4.09E+00	5.68E-03	1.51E-03	2.51E-03	9.27E-04	3.85E+02	8.37E-03	3.77E-01
5.19E+01	6.10E-02	1.15E-02	4.18E-02	1.59E-02	1.04E+03	1.73E-01	5.86E+00
2.85E+01	2.57E-02	1.81E-02	2.46E-02	9.31E-03	9.21E+02	1.85E-01	4.63E+00
7.75E+00	3.97E-03	4.94E-03	6.27E-03	2.27E-03	9.41E+02	4.05E-02	1.07E+00
1.33E+01	7.56E-03	5.08E-03	1.00E-02	3.59E-03	1.37E+03	5.32E-02	1.50E+00
2.18E+01	1.62E-02	8.72E-03	1.68E-02	6.25E-03	1.02E+03	9.65E-02	2.49E+00
3.49E+01	2.23E-02	2.08E-02	2.54E-02	9.51E-03	1.50E+03	2.06E-01	5.16E+00
3.71E+00	5.23E-03	1.52E-03	2.09E-03	7.66E-04	3.77E+02	7.44E-03	3.36E-01
7.37E+00	3.90E+00	2.76E-02	6.92E-04	1.93E-01	1.46E+03	5.89E-02	4.23E+00
1.62E+00	5.40E-03	6.37E-04	3.56E-04	4.39E-04	2.83E+02	2.52E-03	7.68E-02
2.16E+00	9.95E-03	8.43E-04	5.84E-04	7.26E-04	3.61E+02	3.47E-03	1.29E-01
1.95E+00	9.01E-03	8.40E-04	5.38E-04	6.59E-04	3.50E+02	3.16E-03	1.20E-01
1.35E+00	3.17E-02	1.66E-03	2.11E-03	2.37E-02	1.61E+03	2.04E-01	5.78E+00
1.07E+00	3.35E-02	1.66E-03	1.70E-03	1.97E-02	1.52E+03	1.47E-01	4.58E+00
2.11E+00	2.42E-02	1.66E-03	3.72E-03	3.90E-02	1.52E+03	3.25E-01	9.09E+00
1.15E+00	6.09E-03	3.38E-04	1.32E-04	1.81E-03	2.79E+02	2.60E-03	9.03E-02
1.32E+00	1.99E-02	1.26E-03	1.03E-03	1.19E-02	5.68E+02	3.46E-02	9.00E-01
1.58E+00	2.55E-02	1.66E-03	4.35E-03	4.54E-02	8.42E+02	2.48E-01	4.50E+00
7.56E-01	3.58E-02	1.66E-03	1.75E-03	2.04E-02	7.26E+02	8.56E-02	1.69E+00
8.78E-01	3.56E-02	1.66E-03	1.98E-03	2.27E-02	7.88E+02	1.04E-01	2.08E+00
2.38E+00	2.73E-02	1.66E-03	3.52E-03	3.73E-02	1.29E+03	2.63E-01	6.85E+00
1.28E+00	3.15E-02	1.66E-03	3.27E-03	3.52E-02	8.28E+02	1.74E-01	3.07E+00
1.07E+00	3.26E-02	1.66E-03	1.74E-03	2.00E-02	1.49E+03	1.54E-01	4.41E+00
1.48E+00	1.75E-02	1.16E-03	1.19E-03	1.33E-02	5.37E+02	4.16E-02	9.40E-01
1.18E+02	1.31E-01	1.57E-02	7.97E-02	3.06E-02	1.47E+03	2.13E-01	1.06E+01
1.33E+01	2.44E-02	1.72E-03	2.44E-02	8.79E-03	3.83E+02	2.17E-02	8.85E-01
1.65E+00	2.52E-03	1.05E-03	9.86E-04	3.65E-04	2.82E+02	4.07E-03	1.65E-01

2.68E+00	4.02E-03	1.84E-03	2.12E-03	7.84E-04	3.73E+02	5.01E-03	3.21E-01
3.51E+01	5.07E-02	1.40E-02	3.49E-02	1.33E-02	8.61E+02	5.81E-02	4.79E+00
2.12E+01	2.17E-02	2.21E-02	2.10E-02	7.93E-03	8.06E+02	2.09E-02	4.18E+00
6.48E+00	3.44E-03	6.03E-03	5.51E-03	1.99E-03	8.36E+02	9.60E-03	9.75E-01
1.14E+01	7.02E-03	6.20E-03	9.57E-03	3.44E-03	1.21E+03	2.50E-02	1.31E+00
1.56E+01	1.32E-02	1.06E-02	1.39E-02	5.17E-03	8.65E+02	2.02E-02	2.17E+00
3.26E+01	2.18E-02	2.53E-02	2.55E-02	9.55E-03	1.41E+03	8.90E-02	4.92E+00
2.63E+00	3.91E-03	1.85E-03	1.82E-03	6.68E-04	3.72E+02	4.81E-03	2.96E-01
6.38E+00	3.67E+00	3.37E-02	6.46E-04	1.75E-01	1.29E+03	4.17E-02	3.70E+00
1.02E+00	3.88E-03	7.77E-04	2.71E-04	3.30E-04	2.75E+02	1.78E-03	6.38E-02
1.30E+00	6.70E-03	1.03E-03	4.27E-04	5.23E-04	3.49E+02	2.20E-03	9.86E-02
1.24E+00	6.32E-03	1.03E-03	4.08E-04	4.93E-04	3.45E+02	2.16E-03	9.46E-02
1.32E+00	3.02E-02	1.57E-03	2.02E-03	2.26E-02	1.63E+03	2.08E-01	5.77E+00
1.05E+00	3.18E-02	1.56E-03	1.63E-03	1.88E-02	1.55E+03	1.53E-01	4.61E+00
2.04E+00	2.22E-02	1.49E-03	3.46E-03	3.63E-02	1.59E+03	3.30E-01	9.39E+00
1.77E+00	8.10E-03	3.05E-04	1.67E-04	2.32E-03	2.87E+02	3.48E-03	1.03E-01
1.71E+00	2.04E-02	1.14E-03	1.02E-03	1.18E-02	5.76E+02	3.49E-02	9.23E-01
1.64E+00	2.51E-02	1.49E-03	4.28E-03	4.47E-02	1.01E+03	2.58E-01	5.36E+00
7.26E-01	3.28E-02	1.50E-03	1.62E-03	1.89E-02	8.53E+02	8.72E-02	1.90E+00
8.40E-01	3.26E-02	1.50E-03	1.83E-03	2.09E-02	9.09E+02	1.05E-01	2.30E+00
2.53E+00	2.68E-02	1.50E-03	3.53E-03	3.74E-02	1.46E+03	2.92E-01	7.62E+00
1.23E+00	2.89E-02	1.50E-03	3.02E-03	3.25E-02	9.87E+02	1.71E-01	3.56E+00
1.04E+00	2.99E-02	1.50E-03	1.62E-03	1.86E-02	1.58E+03	1.62E-01	4.58E+00
1.85E+00	1.82E-02	1.04E-03	1.16E-03	1.30E-02	5.38E+02	4.15E-02	9.54E-01
1.25E+02	1.39E-01	1.48E-02	8.47E-02	3.25E-02	1.51E+03	3.07E-01	1.08E+01
1.32E+01	2.40E-02	1.55E-03	2.41E-02	8.67E-03	3.92E+02	3.25E-02	8.75E-01
2.43E+00	3.18E-03	9.49E-04	1.14E-03	4.21E-04	2.89E+02	6.08E-03	1.81E-01
3.87E+00	5.24E-03	1.66E-03	2.41E-03	8.91E-04	3.82E+02	8.34E-03	3.57E-01
4.94E+01	6.30E-02	1.26E-02	4.33E-02	1.65E-02	1.04E+03	1.64E-01	5.81E+00
2.89E+01	2.76E-02	1.99E-02	2.69E-02	1.02E-02	9.45E+02	1.90E-01	4.72E+00
7.97E+00	4.29E-03	5.44E-03	6.91E-03	2.51E-03	9.63E+02	4.11E-02	1.09E+00
1.33E+01	7.87E-03	5.59E-03	1.07E-02	3.84E-03	1.37E+03	5.16E-02	1.49E+00
2.13E+01	1.68E-02	9.60E-03	1.79E-02	6.63E-03	1.02E+03	9.72E-02	2.49E+00
3.50E+01	2.35E-02	2.29E-02	2.75E-02	1.03E-02	1.50E+03	2.06E-01	5.17E+00
3.51E+00	4.83E-03	1.67E-03	2.01E-03	7.38E-04	3.75E+02	7.30E-03	3.18E-01
7.39E+00	4.11E+00	3.04E-02	7.24E-04	1.98E-01	1.46E+03	5.85E-02	4.20E+00
1.56E+00	5.02E-03	7.01E-04	3.36E-04	4.14E-04	2.83E+02	2.50E-03	7.25E-02
2.03E+00	9.08E-03	9.27E-04	5.42E-04	6.70E-04	3.58E+02	3.46E-03	1.18E-01
1.81E+00	8.12E-03	9.24E-04	4.95E-04	6.03E-04	3.48E+02	3.10E-03	1.09E-01
1.49E+00	3.81E-02	2.07E-03	2.45E-03	2.75E-02	1.68E+03	2.34E-01	6.07E+00
1.18E+00	4.01E-02	2.07E-03	1.97E-03	2.29E-02	1.58E+03	1.68E-01	4.78E+00
2.34E+00	2.87E-02	2.07E-03	4.28E-03	4.49E-02	1.59E+03	3.73E-01	9.43E+00
1.17E+00	5.76E-03	4.21E-04	1.29E-04	1.76E-03	2.93E+02	2.66E-03	8.58E-02
1.39E+00	2.20E-02	1.58E-03	1.16E-03	1.33E-02	5.88E+02	3.71E-02	9.59E-01
1.70E+00	2.89E-02	2.07E-03	4.90E-03	5.12E-02	8.70E+02	2.76E-01	4.68E+00

8.46E-01	4.22E-02	2.07E-03	2.05E-03	2.39E-02	8.18E+02	9.82E-02	1.92E+00
9.82E-01	4.20E-02	2.07E-03	2.32E-03	2.66E-02	8.81E+02	1.20E-01	2.34E+00
2.50E+00	3.11E-02	2.07E-03	3.87E-03	4.11E-02	1.29E+03	2.88E-01	7.03E+00
1.43E+00	3.73E-02	2.07E-03	3.84E-03	4.13E-02	9.04E+02	1.99E-01	3.37E+00
1.17E+00	3.84E-02	2.07E-03	1.99E-03	2.30E-02	1.54E+03	1.76E-01	4.62E+00
1.57E+00	1.90E-02	1.44E-03	1.34E-03	1.49E-02	5.57E+02	4.48E-02	1.00E+00
1.21E+02	1.50E-01	1.96E-02	9.22E-02	3.54E-02	1.54E+03	2.13E-01	1.08E+01
1.32E+01	2.66E-02	2.14E-03	2.66E-02	9.59E-03	3.78E+02	2.08E-02	8.45E-01
1.71E+00	2.48E-03	1.31E-03	1.03E-03	3.83E-04	2.96E+02	4.13E-03	1.61E-01
2.68E+00	3.86E-03	2.29E-03	2.19E-03	8.13E-04	3.86E+02	4.83E-03	3.07E-01
3.47E+01	5.85E-02	1.74E-02	4.06E-02	1.55E-02	8.86E+02	5.51E-02	4.71E+00
2.32E+01	2.71E-02	2.75E-02	2.74E-02	1.03E-02	8.72E+02	2.15E-02	4.32E+00
7.16E+00	4.38E-03	7.52E-03	7.34E-03	2.66E-03	9.06E+02	9.38E-03	1.01E+00
1.15E+01	8.04E-03	7.73E-03	1.15E-02	4.15E-03	1.23E+03	2.44E-02	1.31E+00
1.66E+01	1.61E-02	1.33E-02	1.76E-02	6.54E-03	9.23E+02	1.93E-02	2.23E+00
3.46E+01	2.62E-02	3.16E-02	3.28E-02	1.23E-02	1.49E+03	9.11E-02	5.07E+00
2.65E+00	3.83E-03	2.31E-03	1.91E-03	7.01E-04	3.86E+02	4.63E-03	2.83E-01
6.45E+00	4.31E+00	4.20E-02	7.45E-04	1.92E-01	1.33E+03	4.03E-02	3.68E+00
1.05E+00	3.75E-03	9.69E-04	2.69E-04	3.27E-04	2.89E+02	1.83E-03	6.08E-02
1.28E+00	6.22E-03	1.28E-03	4.11E-04	5.01E-04	3.62E+02	2.12E-03	9.10E-02
1.23E+00	5.87E-03	1.28E-03	3.93E-04	4.71E-04	3.58E+02	2.08E-03	8.72E-02

Sum of emisRate - 35 mph

RoadType	yearID	FuelType	SourceType	Pollutant PM2.5 Tirewear g/mi
Rural Restricted Access	2018	Diesel Fuel	Combination Long-haul Truck	4.39E-03
			Combination Short-haul Truck	3.94E-03
			Intercity Bus	3.44E-03
			Passenger Car	1.15E-03
			Passenger Truck	1.43E-03
			School Bus	2.09E-03
			Single Unit Long-haul Truck	2.46E-03
			Single Unit Short-haul Truck	2.23E-03
			Transit Bus	2.29E-03
			Motor Home	1.86E-03
			Refuse Truck	4.18E-03
			Light Commercial Truck	1.39E-03
		Gasoline	Combination Short-haul Truck	2.16E-03
			Motorcycle	5.73E-04
			Passenger Car	1.15E-03
			Passenger Truck	1.15E-03
			School Bus	2.09E-03
			Single Unit Long-haul Truck	1.70E-03
			Single Unit Short-haul Truck	1.69E-03
			Transit Bus	3.37E-03
			Motor Home	1.86E-03
			Refuse Truck	1.69E-03
			Light Commercial Truck	1.17E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.29E-03
		Ethanol (E-85)	Passenger Car	1.15E-03
			Passenger Truck	1.15E-03
			Light Commercial Truck	1.15E-03
Rural Unrestricted Acces	2018	Diesel Fuel	Combination Long-haul Truck	4.89E-03
			Combination Short-haul Truck	4.39E-03
			Intercity Bus	4.03E-03
			Passenger Car	1.34E-03
			Passenger Truck	1.68E-03
			School Bus	2.44E-03
			Single Unit Long-haul Truck	2.88E-03
			Single Unit Short-haul Truck	2.61E-03
			Transit Bus	2.68E-03
			Motor Home	2.18E-03
			Refuse Truck	4.89E-03
			Light Commercial Truck	1.63E-03
		Gasoline	Combination Short-haul Truck	2.40E-03
			Motorcycle	6.71E-04
			Passenger Car	1.34E-03

			Passenger Truck	1.35E-03
			School Bus	2.44E-03
			Single Unit Long-haul Truck	1.99E-03
			Single Unit Short-haul Truck	1.98E-03
			Transit Bus	3.94E-03
			Motor Home	2.18E-03
			Refuse Truck	1.98E-03
			Light Commercial Truck	1.37E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.68E-03
		Ethanol (E-85)	Passenger Car	1.34E-03
			Passenger Truck	1.34E-03
			Light Commercial Truck	1.34E-03
Urban Restricted Access	2018	Diesel Fuel	Combination Long-haul Truck	4.70E-03
			Combination Short-haul Truck	4.22E-03
			Intercity Bus	3.71E-03
			Passenger Car	1.24E-03
			Passenger Truck	1.55E-03
			School Bus	2.25E-03
			Single Unit Long-haul Truck	2.65E-03
			Single Unit Short-haul Truck	2.40E-03
			Transit Bus	2.47E-03
			Motor Home	2.01E-03
			Refuse Truck	4.51E-03
			Light Commercial Truck	1.50E-03
		Gasoline	Combination Short-haul Truck	2.31E-03
			Motorcycle	6.19E-04
			Passenger Car	1.24E-03
			Passenger Truck	1.25E-03
			School Bus	2.25E-03
			Single Unit Long-haul Truck	1.83E-03
			Single Unit Short-haul Truck	1.83E-03
			Transit Bus	3.63E-03
			Motor Home	2.01E-03
			Refuse Truck	1.83E-03
			Light Commercial Truck	1.27E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.47E-03
		Ethanol (E-85)	Passenger Car	1.24E-03
			Passenger Truck	1.24E-03
			Light Commercial Truck	1.24E-03
Urban Unrestricted Acces	2018	Diesel Fuel	Combination Long-haul Truck	5.58E-03
			Combination Short-haul Truck	5.02E-03
			Intercity Bus	4.60E-03
			Passenger Car	1.53E-03
			Passenger Truck	1.92E-03
			School Bus	2.79E-03

	Single Unit Long-haul Truck	3.29E-03
	Single Unit Short-haul Truck	2.98E-03
	Transit Bus	3.07E-03
	Motor Home	2.49E-03
	Refuse Truck	5.59E-03
	Light Commercial Truck	1.86E-03
Gasoline	Combination Short-haul Truck	2.75E-03
	Motorcycle	7.67E-04
	Passenger Car	1.53E-03
	Passenger Truck	1.54E-03
	School Bus	2.79E-03
	Single Unit Long-haul Truck	2.27E-03
	Single Unit Short-haul Truck	2.26E-03
	Transit Bus	4.50E-03
	Motor Home	2.49E-03
	Refuse Truck	2.27E-03
	Light Commercial Truck	1.57E-03
Compressed Natural Gas (CNG)	Transit Bus	3.07E-03
Ethanol (E-85)	Passenger Car	1.53E-03
	Passenger Truck	1.53E-03
	Light Commercial Truck	1.53E-03

RateUnit

PM2.5 Brakewear g/mi	PM10 Tirewear g/mi	PM10 Brakewear g/mi	PM10 Total Exh g/mi	VOC g/mi	SO2 g/mi	NOx g/mi
1.19E-02	2.93E-02	9.53E-02	2.52E-01	2.79E-01	1.50E-02	6.01E+00
1.09E-02	2.63E-02	8.70E-02	1.83E-01	2.23E-01	1.43E-02	4.85E+00
9.98E-03	2.29E-02	7.98E-02	3.92E-01	4.73E-01	1.49E-02	9.81E+00
1.54E-03	7.64E-03	1.24E-02	3.73E-03	1.98E-02	2.57E-03	1.07E-01
2.33E-03	9.55E-03	1.86E-02	3.88E-02	1.28E-01	5.18E-03	9.76E-01
7.47E-03	1.39E-02	5.97E-02	2.97E-01	5.80E-01	9.88E-03	6.03E+00
7.92E-03	1.64E-02	6.34E-02	9.71E-02	2.08E-01	7.85E-03	2.04E+00
6.99E-03	1.48E-02	5.59E-02	1.17E-01	2.36E-01	8.43E-03	2.47E+00
6.42E-03	1.53E-02	5.13E-02	3.45E-01	4.66E-01	1.36E-02	8.10E+00
5.48E-03	1.24E-02	4.38E-02	1.92E-01	4.06E-01	9.55E-03	3.96E+00
1.09E-02	2.79E-02	8.75E-02	1.94E-01	2.23E-01	1.47E-02	4.90E+00
2.42E-03	9.28E-03	1.94E-02	4.64E-02	1.49E-01	4.87E-03	1.01E+00
6.72E-03	1.44E-02	5.38E-02	3.34E-01	2.98E+00	1.06E-02	1.11E+01
1.24E-04	3.82E-03	9.92E-04	3.38E-02	5.75E-01	2.57E-03	8.24E-01
1.54E-03	7.64E-03	1.24E-02	6.55E-03	3.51E-02	1.98E-03	1.87E-01
2.45E-03	7.70E-03	1.96E-02	8.76E-03	7.32E-02	2.63E-03	3.68E-01
7.46E-03	1.39E-02	5.97E-02	1.70E-01	1.54E+00	7.15E-03	5.84E+00
4.90E-03	1.13E-02	3.92E-02	1.54E-01	9.81E-01	6.24E-03	4.48E+00
4.87E-03	1.13E-02	3.89E-02	3.50E-02	2.46E-01	6.46E-03	1.04E+00
1.00E-02	2.24E-02	8.01E-02	5.12E-02	4.37E-01	9.51E-03	1.51E+00
5.48E-03	1.24E-02	4.38E-02	8.68E-02	6.50E-01	7.01E-03	2.46E+00
3.94E-03	1.13E-02	3.15E-02	1.93E-01	1.12E+00	1.05E-02	5.28E+00
2.52E-03	7.82E-03	2.02E-02	7.78E-03	6.13E-02	2.58E-03	3.29E-01
6.42E-03	1.53E-02	5.13E-02	5.59E-02	5.23E-01	7.46E-03	4.28E+00
1.54E-03	7.64E-03	1.24E-02	2.76E-03	1.98E-02	2.24E-03	7.51E-02
2.46E-03	7.64E-03	1.96E-02	3.66E-03	3.07E-02	2.85E-03	1.24E-01
2.54E-03	7.64E-03	2.03E-02	3.33E-03	2.87E-02	2.78E-03	1.16E-01
1.67E-02	3.26E-02	1.33E-01	2.76E-01	3.13E-01	1.51E-02	6.14E+00
1.52E-02	2.93E-02	1.21E-01	1.97E-01	2.48E-01	1.42E-02	4.89E+00
1.51E-02	2.68E-02	1.21E-01	4.30E-01	5.50E-01	1.43E-02	9.45E+00
2.50E-03	8.94E-03	2.00E-02	2.95E-03	1.63E-02	2.54E-03	8.81E-02
3.97E-03	1.12E-02	3.18E-02	3.92E-02	1.38E-01	5.16E-03	9.85E-01
1.00E-02	1.63E-02	8.03E-02	2.82E-01	5.75E-01	7.39E-03	4.55E+00
1.13E-02	1.92E-02	9.03E-02	1.06E-01	2.47E-01	7.35E-03	1.98E+00
1.00E-02	1.74E-02	8.01E-02	1.30E-01	2.81E-01	7.92E-03	2.40E+00
9.18E-03	1.79E-02	7.34E-02	3.17E-01	4.32E-01	1.05E-02	6.46E+00
7.97E-03	1.45E-02	6.37E-02	2.13E-01	4.84E-01	8.35E-03	3.52E+00
1.66E-02	3.26E-02	1.32E-01	2.10E-01	2.55E-01	1.41E-02	4.77E+00
4.02E-03	1.09E-02	3.22E-02	4.77E-02	1.63E-01	4.92E-03	1.03E+00
9.28E-03	1.60E-02	7.42E-02	2.46E-01	3.12E+00	1.05E-02	1.08E+01
2.17E-04	4.47E-03	1.74E-03	2.34E-02	6.05E-01	2.41E-03	7.72E-01
2.50E-03	8.94E-03	2.00E-02	4.81E-03	3.24E-02	1.96E-03	1.64E-01

4.14E-03	9.01E-03	3.31E-02	5.79E-03	6.66E-02	2.56E-03	3.10E-01
1.00E-02	1.63E-02	8.03E-02	6.19E-02	1.39E+00	5.31E-03	3.96E+00
6.83E-03	1.32E-02	5.47E-02	2.36E-02	9.36E-01	5.64E-03	4.05E+00
6.87E-03	1.32E-02	5.50E-02	9.61E-03	2.40E-01	5.94E-03	9.55E-01
1.42E-02	2.63E-02	1.14E-01	2.84E-02	4.32E-01	7.58E-03	1.15E+00
7.97E-03	1.45E-02	6.37E-02	2.12E-02	5.95E-01	6.10E-03	2.14E+00
5.92E-03	1.32E-02	4.73E-02	1.01E-01	1.21E+00	1.02E-02	5.10E+00
4.15E-03	9.15E-03	3.32E-02	5.58E-03	5.78E-02	2.56E-03	2.86E-01
9.18E-03	1.79E-02	7.34E-02	3.42E-02	5.06E-01	5.95E-03	3.25E+00
2.50E-03	8.94E-03	2.00E-02	2.13E-03	1.71E-02	2.22E-03	6.23E-02
4.15E-03	8.94E-03	3.32E-02	2.56E-03	2.49E-02	2.77E-03	9.29E-02
4.17E-03	8.94E-03	3.34E-02	2.52E-03	2.41E-02	2.75E-03	8.95E-02
1.53E-02	3.14E-02	1.22E-01	2.69E-01	2.99E-01	1.50E-02	6.04E+00
1.39E-02	2.82E-02	1.11E-01	1.94E-01	2.38E-01	1.42E-02	4.84E+00
1.26E-02	2.48E-02	1.01E-01	4.15E-01	5.09E-01	1.47E-02	9.64E+00
1.98E-03	8.25E-03	1.58E-02	3.66E-03	1.86E-02	2.57E-03	9.89E-02
2.99E-03	1.03E-02	2.39E-02	4.00E-02	1.34E-01	5.18E-03	9.82E-01
9.21E-03	1.50E-02	7.37E-02	3.19E-01	6.35E-01	9.75E-03	5.88E+00
9.57E-03	1.77E-02	7.66E-02	1.05E-01	2.27E-01	8.12E-03	2.11E+00
8.48E-03	1.60E-02	6.79E-02	1.26E-01	2.58E-01	8.64E-03	2.54E+00
8.10E-03	1.65E-02	6.48E-02	3.62E-01	4.94E-01	1.34E-02	7.97E+00
6.71E-03	1.34E-02	5.37E-02	2.06E-01	4.45E-01	9.45E-03	3.90E+00
1.40E-02	3.01E-02	1.12E-01	2.06E-01	2.39E-01	1.46E-02	4.87E+00
3.10E-03	1.00E-02	2.48E-02	4.80E-02	1.56E-01	4.87E-03	1.01E+00
8.51E-03	1.54E-02	6.81E-02	3.14E-01	3.16E+00	1.06E-02	1.10E+01
1.61E-04	4.13E-03	1.29E-03	3.46E-02	5.97E-01	2.53E-03	8.14E-01
1.98E-03	8.25E-03	1.58E-02	6.52E-03	3.44E-02	1.99E-03	1.77E-01
3.16E-03	8.31E-03	2.53E-02	8.65E-03	7.07E-02	2.61E-03	3.43E-01
9.21E-03	1.50E-02	7.37E-02	1.56E-01	1.62E+00	7.18E-03	5.77E+00
5.84E-03	1.22E-02	4.67E-02	1.56E-01	1.08E+00	6.45E-03	4.58E+00
5.85E-03	1.22E-02	4.68E-02	3.48E-02	2.71E-01	6.66E-03	1.06E+00
1.26E-02	2.42E-02	1.01E-01	4.81E-02	4.63E-01	9.49E-03	1.50E+00
6.71E-03	1.34E-02	5.37E-02	8.56E-02	6.94E-01	7.06E-03	2.46E+00
4.97E-03	1.22E-02	3.98E-02	1.88E-01	1.22E+00	1.06E-02	5.29E+00
3.24E-03	8.44E-03	2.59E-02	7.53E-03	5.94E-02	2.57E-03	3.08E-01
8.10E-03	1.65E-02	6.48E-02	5.43E-02	5.51E-01	7.44E-03	4.25E+00
1.98E-03	8.25E-03	1.58E-02	2.73E-03	1.89E-02	2.25E-03	6.95E-02
3.16E-03	8.25E-03	2.53E-02	3.62E-03	2.85E-02	2.83E-03	1.11E-01
3.25E-03	8.25E-03	2.60E-02	3.23E-03	2.65E-02	2.76E-03	1.03E-01
2.90E-02	3.72E-02	2.32E-01	3.42E-01	3.83E-01	1.63E-02	6.70E+00
2.62E-02	3.34E-02	2.10E-01	2.43E-01	3.02E-01	1.54E-02	5.30E+00
2.54E-02	3.07E-02	2.03E-01	5.30E-01	6.70E-01	1.55E-02	1.01E+01
4.06E-03	1.02E-02	3.25E-02	3.11E-03	1.70E-02	2.76E-03	8.26E-02
6.43E-03	1.28E-02	5.14E-02	4.43E-02	1.65E-01	5.55E-03	1.10E+00
1.46E-02	1.86E-02	1.17E-01	3.28E-01	6.79E-01	7.71E-03	4.83E+00

1.79E-02	2.19E-02	1.43E-01	1.29E-01	3.09E-01	8.84E-03	2.41E+00
1.59E-02	1.99E-02	1.27E-01	1.59E-01	3.51E-01	9.43E-03	2.88E+00
1.43E-02	2.04E-02	1.15E-01	3.66E-01	4.83E-01	1.02E-02	6.59E+00
1.24E-02	1.66E-02	9.90E-02	2.59E-01	6.08E-01	9.69E-03	4.12E+00
2.74E-02	3.73E-02	2.20E-01	2.59E-01	3.08E-01	1.52E-02	5.21E+00
6.51E-03	1.24E-02	5.21E-02	5.45E-02	1.95E-01	5.29E-03	1.16E+00
1.55E-02	1.83E-02	1.24E-01	2.52E-01	3.90E+00	1.15E-02	1.12E+01
3.57E-04	5.11E-03	2.86E-03	2.27E-02	6.88E-01	2.36E-03	6.84E-01
4.06E-03	1.02E-02	3.25E-02	5.05E-03	3.61E-02	2.14E-03	1.61E-01
6.75E-03	1.03E-02	5.40E-02	5.78E-03	7.31E-02	2.75E-03	2.94E-01
1.46E-02	1.86E-02	1.17E-01	5.65E-02	1.74E+00	5.38E-03	3.55E+00
1.05E-02	1.51E-02	8.39E-02	2.47E-02	1.29E+00	6.35E-03	4.19E+00
1.06E-02	1.51E-02	8.47E-02	8.86E-03	3.30E-01	6.73E-03	9.99E-01
2.21E-02	3.00E-02	1.77E-01	2.75E-02	5.33E-01	7.62E-03	1.08E+00
1.24E-02	1.66E-02	9.90E-02	1.95E-02	7.91E-01	6.77E-03	2.22E+00
9.40E-03	1.51E-02	7.52E-02	1.05E-01	1.65E+00	1.12E-02	5.39E+00
6.76E-03	1.05E-02	5.41E-02	5.56E-03	6.45E-02	2.75E-03	2.72E-01
1.43E-02	2.04E-02	1.15E-01	2.72E-02	6.15E-01	5.98E-03	3.06E+00
4.06E-03	1.02E-02	3.25E-02	2.26E-03	1.80E-02	2.42E-03	5.88E-02
6.76E-03	1.02E-02	5.41E-02	2.57E-03	2.53E-02	2.98E-03	8.35E-02
6.79E-03	1.02E-02	5.44E-02	2.52E-03	2.45E-02	2.96E-03	8.05E-02

CO g/mi	Methane (CH4) g/mi	N2O g/mi	Benzene g/mi	Formaldehyde g/mi	CO2 Equivalent g/mi	PM2.5 Total Exh g/mi	NOx
1.38E+00	3.26E-02	1.72E-03	2.13E-03	2.39E-02	1.71E+03	2.32E-01	6.01E+00
1.10E+00	3.43E-02	1.72E-03	1.71E-03	1.98E-02	1.64E+03	1.68E-01	4.85E+00
2.12E+00	2.37E-02	1.63E-03	3.60E-03	3.78E-02	1.67E+03	3.61E-01	9.81E+00
1.81E+00	8.59E-03	3.32E-04	1.77E-04	2.46E-03	2.96E+02	3.43E-03	1.07E-01
1.78E+00	2.13E-02	1.24E-03	1.07E-03	1.24E-02	5.94E+02	3.57E-02	9.76E-01
1.71E+00	2.65E-02	1.63E-03	4.53E-03	4.72E-02	1.11E+03	2.73E-01	6.03E+00
7.41E-01	3.47E-02	1.63E-03	1.70E-03	1.98E-02	9.03E+02	8.93E-02	2.04E+00
8.59E-01	3.45E-02	1.63E-03	1.92E-03	2.20E-02	9.66E+02	1.08E-01	2.47E+00
2.62E+00	2.86E-02	1.63E-03	3.59E-03	3.81E-02	1.54E+03	3.17E-01	8.10E+00
1.27E+00	3.04E-02	1.63E-03	3.19E-03	3.43E-02	1.08E+03	1.77E-01	3.96E+00
1.08E+00	3.19E-02	1.63E-03	1.69E-03	1.94E-02	1.68E+03	1.79E-01	4.90E+00
1.94E+00	1.91E-02	1.14E-03	1.22E-03	1.37E-02	5.56E+02	4.27E-02	1.01E+00
1.35E+02	1.60E-01	1.63E-02	9.84E-02	3.78E-02	1.60E+03	2.95E-01	1.11E+01
1.28E+01	2.46E-02	1.69E-03	2.47E-02	8.89E-03	3.88E+02	2.99E-02	8.24E-01
2.50E+00	3.38E-03	1.03E-03	1.21E-03	4.46E-04	2.98E+02	5.80E-03	1.87E-01
4.00E+00	5.57E-03	1.81E-03	2.59E-03	9.56E-04	3.96E+02	7.75E-03	3.68E-01
5.53E+01	7.35E-02	1.37E-02	5.09E-02	1.94E-02	1.08E+03	1.51E-01	5.84E+00
3.03E+01	3.15E-02	2.17E-02	3.19E-02	1.21E-02	9.46E+02	1.36E-01	4.48E+00
8.34E+00	5.01E-03	5.93E-03	8.36E-03	3.04E-03	9.74E+02	3.10E-02	1.04E+00
1.45E+01	9.25E-03	6.09E-03	1.30E-02	4.68E-03	1.43E+03	4.53E-02	1.51E+00
2.34E+01	1.96E-02	1.05E-02	2.13E-02	7.93E-03	1.06E+03	7.68E-02	2.46E+00
3.88E+01	2.85E-02	2.49E-02	3.52E-02	1.32E-02	1.59E+03	1.70E-01	5.28E+00
3.65E+00	5.24E-03	1.82E-03	2.19E-03	8.04E-04	3.89E+02	6.88E-03	3.29E-01
8.06E+00	4.92E+00	3.31E-02	8.56E-04	2.25E-01	1.54E+03	4.95E-02	4.28E+00
1.59E+00	5.32E-03	7.64E-04	3.55E-04	4.38E-04	2.91E+02	2.44E-03	7.51E-02
2.08E+00	9.60E-03	1.01E-03	5.74E-04	7.12E-04	3.70E+02	3.24E-03	1.24E-01
1.89E+00	8.75E-03	1.01E-03	5.31E-04	6.51E-04	3.61E+02	2.94E-03	1.16E-01
1.50E+00	3.81E-02	2.05E-03	2.41E-03	2.72E-02	1.72E+03	2.54E-01	6.14E+00
1.19E+00	4.02E-02	2.05E-03	1.94E-03	2.26E-02	1.63E+03	1.82E-01	4.89E+00
2.35E+00	2.90E-02	2.05E-03	4.24E-03	4.46E-02	1.61E+03	3.96E-01	9.45E+00
1.25E+00	6.27E-03	4.18E-04	1.39E-04	1.90E-03	2.92E+02	2.71E-03	8.81E-02
1.44E+00	2.19E-02	1.56E-03	1.15E-03	1.32E-02	5.92E+02	3.61E-02	9.85E-01
1.53E+00	2.62E-02	2.05E-03	4.52E-03	4.72E-02	8.30E+02	2.59E-01	4.55E+00
8.41E-01	4.22E-02	2.05E-03	2.05E-03	2.39E-02	8.45E+02	9.74E-02	1.98E+00
9.77E-01	4.21E-02	2.05E-03	2.31E-03	2.65E-02	9.09E+02	1.19E-01	2.40E+00
2.24E+00	2.84E-02	2.05E-03	3.37E-03	3.59E-02	1.18E+03	2.92E-01	6.46E+00
1.44E+00	3.73E-02	2.05E-03	3.85E-03	4.14E-02	9.47E+02	1.96E-01	3.52E+00
1.20E+00	3.91E-02	2.05E-03	1.99E-03	2.30E-02	1.61E+03	1.93E-01	4.77E+00
1.64E+00	1.91E-02	1.43E-03	1.33E-03	1.48E-02	5.61E+02	4.39E-02	1.03E+00
1.31E+02	1.68E-01	1.94E-02	1.03E-01	3.97E-02	1.59E+03	2.18E-01	1.08E+01
1.23E+01	2.61E-02	2.12E-03	2.61E-02	9.41E-03	3.64E+02	2.07E-02	7.72E-01
1.82E+00	2.66E-03	1.30E-03	1.08E-03	4.01E-04	2.95E+02	4.26E-03	1.64E-01

2.82E+00	4.11E-03	2.27E-03	2.30E-03	8.51E-04	3.85E+02	5.12E-03	3.10E-01
3.62E+01	6.59E-02	1.73E-02	4.64E-02	1.77E-02	8.05E+02	5.48E-02	3.96E+00
2.47E+01	2.98E-02	2.73E-02	3.06E-02	1.16E-02	8.57E+02	2.08E-02	4.05E+00
7.56E+00	4.87E-03	7.45E-03	8.27E-03	3.01E-03	8.96E+02	8.50E-03	9.55E-01
1.13E+01	9.20E-03	7.66E-03	1.39E-02	5.04E-03	1.14E+03	2.51E-02	1.15E+00
1.80E+01	1.78E-02	1.32E-02	1.98E-02	7.34E-03	9.22E+02	1.88E-02	2.14E+00
3.83E+01	3.02E-02	3.13E-02	3.86E-02	1.45E-02	1.54E+03	8.90E-02	5.10E+00
2.80E+00	4.15E-03	2.29E-03	2.03E-03	7.46E-04	3.85E+02	4.94E-03	2.86E-01
6.33E+00	5.08E+00	4.17E-02	8.60E-04	2.08E-01	1.26E+03	3.02E-02	3.25E+00
1.12E+00	4.04E-03	9.60E-04	2.86E-04	3.50E-04	2.88E+02	1.88E-03	6.23E-02
1.36E+00	6.62E-03	1.27E-03	4.33E-04	5.30E-04	3.61E+02	2.26E-03	9.29E-02
1.31E+00	6.30E-03	1.27E-03	4.16E-04	5.02E-04	3.57E+02	2.23E-03	8.95E-02
1.45E+00	3.60E-02	1.92E-03	2.30E-03	2.58E-02	1.71E+03	2.47E-01	6.04E+00
1.16E+00	3.79E-02	1.92E-03	1.84E-03	2.15E-02	1.63E+03	1.79E-01	4.84E+00
2.24E+00	2.62E-02	1.82E-03	3.90E-03	4.10E-02	1.65E+03	3.82E-01	9.64E+00
1.71E+00	7.73E-03	3.71E-04	1.63E-04	2.26E-03	2.97E+02	3.37E-03	9.89E-02
1.72E+00	2.19E-02	1.39E-03	1.12E-03	1.29E-02	5.94E+02	3.68E-02	9.82E-01
1.83E+00	2.94E-02	1.82E-03	4.97E-03	5.19E-02	1.09E+03	2.94E-01	5.88E+00
7.97E-01	3.82E-02	1.82E-03	1.87E-03	2.18E-02	9.34E+02	9.63E-02	2.11E+00
9.22E-01	3.80E-02	1.82E-03	2.11E-03	2.41E-02	9.90E+02	1.16E-01	2.54E+00
2.72E+00	3.16E-02	1.82E-03	3.82E-03	4.07E-02	1.51E+03	3.33E-01	7.97E+00
1.36E+00	3.36E-02	1.82E-03	3.50E-03	3.77E-02	1.07E+03	1.90E-01	3.90E+00
1.14E+00	3.53E-02	1.82E-03	1.83E-03	2.12E-02	1.67E+03	1.90E-01	4.87E+00
1.86E+00	1.93E-02	1.27E-03	1.28E-03	1.43E-02	5.56E+02	4.42E-02	1.01E+00
1.34E+02	1.70E-01	1.81E-02	1.04E-01	4.01E-02	1.61E+03	2.78E-01	1.10E+01
1.28E+01	2.56E-02	1.89E-03	2.57E-02	9.26E-03	3.81E+02	3.06E-02	8.14E-01
2.37E+00	3.12E-03	1.16E-03	1.17E-03	4.33E-04	2.99E+02	5.77E-03	1.77E-01
3.73E+00	5.03E-03	2.02E-03	2.48E-03	9.16E-04	3.93E+02	7.65E-03	3.43E-01
5.25E+01	7.71E-02	1.54E-02	5.37E-02	2.05E-02	1.09E+03	1.38E-01	5.77E+00
3.11E+01	3.44E-02	2.43E-02	3.54E-02	1.34E-02	9.78E+02	1.38E-01	4.58E+00
8.67E+00	5.50E-03	6.63E-03	9.36E-03	3.40E-03	1.00E+03	3.08E-02	1.06E+00
1.45E+01	9.80E-03	6.81E-03	1.41E-02	5.09E-03	1.43E+03	4.25E-02	1.50E+00
2.29E+01	2.08E-02	1.17E-02	2.31E-02	8.57E-03	1.07E+03	7.58E-02	2.46E+00
3.93E+01	3.05E-02	2.78E-02	3.88E-02	1.46E-02	1.60E+03	1.66E-01	5.29E+00
3.40E+00	4.75E-03	2.03E-03	2.11E-03	7.75E-04	3.87E+02	6.66E-03	3.08E-01
8.16E+00	5.29E+00	3.70E-02	9.12E-04	2.34E-01	1.55E+03	4.80E-02	4.25E+00
1.51E+00	4.86E-03	8.54E-04	3.30E-04	4.07E-04	2.92E+02	2.41E-03	6.95E-02
1.91E+00	8.49E-03	1.13E-03	5.20E-04	6.42E-04	3.68E+02	3.20E-03	1.11E-01
1.72E+00	7.65E-03	1.13E-03	4.78E-04	5.82E-04	3.59E+02	2.85E-03	1.03E-01
1.75E+00	4.93E-02	2.77E-03	2.99E-03	3.39E-02	1.86E+03	3.14E-01	6.70E+00
1.39E+00	5.19E-02	2.77E-03	2.40E-03	2.81E-02	1.77E+03	2.24E-01	5.30E+00
2.75E+00	3.70E-02	2.76E-03	5.20E-03	5.48E-02	1.73E+03	4.88E-01	1.01E+01
1.33E+00	6.03E-03	5.63E-04	1.41E-04	1.90E-03	3.18E+02	2.86E-03	8.26E-02
1.60E+00	2.57E-02	2.11E-03	1.37E-03	1.58E-02	6.36E+02	4.08E-02	1.10E+00
1.66E+00	3.11E-02	2.76E-03	5.35E-03	5.58E-02	8.67E+02	3.02E-01	4.83E+00

9.96E-01	5.35E-02	2.77E-03	2.57E-03	3.00E-02	1.02E+03	1.19E-01	2.41E+00
1.16E+00	5.34E-02	2.77E-03	2.90E-03	3.33E-02	1.08E+03	1.46E-01	2.88E+00
2.35E+00	3.41E-02	2.76E-03	3.80E-03	4.07E-02	1.15E+03	3.36E-01	6.59E+00
1.71E+00	4.74E-02	2.77E-03	4.84E-03	5.22E-02	1.10E+03	2.39E-01	4.12E+00
1.39E+00	4.95E-02	2.77E-03	2.43E-03	2.83E-02	1.74E+03	2.38E-01	5.21E+00
1.83E+00	2.20E-02	1.93E-03	1.59E-03	1.76E-02	6.04E+02	5.02E-02	1.16E+00
1.40E+02	2.10E-01	2.62E-02	1.30E-01	4.98E-02	1.75E+03	2.23E-01	1.12E+01
1.20E+01	2.99E-02	2.86E-03	2.99E-02	1.08E-02	3.56E+02	2.00E-02	6.84E-01
1.96E+00	2.71E-03	1.75E-03	1.19E-03	4.44E-04	3.22E+02	4.47E-03	1.61E-01
2.93E+00	4.06E-03	3.06E-03	2.51E-03	9.33E-04	4.14E+02	5.11E-03	2.94E-01
3.61E+01	8.23E-02	2.33E-02	5.86E-02	2.24E-02	8.19E+02	5.00E-02	3.55E+00
2.87E+01	4.02E-02	3.68E-02	4.29E-02	1.62E-02	9.67E+02	2.18E-02	4.19E+00
8.87E+00	6.69E-03	1.00E-02	1.18E-02	4.31E-03	1.02E+03	7.84E-03	9.99E-01
1.13E+01	1.14E-02	1.03E-02	1.81E-02	6.59E-03	1.15E+03	2.43E-02	1.08E+00
2.02E+01	2.35E-02	1.77E-02	2.70E-02	1.00E-02	1.02E+03	1.72E-02	2.22E+00
4.34E+01	3.95E-02	4.22E-02	5.36E-02	2.02E-02	1.70E+03	9.30E-02	5.39E+00
2.93E+00	4.25E-03	3.09E-03	2.27E-03	8.35E-04	4.15E+02	4.92E-03	2.72E-01
6.42E+00	6.47E+00	5.62E-02	1.08E-03	2.44E-01	1.31E+03	2.41E-02	3.06E+00
1.20E+00	4.00E-03	1.30E-03	2.92E-04	3.59E-04	3.14E+02	2.00E-03	5.88E-02
1.38E+00	6.21E-03	1.71E-03	4.26E-04	5.19E-04	3.87E+02	2.27E-03	8.35E-02
1.35E+00	5.93E-03	1.71E-03	4.12E-04	4.94E-04	3.85E+02	2.22E-03	8.05E-02

Sum of emisRate - 2.5 mph

RoadType	yearID	FuelType	SourceType	Pollutant PM2.5 Tirewear g/mi
Rural Restricted Access	2018	Diesel Fuel	Combination Long-haul Truck	3.92E-03
			Combination Short-haul Truck	3.52E-03
			Intercity Bus	3.00E-03
			Passenger Car	9.99E-04
			Passenger Truck	1.25E-03
			School Bus	1.82E-03
			Single Unit Long-haul Truck	2.14E-03
			Single Unit Short-haul Truck	1.94E-03
			Transit Bus	2.00E-03
			Motor Home	1.62E-03
			Refuse Truck	3.64E-03
			Light Commercial Truck	1.21E-03
		Gasoline	Combination Short-haul Truck	1.93E-03
			Motorcycle	5.00E-04
			Passenger Car	9.99E-04
			Passenger Truck	1.01E-03
			School Bus	1.82E-03
			Single Unit Long-haul Truck	1.48E-03
			Single Unit Short-haul Truck	1.47E-03
			Transit Bus	2.93E-03
			Motor Home	1.62E-03
			Refuse Truck	1.48E-03
			Light Commercial Truck	1.02E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.00E-03
		Ethanol (E-85)	Passenger Car	9.99E-04
			Passenger Truck	9.99E-04
			Light Commercial Truck	9.99E-04
Rural Unrestricted Acces	2018	Diesel Fuel	Combination Long-haul Truck	4.62E-03
			Combination Short-haul Truck	4.15E-03
			Intercity Bus	3.81E-03
			Passenger Car	1.27E-03
			Passenger Truck	1.59E-03
			School Bus	2.31E-03
			Single Unit Long-haul Truck	2.72E-03
			Single Unit Short-haul Truck	2.46E-03
			Transit Bus	2.54E-03
			Motor Home	2.06E-03
			Refuse Truck	4.62E-03
			Light Commercial Truck	1.54E-03
		Gasoline	Combination Short-haul Truck	2.27E-03
			Motorcycle	6.34E-04
			Passenger Car	1.27E-03

			Passenger Truck	1.28E-03
			School Bus	2.31E-03
			Single Unit Long-haul Truck	1.88E-03
			Single Unit Short-haul Truck	1.87E-03
			Transit Bus	3.72E-03
			Motor Home	2.06E-03
			Refuse Truck	1.87E-03
			Light Commercial Truck	1.30E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.54E-03
		Ethanol (E-85)	Passenger Car	1.27E-03
			Passenger Truck	1.27E-03
			Light Commercial Truck	1.27E-03
Urban Restricted Access	2018	Diesel Fuel	Combination Long-haul Truck	4.34E-03
			Combination Short-haul Truck	3.90E-03
			Intercity Bus	3.35E-03
			Passenger Car	1.12E-03
			Passenger Truck	1.39E-03
			School Bus	2.03E-03
			Single Unit Long-haul Truck	2.39E-03
			Single Unit Short-haul Truck	2.17E-03
			Transit Bus	2.23E-03
			Motor Home	1.81E-03
			Refuse Truck	4.07E-03
			Light Commercial Truck	1.35E-03
		Gasoline	Combination Short-haul Truck	2.14E-03
			Motorcycle	5.58E-04
			Passenger Car	1.12E-03
			Passenger Truck	1.12E-03
			School Bus	2.03E-03
			Single Unit Long-haul Truck	1.65E-03
			Single Unit Short-haul Truck	1.65E-03
			Transit Bus	3.27E-03
			Motor Home	1.81E-03
			Refuse Truck	1.65E-03
			Light Commercial Truck	1.14E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.23E-03
		Ethanol (E-85)	Passenger Car	1.12E-03
			Passenger Truck	1.12E-03
			Light Commercial Truck	1.12E-03
Urban Unrestricted Acces	2018	Diesel Fuel	Combination Long-haul Truck	5.87E-03
			Combination Short-haul Truck	5.27E-03
			Intercity Bus	4.84E-03
			Passenger Car	1.61E-03
			Passenger Truck	2.01E-03
			School Bus	2.94E-03

	Single Unit Long-haul Truck	3.45E-03
	Single Unit Short-haul Truck	3.13E-03
	Transit Bus	3.22E-03
	Motor Home	2.61E-03
	Refuse Truck	5.87E-03
	Light Commercial Truck	1.96E-03
Gasoline	Combination Short-haul Truck	2.89E-03
	Motorcycle	8.05E-04
	Passenger Car	1.61E-03
	Passenger Truck	1.62E-03
	School Bus	2.93E-03
	Single Unit Long-haul Truck	2.38E-03
	Single Unit Short-haul Truck	2.38E-03
	Transit Bus	4.73E-03
	Motor Home	2.61E-03
	Refuse Truck	2.38E-03
	Light Commercial Truck	1.65E-03
Compressed Natural Gas (CNG)	Transit Bus	3.22E-03
Ethanol (E-85)	Passenger Car	1.61E-03
	Passenger Truck	1.61E-03
	Light Commercial Truck	1.61E-03

RateUnit

PM2.5 Brakewear g/mi	PM10 Tirewear g/mi	PM10 Brakewear g/mi	PM10 Total Exh g/mi	VOC g/mi	SO2 g/mi	NOx g/mi
1.16E-02	2.61E-02	9.25E-02	2.83E-01	3.61E-01	1.70E-02	7.02E+00
1.04E-02	2.35E-02	8.29E-02	2.07E-01	2.85E-01	1.62E-02	5.68E+00
8.95E-03	2.00E-02	7.16E-02	4.40E-01	5.89E-01	1.70E-02	1.15E+01
1.74E-03	6.66E-03	1.39E-02	4.26E-03	2.32E-02	2.97E-03	1.20E-01
2.63E-03	8.32E-03	2.11E-02	4.90E-02	1.59E-01	5.91E-03	1.13E+00
6.79E-03	1.21E-02	5.43E-02	3.62E-01	7.12E-01	1.17E-02	7.36E+00
7.44E-03	1.43E-02	5.95E-02	1.19E-01	2.59E-01	9.20E-03	2.48E+00
6.51E-03	1.29E-02	5.21E-02	1.43E-01	2.94E-01	9.82E-03	2.98E+00
5.78E-03	1.33E-02	4.63E-02	3.89E-01	5.94E-01	1.57E-02	9.82E+00
4.78E-03	1.08E-02	3.83E-02	2.38E-01	5.02E-01	1.13E-02	4.86E+00
1.00E-02	2.43E-02	8.02E-02	2.15E-01	2.80E-01	1.66E-02	5.69E+00
2.71E-03	8.09E-03	2.17E-02	5.85E-02	1.85E-01	5.55E-03	1.18E+00
6.23E-03	1.29E-02	4.98E-02	3.91E-01	3.11E+00	1.15E-02	1.21E+01
1.65E-04	3.33E-03	1.32E-03	3.46E-02	6.92E-01	2.91E-03	8.97E-01
1.74E-03	6.66E-03	1.39E-02	7.31E-03	4.18E-02	2.30E-03	2.05E-01
2.86E-03	6.71E-03	2.29E-02	9.43E-03	8.69E-02	3.05E-03	4.11E-01
6.78E-03	1.21E-02	5.43E-02	2.12E-01	1.71E+00	8.12E-03	6.51E+00
4.59E-03	9.86E-03	3.68E-02	1.86E-01	1.10E+00	7.06E-03	4.98E+00
4.52E-03	9.83E-03	3.62E-02	4.21E-02	2.71E-01	7.24E-03	1.14E+00
8.96E-03	1.96E-02	7.17E-02	6.16E-02	4.63E-01	1.05E-02	1.64E+00
4.78E-03	1.08E-02	3.83E-02	1.02E-01	7.24E-01	7.97E-03	2.74E+00
3.45E-03	9.84E-03	2.76E-02	2.24E-01	1.14E+00	1.14E-02	5.63E+00
2.89E-03	6.82E-03	2.31E-02	8.64E-03	7.22E-02	3.00E-03	3.68E-01
5.78E-03	1.33E-02	4.63E-02	6.74E-02	5.53E-01	8.23E-03	4.66E+00
1.74E-03	6.66E-03	1.39E-02	3.14E-03	2.31E-02	2.61E-03	8.36E-02
2.86E-03	6.66E-03	2.29E-02	3.95E-03	3.62E-02	3.31E-03	1.43E-01
2.91E-03	6.66E-03	2.33E-02	3.70E-03	3.39E-02	3.22E-03	1.34E-01
2.07E-02	3.08E-02	1.66E-01	3.35E-01	4.41E-01	1.77E-02	7.53E+00
1.85E-02	2.77E-02	1.48E-01	2.41E-01	3.47E-01	1.68E-02	6.00E+00
1.68E-02	2.54E-02	1.35E-01	5.23E-01	7.45E-01	1.69E-02	1.15E+01
3.49E-03	8.45E-03	2.79E-02	3.55E-03	1.91E-02	3.11E-03	9.36E-02
5.40E-03	1.06E-02	4.32E-02	5.59E-02	1.90E-01	6.15E-03	1.19E+00
1.15E-02	1.54E-02	9.17E-02	4.15E-01	8.66E-01	1.03E-02	6.51E+00
1.33E-02	1.81E-02	1.07E-01	1.48E-01	3.47E-01	9.64E-03	2.71E+00
1.17E-02	1.64E-02	9.39E-02	1.80E-01	3.95E-01	1.02E-02	3.23E+00
1.06E-02	1.69E-02	8.48E-02	4.20E-01	6.74E-01	1.40E-02	9.21E+00
8.91E-03	1.37E-02	7.13E-02	2.99E-01	6.75E-01	1.09E-02	4.78E+00
1.86E-02	3.08E-02	1.49E-01	2.40E-01	3.30E-01	1.56E-02	5.50E+00
5.47E-03	1.03E-02	4.38E-02	6.78E-02	2.25E-01	5.87E-03	1.27E+00
1.09E-02	1.51E-02	8.74E-02	2.82E-01	3.54E+00	1.19E-02	1.20E+01
3.26E-04	4.23E-03	2.61E-03	2.63E-02	8.01E-01	2.85E-03	8.77E-01
3.49E-03	8.45E-03	2.79E-02	5.67E-03	4.04E-02	2.41E-03	1.76E-01

5.80E-03	8.52E-03	4.64E-02	6.28E-03	8.18E-02	3.13E-03	3.35E-01
1.15E-02	1.54E-02	9.16E-02	8.00E-02	1.78E+00	7.14E-03	5.24E+00
7.93E-03	1.25E-02	6.35E-02	3.18E-02	1.30E+00	7.13E-03	4.88E+00
7.94E-03	1.25E-02	6.36E-02	1.24E-02	3.23E-01	7.36E-03	1.13E+00
1.64E-02	2.48E-02	1.31E-01	3.09E-02	5.22E-01	9.65E-03	1.45E+00
8.91E-03	1.37E-02	7.13E-02	2.79E-02	7.97E-01	7.63E-03	2.56E+00
6.49E-03	1.25E-02	5.19E-02	1.09E-01	1.28E+00	1.10E-02	5.40E+00
5.78E-03	8.65E-03	4.63E-02	6.03E-03	7.02E-02	3.14E-03	3.10E-01
1.06E-02	1.69E-02	8.48E-02	4.67E-02	6.11E-01	7.57E-03	4.09E+00
3.49E-03	8.45E-03	2.79E-02	2.56E-03	2.03E-02	2.73E-03	6.63E-02
5.81E-03	8.45E-03	4.65E-02	2.76E-03	2.94E-02	3.40E-03	1.01E-01
5.82E-03	8.45E-03	4.66E-02	2.73E-03	2.83E-02	3.37E-03	9.70E-02
1.69E-02	2.90E-02	1.35E-01	3.17E-01	4.07E-01	1.73E-02	7.25E+00
1.52E-02	2.60E-02	1.22E-01	2.30E-01	3.21E-01	1.65E-02	5.82E+00
1.28E-02	2.23E-02	1.03E-01	4.85E-01	6.66E-01	1.70E-02	1.16E+01
2.46E-03	7.44E-03	1.97E-02	4.26E-03	2.19E-02	3.06E-03	1.09E-01
3.74E-03	9.29E-03	2.99E-02	5.27E-02	1.74E-01	6.03E-03	1.16E+00
9.40E-03	1.35E-02	7.52E-02	4.08E-01	8.21E-01	1.18E-02	7.37E+00
9.95E-03	1.59E-02	7.96E-02	1.35E-01	2.99E-01	9.86E-03	2.68E+00
8.77E-03	1.44E-02	7.01E-02	1.63E-01	3.39E-01	1.04E-02	3.18E+00
8.32E-03	1.49E-02	6.65E-02	4.25E-01	6.60E-01	1.57E-02	9.92E+00
6.60E-03	1.21E-02	5.28E-02	2.68E-01	5.80E-01	1.15E-02	4.93E+00
1.46E-02	2.71E-02	1.17E-01	2.37E-01	3.15E-01	1.67E-02	5.80E+00
3.84E-03	9.03E-03	3.07E-02	6.33E-02	2.04E-01	5.68E-03	1.22E+00
9.03E-03	1.42E-02	7.23E-02	3.70E-01	3.42E+00	1.18E-02	1.21E+01
2.30E-04	3.72E-03	1.84E-03	3.59E-02	7.48E-01	2.91E-03	8.95E-01
2.46E-03	7.44E-03	1.97E-02	7.40E-03	4.19E-02	2.37E-03	1.93E-01
4.04E-03	7.49E-03	3.23E-02	9.38E-03	8.54E-02	3.10E-03	3.79E-01
9.40E-03	1.35E-02	7.52E-02	1.97E-01	1.87E+00	8.34E-03	6.53E+00
6.03E-03	1.10E-02	4.82E-02	1.93E-01	1.28E+00	7.54E-03	5.22E+00
6.01E-03	1.10E-02	4.80E-02	4.29E-02	3.15E-01	7.68E-03	1.20E+00
1.29E-02	2.18E-02	1.03E-01	5.85E-02	5.08E-01	1.06E-02	1.65E+00
6.60E-03	1.21E-02	5.28E-02	1.02E-01	8.07E-01	8.21E-03	2.79E+00
4.98E-03	1.10E-02	3.99E-02	2.22E-01	1.31E+00	1.16E-02	5.71E+00
4.08E-03	7.61E-03	3.26E-02	8.40E-03	7.13E-02	3.06E-03	3.40E-01
8.32E-03	1.49E-02	6.65E-02	6.68E-02	6.02E-01	8.34E-03	4.67E+00
2.46E-03	7.44E-03	1.97E-02	3.15E-03	2.23E-02	2.68E-03	7.64E-02
4.05E-03	7.44E-03	3.24E-02	3.93E-03	3.37E-02	3.36E-03	1.25E-01
4.11E-03	7.44E-03	3.29E-02	3.60E-03	3.15E-02	3.29E-03	1.17E-01
4.82E-02	3.91E-02	3.86E-01	5.04E-01	6.60E-01	2.18E-02	9.51E+00
4.31E-02	3.51E-02	3.45E-01	3.60E-01	5.16E-01	2.08E-02	7.51E+00
3.89E-02	3.22E-02	3.11E-01	7.81E-01	1.11E+00	2.07E-02	1.40E+01
7.18E-03	1.07E-02	5.74E-02	4.33E-03	2.25E-02	3.93E-03	8.84E-02
1.12E-02	1.34E-02	8.92E-02	7.72E-02	2.76E-01	7.57E-03	1.57E+00
2.16E-02	1.96E-02	1.73E-01	5.90E-01	1.25E+00	1.27E-02	8.27E+00

2.80E-02	2.30E-02	2.24E-01	2.22E-01	5.32E-01	1.40E-02	4.03E+00
2.46E-02	2.09E-02	1.97E-01	2.71E-01	6.07E-01	1.47E-02	4.72E+00
2.19E-02	2.15E-02	1.75E-01	5.81E-01	9.26E-01	1.55E-02	1.12E+01
1.84E-02	1.74E-02	1.47E-01	4.46E-01	1.04E+00	1.51E-02	6.76E+00
4.19E-02	3.92E-02	3.36E-01	3.59E-01	4.83E-01	1.88E-02	6.83E+00
1.13E-02	1.30E-02	9.04E-02	9.47E-02	3.27E-01	7.26E-03	1.69E+00
2.46E-02	1.92E-02	1.96E-01	3.16E-01	5.37E+00	1.48E-02	1.36E+01
6.77E-04	5.37E-03	5.42E-03	2.71E-02	1.09E+00	3.02E-03	7.71E-01
7.18E-03	1.07E-02	5.74E-02	6.84E-03	5.32E-02	3.06E-03	1.79E-01
1.20E-02	1.08E-02	9.58E-02	6.80E-03	1.05E-01	3.87E-03	3.21E-01
2.16E-02	1.96E-02	1.73E-01	8.00E-02	2.72E+00	8.41E-03	5.19E+00
1.60E-02	1.59E-02	1.28E-01	3.91E-02	2.24E+00	9.48E-03	5.68E+00
1.61E-02	1.59E-02	1.29E-01	1.27E-02	5.56E-01	9.83E-03	1.33E+00
3.36E-02	3.15E-02	2.69E-01	3.07E-02	7.80E-01	1.10E-02	1.49E+00
1.84E-02	1.74E-02	1.47E-01	2.85E-02	1.32E+00	9.93E-03	2.97E+00
1.39E-02	1.59E-02	1.11E-01	1.24E-01	2.20E+00	1.36E-02	6.17E+00
1.19E-02	1.10E-02	9.56E-02	6.54E-03	9.19E-02	3.90E-03	3.00E-01
2.19E-02	2.15E-02	1.75E-01	4.03E-02	8.95E-01	8.63E-03	4.22E+00
7.18E-03	1.07E-02	5.74E-02	3.16E-03	2.44E-02	3.46E-03	6.32E-02
1.20E-02	1.07E-02	9.60E-02	3.02E-03	3.31E-02	4.20E-03	8.76E-02
1.20E-02	1.07E-02	9.62E-02	2.97E-03	3.21E-02	4.19E-03	8.45E-02

CO g/mi	Methane (CH4) g/mi	N2O g/mi	Benzene g/mi	Formaldehyde g/mi	CO2 Equivalent g/mi	PM2.5 Total Exh g/mi	NOx
1.59E+00	4.29E-02	2.60E-03	2.78E-03	3.13E-02	1.93E+03	2.60E-01	7.02E+00
1.27E+00	4.51E-02	2.59E-03	2.22E-03	2.59E-02	1.86E+03	1.90E-01	5.68E+00
2.40E+00	3.02E-02	2.40E-03	4.52E-03	4.74E-02	1.90E+03	4.05E-01	1.15E+01
2.06E+00	9.94E-03	4.89E-04	2.06E-04	2.87E-03	3.43E+02	3.92E-03	1.20E-01
2.09E+00	2.65E-02	1.83E-03	1.33E-03	1.54E-02	6.77E+02	4.51E-02	1.13E+00
1.93E+00	3.36E-02	2.40E-03	5.56E-03	5.82E-02	1.32E+03	3.33E-01	7.36E+00
8.55E-01	4.42E-02	2.40E-03	2.13E-03	2.49E-02	1.06E+03	1.10E-01	2.48E+00
9.89E-01	4.40E-02	2.40E-03	2.41E-03	2.76E-02	1.13E+03	1.32E-01	2.98E+00
3.01E+00	3.64E-02	2.40E-03	4.60E-03	4.88E-02	1.78E+03	3.58E-01	9.82E+00
1.45E+00	3.86E-02	2.40E-03	3.95E-03	4.26E-02	1.29E+03	2.19E-01	4.86E+00
1.21E+00	4.09E-02	2.40E-03	2.15E-03	2.48E-02	1.90E+03	1.98E-01	5.69E+00
2.31E+00	2.38E-02	1.67E-03	1.52E-03	1.71E-02	6.34E+02	5.39E-02	1.18E+00
1.37E+02	1.67E-01	2.45E-02	1.03E-01	3.94E-02	1.74E+03	3.46E-01	1.21E+01
1.48E+01	2.97E-02	2.49E-03	2.98E-02	1.07E-02	4.40E+02	3.06E-02	8.97E-01
2.84E+00	3.94E-03	1.52E-03	1.44E-03	5.31E-04	3.47E+02	6.47E-03	2.05E-01
4.61E+00	6.59E-03	2.66E-03	3.07E-03	1.13E-03	4.60E+02	8.35E-03	4.11E-01
6.00E+01	8.15E-02	2.02E-02	5.63E-02	2.15E-02	1.23E+03	1.88E-01	6.51E+00
3.16E+01	3.51E-02	3.19E-02	3.56E-02	1.35E-02	1.07E+03	1.64E-01	4.98E+00
8.50E+00	5.49E-03	8.72E-03	9.17E-03	3.33E-03	1.09E+03	3.73E-02	1.14E+00
1.47E+01	9.72E-03	8.97E-03	1.35E-02	4.87E-03	1.58E+03	5.45E-02	1.64E+00
2.49E+01	2.18E-02	1.54E-02	2.37E-02	8.80E-03	1.20E+03	8.98E-02	2.74E+00
3.85E+01	2.91E-02	3.66E-02	3.55E-02	1.33E-02	1.72E+03	1.98E-01	5.63E+00
4.22E+00	6.19E-03	2.68E-03	2.58E-03	9.46E-04	4.52E+02	7.64E-03	3.68E-01
8.09E+00	5.15E+00	4.87E-02	9.01E-04	2.40E-01	1.70E+03	5.96E-02	4.66E+00
1.80E+00	6.18E-03	1.12E-03	4.13E-04	5.11E-04	3.39E+02	2.77E-03	8.36E-02
2.40E+00	1.14E-02	1.49E-03	6.77E-04	8.43E-04	4.31E+02	3.49E-03	1.43E-01
2.22E+00	1.05E-02	1.48E-03	6.30E-04	7.75E-04	4.19E+02	3.27E-03	1.34E-01
1.86E+00	5.53E-02	3.42E-03	3.46E-03	3.90E-02	2.01E+03	3.08E-01	7.53E+00
1.48E+00	5.82E-02	3.42E-03	2.76E-03	3.23E-02	1.93E+03	2.21E-01	6.00E+00
2.85E+00	4.00E-02	3.41E-03	5.78E-03	6.09E-02	1.89E+03	4.81E-01	1.15E+01
1.40E+00	6.83E-03	6.97E-04	1.59E-04	2.14E-03	3.59E+02	3.27E-03	9.36E-02
1.77E+00	3.00E-02	2.61E-03	1.59E-03	1.83E-02	7.05E+02	5.14E-02	1.19E+00
2.15E+00	4.11E-02	3.42E-03	6.82E-03	7.13E-02	1.16E+03	3.82E-01	6.51E+00
1.08E+00	6.07E-02	3.42E-03	2.89E-03	3.38E-02	1.11E+03	1.36E-01	2.71E+00
1.25E+00	6.05E-02	3.42E-03	3.27E-03	3.76E-02	1.17E+03	1.66E-01	3.23E+00
3.12E+00	4.46E-02	3.42E-03	5.29E-03	5.64E-02	1.58E+03	3.86E-01	9.21E+00
1.83E+00	5.35E-02	3.42E-03	5.39E-03	5.81E-02	1.24E+03	2.75E-01	4.78E+00
1.38E+00	5.05E-02	3.42E-03	2.61E-03	3.01E-02	1.78E+03	2.21E-01	5.50E+00
2.01E+00	2.58E-02	2.39E-03	1.84E-03	2.04E-02	6.70E+02	6.24E-02	1.27E+00
1.33E+02	1.90E-01	3.24E-02	1.17E-01	4.50E-02	1.81E+03	2.49E-01	1.20E+01
1.53E+01	3.47E-02	3.54E-03	3.48E-02	1.25E-02	4.30E+02	2.32E-02	8.77E-01
2.05E+00	3.05E-03	2.17E-03	1.34E-03	4.96E-04	3.63E+02	5.01E-03	1.76E-01

3.24E+00	4.73E-03	3.79E-03	2.80E-03	1.04E-03	4.72E+02	5.55E-03	3.35E-01
4.23E+01	8.46E-02	2.88E-02	5.94E-02	2.27E-02	1.09E+03	7.08E-02	5.24E+00
2.80E+01	4.02E-02	4.55E-02	4.27E-02	1.61E-02	1.09E+03	2.81E-02	4.88E+00
8.34E+00	6.47E-03	1.24E-02	1.13E-02	4.13E-03	1.11E+03	1.10E-02	1.13E+00
1.31E+01	1.10E-02	1.28E-02	1.65E-02	5.97E-03	1.46E+03	2.74E-02	1.45E+00
2.02E+01	2.35E-02	2.19E-02	2.68E-02	9.96E-03	1.16E+03	2.47E-02	2.56E+00
3.71E+01	3.18E-02	5.22E-02	4.05E-02	1.52E-02	1.67E+03	9.66E-02	5.40E+00
3.17E+00	4.73E-03	3.82E-03	2.44E-03	8.98E-04	4.73E+02	5.34E-03	3.10E-01
7.32E+00	6.06E+00	6.95E-02	1.03E-03	2.54E-01	1.60E+03	4.13E-02	4.09E+00
1.24E+00	4.51E-03	1.60E-03	3.28E-04	4.03E-04	3.55E+02	2.26E-03	6.63E-02
1.54E+00	7.46E-03	2.12E-03	4.99E-04	6.11E-04	4.42E+02	2.45E-03	1.01E-01
1.48E+00	7.07E-03	2.11E-03	4.78E-04	5.76E-04	4.39E+02	2.41E-03	9.70E-02
1.75E+00	5.02E-02	3.07E-03	3.18E-03	3.58E-02	1.97E+03	2.91E-01	7.25E+00
1.39E+00	5.28E-02	3.07E-03	2.53E-03	2.96E-02	1.89E+03	2.12E-01	5.82E+00
2.62E+00	3.53E-02	2.84E-03	5.14E-03	5.41E-02	1.91E+03	4.46E-01	1.16E+01
1.94E+00	8.84E-03	5.78E-04	1.90E-04	2.62E-03	3.53E+02	3.91E-03	1.09E-01
2.06E+00	2.84E-02	2.16E-03	1.45E-03	1.68E-02	6.92E+02	4.85E-02	1.16E+00
2.17E+00	3.93E-02	2.84E-03	6.44E-03	6.74E-02	1.33E+03	3.76E-01	7.37E+00
9.63E-01	5.14E-02	2.84E-03	2.47E-03	2.88E-02	1.13E+03	1.24E-01	2.68E+00
1.11E+00	5.13E-02	2.84E-03	2.79E-03	3.20E-02	1.19E+03	1.50E-01	3.18E+00
3.25E+00	4.26E-02	2.84E-03	5.15E-03	5.48E-02	1.78E+03	3.91E-01	9.92E+00
1.62E+00	4.53E-02	2.84E-03	4.59E-03	4.94E-02	1.31E+03	2.47E-01	4.93E+00
1.34E+00	4.80E-02	2.84E-03	2.46E-03	2.84E-02	1.91E+03	2.18E-01	5.80E+00
2.26E+00	2.48E-02	1.98E-03	1.67E-03	1.87E-02	6.49E+02	5.82E-02	1.22E+00
1.35E+02	1.84E-01	2.90E-02	1.13E-01	4.34E-02	1.79E+03	3.27E-01	1.21E+01
1.51E+01	3.23E-02	2.94E-03	3.23E-02	1.17E-02	4.39E+02	3.18E-02	8.95E-01
2.71E+00	3.65E-03	1.80E-03	1.42E-03	5.26E-04	3.57E+02	6.55E-03	1.93E-01
4.30E+00	5.92E-03	3.15E-03	2.98E-03	1.10E-03	4.67E+02	8.30E-03	3.79E-01
5.65E+01	8.86E-02	2.39E-02	6.18E-02	2.36E-02	1.26E+03	1.74E-01	6.53E+00
3.30E+01	4.03E-02	3.78E-02	4.19E-02	1.58E-02	1.15E+03	1.71E-01	5.22E+00
9.05E+00	6.35E-03	1.03E-02	1.09E-02	3.96E-03	1.16E+03	3.80E-02	1.20E+00
1.48E+01	1.07E-02	1.06E-02	1.54E-02	5.55E-03	1.60E+03	5.17E-02	1.65E+00
2.45E+01	2.40E-02	1.82E-02	2.68E-02	9.96E-03	1.24E+03	9.04E-02	2.79E+00
3.93E+01	3.24E-02	4.34E-02	4.13E-02	1.55E-02	1.75E+03	1.96E-01	5.71E+00
3.94E+00	5.59E-03	3.17E-03	2.52E-03	9.26E-04	4.61E+02	7.43E-03	3.40E-01
8.25E+00	5.77E+00	5.77E-02	9.97E-04	2.56E-01	1.73E+03	5.91E-02	4.67E+00
1.71E+00	5.61E-03	1.33E-03	3.86E-04	4.76E-04	3.49E+02	2.79E-03	7.64E-02
2.20E+00	9.94E-03	1.76E-03	6.12E-04	7.57E-04	4.37E+02	3.48E-03	1.25E-01
2.01E+00	9.03E-03	1.75E-03	5.65E-04	6.90E-04	4.27E+02	3.19E-03	1.17E-01
2.58E+00	8.83E-02	5.71E-03	5.27E-03	5.98E-02	2.48E+03	4.63E-01	9.51E+00
2.06E+00	9.30E-02	5.70E-03	4.19E-03	4.94E-02	2.38E+03	3.31E-01	7.51E+00
3.96E+00	6.28E-02	5.69E-03	8.67E-03	9.15E-02	2.32E+03	7.19E-01	1.40E+01
1.66E+00	6.93E-03	1.16E-03	1.80E-04	2.36E-03	4.53E+02	3.99E-03	8.84E-02
2.30E+00	4.27E-02	4.35E-03	2.30E-03	2.64E-02	8.69E+02	7.11E-02	1.57E+00
2.80E+00	6.01E-02	5.69E-03	9.90E-03	1.04E-01	1.43E+03	5.42E-01	8.27E+00

1.54E+00	9.47E-02	5.70E-03	4.45E-03	5.22E-02	1.62E+03	2.04E-01	4.03E+00
1.79E+00	9.46E-02	5.71E-03	5.05E-03	5.81E-02	1.68E+03	2.49E-01	4.72E+00
3.90E+00	6.60E-02	5.70E-03	7.34E-03	7.86E-02	1.75E+03	5.34E-01	1.12E+01
2.62E+00	8.39E-02	5.70E-03	8.34E-03	9.00E-02	1.72E+03	4.10E-01	6.76E+00
1.87E+00	7.86E-02	5.70E-03	3.89E-03	4.52E-02	2.15E+03	3.31E-01	6.83E+00
2.64E+00	3.57E-02	3.98E-03	2.67E-03	2.95E-02	8.29E+02	8.71E-02	1.69E+00
1.52E+02	2.88E-01	5.40E-02	1.79E-01	6.87E-02	2.25E+03	2.80E-01	1.36E+01
1.65E+01	4.76E-02	5.91E-03	4.77E-02	1.72E-02	4.57E+02	2.40E-02	7.71E-01
2.50E+00	3.48E-03	3.61E-03	1.74E-03	6.50E-04	4.61E+02	6.05E-03	1.79E-01
3.73E+00	5.06E-03	6.32E-03	3.56E-03	1.33E-03	5.85E+02	6.02E-03	3.21E-01
4.60E+01	1.29E-01	4.80E-02	9.18E-02	3.51E-02	1.28E+03	7.08E-02	5.19E+00
3.81E+01	6.76E-02	7.59E-02	7.50E-02	2.84E-02	1.45E+03	3.46E-02	5.68E+00
1.15E+01	1.11E-02	2.07E-02	2.04E-02	7.43E-03	1.48E+03	1.12E-02	1.33E+00
1.43E+01	1.66E-02	2.13E-02	2.66E-02	9.67E-03	1.66E+03	2.71E-02	1.49E+00
2.61E+01	3.84E-02	3.66E-02	4.58E-02	1.70E-02	1.51E+03	2.52E-02	2.97E+00
4.65E+01	5.17E-02	8.71E-02	7.21E-02	2.72E-02	2.07E+03	1.10E-01	6.17E+00
3.69E+00	5.34E-03	6.36E-03	3.19E-03	1.18E-03	5.88E+02	5.79E-03	3.00E-01
8.10E+00	9.46E+00	1.16E-01	1.57E-03	3.54E-01	1.90E+03	3.57E-02	4.22E+00
1.50E+00	4.87E-03	2.67E-03	3.77E-04	4.65E-04	4.50E+02	2.79E-03	6.32E-02
1.69E+00	7.22E-03	3.53E-03	5.30E-04	6.46E-04	5.47E+02	2.67E-03	8.76E-02
1.66E+00	6.88E-03	3.52E-03	5.11E-04	6.11E-04	5.45E+02	2.63E-03	8.45E-02

Sum of emisRate - 35 mph

RoadType	yearID	FuelType	SourceType	Pollutant PM2.5 Tirewear g/mi
Rural Restricted Access	2028	Diesel Fuel	Combination Long-haul Truck	4.39E-03
			Combination Short-haul Truck	3.92E-03
			Intercity Bus	3.44E-03
			Passenger Car	1.15E-03
			Passenger Truck	1.44E-03
			School Bus	2.09E-03
			Single Unit Long-haul Truck	2.46E-03
			Single Unit Short-haul Truck	2.19E-03
			Transit Bus	2.29E-03
			Motor Home	1.86E-03
			Refuse Truck	4.21E-03
			Light Commercial Truck	1.39E-03
		Gasoline	Combination Short-haul Truck	4.49E-03
			Motorcycle	5.73E-04
			Passenger Car	1.15E-03
			Passenger Truck	1.15E-03
			School Bus	2.09E-03
			Single Unit Long-haul Truck	1.69E-03
			Single Unit Short-haul Truck	1.69E-03
			Transit Bus	3.37E-03
			Motor Home	1.86E-03
			Refuse Truck	1.59E-03
			Light Commercial Truck	1.17E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.29E-03
		Ethanol (E-85)	Passenger Car	1.15E-03
			Passenger Truck	1.15E-03
			Light Commercial Truck	1.15E-03
Rural Unrestricted Acces	2028	Diesel Fuel	Combination Long-haul Truck	4.88E-03
			Combination Short-haul Truck	4.36E-03
			Intercity Bus	4.03E-03
			Passenger Car	1.34E-03
			Passenger Truck	1.68E-03
			School Bus	2.44E-03
			Single Unit Long-haul Truck	2.88E-03
			Single Unit Short-haul Truck	2.57E-03
			Transit Bus	2.68E-03
			Motor Home	2.18E-03
			Refuse Truck	4.92E-03
			Light Commercial Truck	1.62E-03
		Gasoline	Combination Short-haul Truck	4.99E-03
			Motorcycle	6.71E-04
			Passenger Car	1.34E-03

			Passenger Truck	1.35E-03
			School Bus	2.44E-03
			Single Unit Long-haul Truck	1.98E-03
			Single Unit Short-haul Truck	1.98E-03
			Transit Bus	3.94E-03
			Motor Home	2.18E-03
			Refuse Truck	1.87E-03
			Light Commercial Truck	1.37E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.68E-03
		Ethanol (E-85)	Passenger Car	1.34E-03
			Passenger Truck	1.34E-03
			Light Commercial Truck	1.34E-03
Urban Restricted Access	2028	Diesel Fuel	Combination Long-haul Truck	4.70E-03
			Combination Short-haul Truck	4.20E-03
			Intercity Bus	3.71E-03
			Passenger Car	1.24E-03
			Passenger Truck	1.55E-03
			School Bus	2.25E-03
			Single Unit Long-haul Truck	2.65E-03
			Single Unit Short-haul Truck	2.37E-03
			Transit Bus	2.47E-03
			Motor Home	2.01E-03
			Refuse Truck	4.54E-03
			Light Commercial Truck	1.50E-03
		Gasoline	Combination Short-haul Truck	4.81E-03
			Motorcycle	6.19E-04
			Passenger Car	1.24E-03
			Passenger Truck	1.25E-03
			School Bus	2.25E-03
			Single Unit Long-haul Truck	1.82E-03
			Single Unit Short-haul Truck	1.82E-03
			Transit Bus	3.64E-03
			Motor Home	2.01E-03
			Refuse Truck	1.72E-03
			Light Commercial Truck	1.27E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.47E-03
		Ethanol (E-85)	Passenger Car	1.24E-03
			Passenger Truck	1.24E-03
			Light Commercial Truck	1.24E-03
Urban Unrestricted Acces	2028	Diesel Fuel	Combination Long-haul Truck	5.58E-03
			Combination Short-haul Truck	4.98E-03
			Intercity Bus	4.60E-03
			Passenger Car	1.53E-03
			Passenger Truck	1.92E-03
			School Bus	2.79E-03

	Single Unit Long-haul Truck	3.29E-03
	Single Unit Short-haul Truck	2.93E-03
	Transit Bus	3.07E-03
	Motor Home	2.49E-03
	Refuse Truck	5.63E-03
	Light Commercial Truck	1.86E-03
Gasoline	Combination Short-haul Truck	5.71E-03
	Motorcycle	7.67E-04
	Passenger Car	1.53E-03
	Passenger Truck	1.54E-03
	School Bus	2.79E-03
	Single Unit Long-haul Truck	2.26E-03
	Single Unit Short-haul Truck	2.26E-03
	Transit Bus	4.51E-03
	Motor Home	2.49E-03
	Refuse Truck	2.13E-03
	Light Commercial Truck	1.57E-03
Compressed Natural Gas (CNG)	Transit Bus	3.07E-03
Ethanol (E-85)	Passenger Car	1.53E-03
	Passenger Truck	1.53E-03
	Light Commercial Truck	1.53E-03

RateUnit

PM2.5 Brakewea:	PM10 Tirewear	PM10 Brakewear	PM10 Total Exh	VOC	SO2	NOx
g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi
1.19E-02	2.93E-02	9.53E-02	6.81E-02	1.01E-01	1.38E-02	2.11E+00
1.08E-02	2.61E-02	8.65E-02	3.96E-02	7.73E-02	1.33E-02	1.57E+00
9.98E-03	2.29E-02	7.98E-02	1.14E-01	1.76E-01	1.40E-02	3.19E+00
1.54E-03	7.64E-03	1.24E-02	3.23E-03	1.06E-02	1.81E-03	5.70E-02
2.32E-03	9.59E-03	1.86E-02	1.12E-02	3.60E-02	4.37E-03	3.38E-01
7.47E-03	1.39E-02	5.97E-02	7.43E-02	1.96E-01	9.20E-03	2.08E+00
7.91E-03	1.64E-02	6.33E-02	2.15E-02	6.34E-02	7.43E-03	7.80E-01
6.84E-03	1.46E-02	5.47E-02	2.17E-02	6.29E-02	7.91E-03	8.23E-01
6.42E-03	1.53E-02	5.13E-02	8.52E-02	1.41E-01	1.27E-02	2.46E+00
5.48E-03	1.24E-02	4.38E-02	4.65E-02	1.27E-01	8.93E-03	1.41E+00
1.10E-02	2.80E-02	8.80E-02	4.09E-02	7.22E-02	1.40E-02	1.56E+00
2.42E-03	9.25E-03	1.94E-02	1.10E-02	3.64E-02	3.94E-03	3.10E-01
1.21E-02	2.99E-02	9.71E-02	1.35E-01	7.83E-01	1.06E-02	3.05E+00
1.24E-04	3.82E-03	9.92E-04	3.25E-02	5.02E-01	2.58E-03	8.07E-01
1.54E-03	7.64E-03	1.24E-02	3.18E-03	1.15E-02	1.41E-03	5.31E-02
2.45E-03	7.70E-03	1.96E-02	5.01E-03	2.18E-02	1.92E-03	1.12E-01
7.45E-03	1.39E-02	5.96E-02	3.99E-02	2.48E-01	6.93E-03	8.29E-01
4.78E-03	1.13E-02	3.83E-02	1.86E-01	6.71E-01	6.25E-03	3.70E+00
4.86E-03	1.13E-02	3.89E-02	2.34E-02	1.10E-01	6.28E-03	4.04E-01
1.00E-02	2.25E-02	8.01E-02	3.60E-02	2.53E-01	9.27E-03	7.52E-01
5.48E-03	1.24E-02	4.38E-02	4.12E-02	2.19E-01	6.82E-03	6.98E-01
2.71E-03	1.06E-02	2.16E-02	5.51E-02	2.83E-01	1.01E-02	8.62E-01
2.52E-03	7.82E-03	2.02E-02	4.82E-03	2.05E-02	1.91E-03	1.12E-01
6.42E-03	1.53E-02	5.13E-02	1.20E-02	1.71E-01	7.29E-03	2.12E+00
1.54E-03	7.64E-03	1.24E-02	1.99E-03	1.35E-02	1.62E-03	4.41E-02
2.46E-03	7.64E-03	1.96E-02	2.88E-03	2.16E-02	2.15E-03	7.91E-02
2.54E-03	7.64E-03	2.03E-02	2.63E-03	2.00E-02	2.09E-03	7.29E-02
1.67E-02	3.26E-02	1.33E-01	7.46E-02	1.13E-01	1.39E-02	2.18E+00
1.51E-02	2.91E-02	1.21E-01	4.30E-02	8.58E-02	1.33E-02	1.61E+00
1.51E-02	2.68E-02	1.21E-01	1.27E-01	2.04E-01	1.35E-02	3.13E+00
2.50E-03	8.94E-03	2.00E-02	2.62E-03	8.17E-03	1.79E-03	4.13E-02
3.97E-03	1.12E-02	3.17E-02	1.12E-02	3.79E-02	4.35E-03	3.45E-01
1.00E-02	1.63E-02	8.03E-02	7.35E-02	1.90E-01	6.89E-03	1.62E+00
1.13E-02	1.92E-02	9.01E-02	2.28E-02	7.40E-02	6.95E-03	7.79E-01
9.79E-03	1.71E-02	7.83E-02	2.35E-02	7.36E-02	7.44E-03	8.22E-01
9.18E-03	1.79E-02	7.34E-02	8.04E-02	1.31E-01	9.75E-03	1.98E+00
7.97E-03	1.45E-02	6.37E-02	5.13E-02	1.49E-01	7.81E-03	1.31E+00
1.66E-02	3.28E-02	1.33E-01	4.38E-02	8.13E-02	1.33E-02	1.55E+00
4.02E-03	1.08E-02	3.22E-02	1.11E-02	3.82E-02	3.98E-03	3.15E-01
1.70E-02	3.33E-02	1.36E-01	7.26E-02	8.47E-01	1.06E-02	3.03E+00
2.17E-04	4.47E-03	1.74E-03	2.24E-02	5.27E-01	2.42E-03	7.57E-01
2.50E-03	8.94E-03	2.00E-02	2.56E-03	9.13E-03	1.40E-03	3.84E-02

4.14E-03	9.01E-03	3.31E-02	3.61E-03	1.64E-02	1.87E-03	7.98E-02
1.00E-02	1.63E-02	8.02E-02	1.09E-02	2.30E-01	5.15E-03	5.90E-01
6.67E-03	1.32E-02	5.34E-02	1.56E-02	6.55E-01	5.65E-03	3.40E+00
6.86E-03	1.32E-02	5.49E-02	7.93E-03	1.07E-01	5.78E-03	3.69E-01
1.42E-02	2.63E-02	1.14E-01	2.02E-02	2.54E-01	7.39E-03	5.81E-01
7.97E-03	1.45E-02	6.37E-02	1.10E-02	2.03E-01	5.93E-03	6.24E-01
4.06E-03	1.24E-02	3.25E-02	3.03E-02	2.98E-01	9.77E-03	8.27E-01
4.16E-03	9.15E-03	3.32E-02	3.74E-03	1.64E-02	1.89E-03	8.49E-02
9.18E-03	1.79E-02	7.34E-02	7.51E-03	1.86E-01	5.81E-03	1.63E+00
2.50E-03	8.94E-03	2.00E-02	1.61E-03	1.11E-02	1.60E-03	3.16E-02
4.15E-03	8.94E-03	3.32E-02	2.11E-03	1.63E-02	2.09E-03	5.36E-02
4.17E-03	8.94E-03	3.34E-02	2.07E-03	1.58E-02	2.07E-03	5.12E-02
1.53E-02	3.13E-02	1.22E-01	7.27E-02	1.08E-01	1.38E-02	2.14E+00
1.38E-02	2.80E-02	1.11E-01	4.21E-02	8.25E-02	1.33E-02	1.59E+00
1.26E-02	2.48E-02	1.01E-01	1.21E-01	1.89E-01	1.38E-02	3.16E+00
1.98E-03	8.25E-03	1.58E-02	3.16E-03	9.68E-03	1.81E-03	5.00E-02
2.99E-03	1.03E-02	2.39E-02	1.15E-02	3.74E-02	4.37E-03	3.42E-01
9.21E-03	1.50E-02	7.37E-02	7.97E-02	2.13E-01	9.08E-03	2.06E+00
9.55E-03	1.77E-02	7.64E-02	2.29E-02	6.91E-02	7.68E-03	8.15E-01
8.29E-03	1.58E-02	6.63E-02	2.32E-02	6.85E-02	8.11E-03	8.53E-01
8.10E-03	1.65E-02	6.48E-02	8.99E-02	1.51E-01	1.25E-02	2.43E+00
6.71E-03	1.34E-02	5.37E-02	4.96E-02	1.39E-01	8.84E-03	1.42E+00
1.40E-02	3.03E-02	1.12E-01	4.31E-02	7.69E-02	1.38E-02	1.57E+00
3.10E-03	9.99E-03	2.48E-02	1.13E-02	3.75E-02	3.95E-03	3.11E-01
1.56E-02	3.21E-02	1.25E-01	1.28E-01	8.80E-01	1.07E-02	3.07E+00
1.61E-04	4.13E-03	1.29E-03	3.32E-02	5.21E-01	2.54E-03	7.97E-01
1.98E-03	8.25E-03	1.58E-02	3.11E-03	1.07E-02	1.42E-03	4.65E-02
3.16E-03	8.31E-03	2.53E-02	4.95E-03	1.98E-02	1.91E-03	9.80E-02
9.19E-03	1.50E-02	7.36E-02	3.73E-02	2.69E-01	6.96E-03	8.39E-01
5.71E-03	1.21E-02	4.56E-02	1.88E-01	7.61E-01	6.46E-03	3.79E+00
5.84E-03	1.22E-02	4.67E-02	2.31E-02	1.21E-01	6.47E-03	4.13E-01
1.26E-02	2.42E-02	1.01E-01	3.43E-02	2.69E-01	9.25E-03	7.53E-01
6.71E-03	1.34E-02	5.37E-02	4.08E-02	2.37E-01	6.86E-03	7.08E-01
3.41E-03	1.15E-02	2.73E-02	5.45E-02	3.04E-01	1.01E-02	8.64E-01
3.24E-03	8.44E-03	2.59E-02	4.67E-03	1.86E-02	1.90E-03	9.87E-02
8.10E-03	1.65E-02	6.48E-02	1.17E-02	1.87E-01	7.27E-03	2.12E+00
1.98E-03	8.25E-03	1.58E-02	1.95E-03	1.26E-02	1.63E-03	3.85E-02
3.16E-03	8.25E-03	2.53E-02	2.84E-03	1.97E-02	2.13E-03	6.82E-02
3.25E-03	8.25E-03	2.60E-02	2.55E-03	1.81E-02	2.08E-03	6.22E-02
2.90E-02	3.72E-02	2.32E-01	9.19E-02	1.39E-01	1.51E-02	2.42E+00
2.61E-02	3.32E-02	2.09E-01	5.25E-02	1.05E-01	1.44E-02	1.78E+00
2.54E-02	3.07E-02	2.03E-01	1.56E-01	2.50E-01	1.45E-02	3.40E+00
4.06E-03	1.02E-02	3.25E-02	2.76E-03	8.08E-03	1.95E-03	3.60E-02
6.42E-03	1.28E-02	5.14E-02	1.27E-02	4.46E-02	4.68E-03	3.93E-01
1.46E-02	1.86E-02	1.17E-01	8.39E-02	2.24E-01	7.21E-03	1.71E+00

1.79E-02	2.19E-02	1.43E-01	2.71E-02	9.27E-02	8.36E-03	9.41E-01
1.55E-02	1.96E-02	1.24E-01	2.79E-02	9.24E-02	8.86E-03	9.82E-01
1.43E-02	2.04E-02	1.15E-01	9.31E-02	1.49E-01	9.47E-03	2.04E+00
1.24E-02	1.66E-02	9.90E-02	6.02E-02	1.87E-01	9.06E-03	1.53E+00
2.76E-02	3.75E-02	2.21E-01	5.35E-02	9.81E-02	1.44E-02	1.73E+00
6.52E-03	1.24E-02	5.21E-02	1.24E-02	4.46E-02	4.29E-03	3.56E-01
2.95E-02	3.80E-02	2.36E-01	7.82E-02	1.21E+00	1.16E-02	3.20E+00
3.57E-04	5.11E-03	2.86E-03	2.17E-02	5.99E-01	2.36E-03	6.70E-01
4.06E-03	1.02E-02	3.25E-02	2.70E-03	9.15E-03	1.52E-03	3.35E-02
6.75E-03	1.03E-02	5.40E-02	3.62E-03	1.61E-02	2.01E-03	6.97E-02
1.46E-02	1.86E-02	1.17E-01	8.42E-03	2.96E-01	5.23E-03	5.28E-01
1.02E-02	1.51E-02	8.19E-02	1.36E-02	9.53E-01	6.36E-03	3.47E+00
1.06E-02	1.51E-02	8.46E-02	7.13E-03	1.46E-01	6.54E-03	3.83E-01
2.21E-02	3.00E-02	1.77E-01	1.90E-02	3.16E-01	7.43E-03	5.51E-01
1.24E-02	1.66E-02	9.90E-02	9.41E-03	2.73E-01	6.58E-03	6.38E-01
6.46E-03	1.42E-02	5.17E-02	3.17E-02	3.92E-01	1.08E-02	8.73E-01
6.76E-03	1.05E-02	5.41E-02	3.73E-03	1.63E-02	2.04E-03	7.50E-02
1.43E-02	2.04E-02	1.15E-01	6.32E-03	2.45E-01	5.84E-03	1.54E+00
4.06E-03	1.02E-02	3.25E-02	1.69E-03	1.12E-02	1.75E-03	2.74E-02
6.76E-03	1.02E-02	5.41E-02	2.11E-03	1.60E-02	2.25E-03	4.56E-02
6.79E-03	1.02E-02	5.44E-02	2.07E-03	1.55E-02	2.22E-03	4.36E-02

CO g/mi	Methane (CH4) g/mi	N2O g/mi	Benzene g/mi	Formaldehyde g/mi	CO2 Equivalent g/mi	PM2.5 Total Ex g/mi	NOx
4.84E-01	3.85E-02	1.72E-03	7.72E-04	1.09E-02	1.60E+03	6.27E-02	2.11E+00
3.83E-01	3.91E-02	1.72E-03	6.04E-04	9.24E-03	1.55E+03	3.65E-02	1.57E+00
7.89E-01	3.44E-02	1.63E-03	1.34E-03	1.62E-02	1.61E+03	1.04E-01	3.19E+00
1.39E+00	9.24E-03	3.32E-04	1.13E-04	1.89E-03	2.10E+02	2.98E-03	5.70E-02
8.48E-01	2.34E-02	1.26E-03	3.60E-04	5.52E-03	5.08E+02	1.03E-02	3.38E-01
6.99E-01	3.68E-02	1.63E-03	1.57E-03	1.87E-02	1.06E+03	6.84E-02	2.08E+00
3.19E-01	3.87E-02	1.63E-03	5.94E-04	9.12E-03	8.64E+02	1.97E-02	7.80E-01
3.26E-01	3.88E-02	1.63E-03	5.94E-04	9.12E-03	9.20E+02	2.00E-02	8.23E-01
7.35E-01	3.70E-02	1.63E-03	1.10E-03	1.40E-02	1.47E+03	7.84E-02	2.46E+00
5.08E-01	3.83E-02	1.63E-03	1.05E-03	1.36E-02	1.03E+03	4.28E-02	1.41E+00
3.45E-01	3.71E-02	1.63E-03	5.44E-04	8.48E-03	1.62E+03	3.77E-02	1.56E+00
9.75E-01	2.13E-02	1.13E-03	3.56E-04	5.30E-03	4.58E+02	1.02E-02	3.10E-01
2.35E+01	7.93E-03	1.23E-02	2.90E-02	1.05E-02	1.59E+03	1.19E-01	3.05E+00
1.16E+01	2.46E-02	1.68E-03	2.18E-02	7.86E-03	3.88E+02	2.87E-02	8.07E-01
1.43E+00	1.92E-03	7.85E-04	4.27E-04	1.52E-04	2.12E+02	2.81E-03	5.31E-02
2.09E+00	2.87E-03	9.55E-04	8.35E-04	3.01E-04	2.89E+02	4.44E-03	1.12E-01
6.04E+00	2.23E-03	4.85E-03	7.38E-03	2.60E-03	1.04E+03	3.53E-02	8.29E-01
1.68E+01	7.67E-03	2.32E-02	2.09E-02	8.02E-03	9.45E+02	1.65E-01	3.70E+00
2.92E+00	1.16E-03	2.91E-03	3.38E-03	1.18E-03	9.43E+02	2.07E-02	4.04E-01
5.34E+00	2.15E-03	3.30E-03	6.56E-03	2.25E-03	1.39E+03	3.19E-02	7.52E-01
5.22E+00	1.85E-03	4.26E-03	6.22E-03	2.18E-03	1.03E+03	3.64E-02	6.98E-01
5.02E+00	2.24E-03	5.68E-03	6.52E-03	2.31E-03	1.52E+03	4.88E-02	8.62E-01
1.98E+00	2.72E-03	1.04E-03	7.81E-04	2.81E-04	2.88E+02	4.26E-03	1.12E-01
6.41E+00	2.64E+00	3.31E-02	3.64E-04	4.80E-02	1.45E+03	1.06E-02	2.12E+00
1.09E+00	3.25E-03	7.83E-04	2.60E-04	3.02E-04	2.11E+02	1.76E-03	4.41E-02
1.47E+00	5.11E-03	8.77E-04	4.35E-04	5.18E-04	2.80E+02	2.55E-03	7.91E-02
1.33E+00	4.65E-03	8.77E-04	3.98E-04	4.71E-04	2.71E+02	2.33E-03	7.29E-02
5.37E-01	4.50E-02	2.05E-03	8.95E-04	1.26E-02	1.61E+03	6.86E-02	2.18E+00
4.26E-01	4.57E-02	2.05E-03	7.02E-04	1.08E-02	1.55E+03	3.96E-02	1.61E+00
8.92E-01	4.23E-02	2.05E-03	1.60E-03	1.95E-02	1.55E+03	1.16E-01	3.13E+00
9.29E-01	6.74E-03	4.18E-04	8.27E-05	1.38E-03	2.08E+02	2.41E-03	4.13E-02
6.38E-01	2.45E-02	1.58E-03	3.80E-04	5.81E-03	5.06E+02	1.03E-02	3.45E-01
6.17E-01	3.63E-02	2.05E-03	1.56E-03	1.85E-02	7.94E+02	6.76E-02	1.62E+00
3.65E-01	4.72E-02	2.05E-03	7.22E-04	1.11E-02	8.09E+02	2.10E-02	7.79E-01
3.74E-01	4.74E-02	2.05E-03	7.23E-04	1.11E-02	8.66E+02	2.16E-02	8.22E-01
6.39E-01	3.69E-02	2.05E-03	1.06E-03	1.36E-02	1.13E+03	7.39E-02	1.98E+00
5.76E-01	4.71E-02	2.05E-03	1.28E-03	1.66E-02	9.04E+02	4.72E-02	1.31E+00
3.99E-01	4.55E-02	2.05E-03	6.63E-04	1.04E-02	1.55E+03	4.03E-02	1.55E+00
7.46E-01	2.17E-02	1.42E-03	3.72E-04	5.50E-03	4.62E+02	1.02E-02	3.15E-01
2.55E+01	8.71E-03	1.47E-02	3.18E-02	1.15E-02	1.59E+03	6.42E-02	3.03E+00
1.12E+01	2.60E-02	2.12E-03	2.31E-02	8.33E-03	3.65E+02	1.98E-02	7.57E-01
9.61E-01	1.40E-03	9.87E-04	3.17E-04	1.12E-04	2.10E+02	2.26E-03	3.84E-02

1.38E+00	1.96E-03	1.20E-03	5.91E-04	2.12E-04	2.81E+02	3.19E-03	7.98E-02
4.54E+00	2.28E-03	6.10E-03	7.52E-03	2.68E-03	7.75E+02	9.60E-03	5.90E-01
1.67E+01	7.56E-03	2.92E-02	2.06E-02	7.91E-03	8.57E+02	1.38E-02	3.40E+00
2.88E+00	1.14E-03	3.65E-03	3.36E-03	1.18E-03	8.68E+02	7.02E-03	3.69E-01
4.38E+00	2.49E-03	4.15E-03	7.62E-03	2.67E-03	1.11E+03	1.79E-02	5.81E-01
5.09E+00	1.77E-03	5.35E-03	5.97E-03	2.10E-03	8.92E+02	9.75E-03	6.24E-01
5.33E+00	2.52E-03	7.14E-03	7.29E-03	2.60E-03	1.47E+03	2.68E-02	8.27E-01
1.43E+00	1.98E-03	1.31E-03	5.90E-04	2.12E-04	2.85E+02	3.31E-03	8.49E-02
5.22E+00	3.02E+00	4.17E-02	4.09E-04	4.84E-02	1.18E+03	6.64E-03	1.63E+00
7.34E-01	2.38E-03	9.85E-04	1.97E-04	2.21E-04	2.09E+02	1.42E-03	3.16E-02
9.41E-01	3.44E-03	1.10E-03	3.02E-04	3.48E-04	2.72E+02	1.86E-03	5.36E-02
9.02E-01	3.28E-03	1.10E-03	2.89E-04	3.32E-04	2.69E+02	1.83E-03	5.12E-02
5.14E-01	4.25E-02	1.92E-03	8.46E-04	1.19E-02	1.60E+03	6.69E-02	2.14E+00
4.07E-01	4.31E-02	1.92E-03	6.64E-04	1.02E-02	1.55E+03	3.88E-02	1.59E+00
8.38E-01	3.81E-02	1.83E-03	1.46E-03	1.77E-02	1.59E+03	1.11E-01	3.16E+00
1.30E+00	8.31E-03	3.71E-04	1.02E-04	1.70E-03	2.11E+02	2.91E-03	5.00E-02
8.06E-01	2.43E-02	1.41E-03	3.75E-04	5.74E-03	5.08E+02	1.06E-02	3.42E-01
7.47E-01	4.08E-02	1.83E-03	1.73E-03	2.06E-02	1.05E+03	7.33E-02	2.06E+00
3.42E-01	4.27E-02	1.83E-03	6.54E-04	1.00E-02	8.94E+02	2.11E-02	8.15E-01
3.49E-01	4.28E-02	1.83E-03	6.55E-04	1.01E-02	9.43E+02	2.13E-02	8.53E-01
7.73E-01	4.10E-02	1.83E-03	1.19E-03	1.53E-02	1.44E+03	8.27E-02	2.43E+00
5.42E-01	4.25E-02	1.83E-03	1.16E-03	1.50E-02	1.02E+03	4.57E-02	1.42E+00
3.71E-01	4.11E-02	1.83E-03	6.01E-04	9.38E-03	1.60E+03	3.97E-02	1.57E+00
9.10E-01	2.17E-02	1.26E-03	3.67E-04	5.44E-03	4.58E+02	1.04E-02	3.11E-01
2.50E+01	9.09E-03	1.37E-02	3.32E-02	1.20E-02	1.61E+03	1.13E-01	3.07E+00
1.16E+01	2.56E-02	1.88E-03	2.27E-02	8.19E-03	3.82E+02	2.94E-02	7.97E-01
1.34E+00	1.73E-03	8.77E-04	3.86E-04	1.38E-04	2.13E+02	2.76E-03	4.65E-02
1.93E+00	2.54E-03	1.07E-03	7.44E-04	2.68E-04	2.87E+02	4.38E-03	9.80E-02
6.40E+00	2.51E-03	5.43E-03	8.29E-03	2.93E-03	1.05E+03	3.30E-02	8.39E-01
1.80E+01	8.80E-03	2.60E-02	2.40E-02	9.21E-03	9.78E+02	1.67E-01	3.79E+00
3.12E+00	1.32E-03	3.25E-03	3.84E-03	1.35E-03	9.72E+02	2.05E-02	4.13E-01
5.62E+00	2.40E-03	3.69E-03	7.32E-03	2.53E-03	1.39E+03	3.03E-02	7.53E-01
5.55E+00	2.09E-03	4.76E-03	7.01E-03	2.46E-03	1.03E+03	3.61E-02	7.08E-01
5.29E+00	2.54E-03	6.35E-03	7.34E-03	2.62E-03	1.53E+03	4.82E-02	8.64E-01
1.82E+00	2.39E-03	1.16E-03	6.94E-04	2.49E-04	2.86E+02	4.14E-03	9.87E-02
6.70E+00	2.93E+00	3.70E-02	4.02E-04	5.12E-02	1.46E+03	1.04E-02	2.12E+00
1.02E+00	2.92E-03	8.76E-04	2.37E-04	2.72E-04	2.11E+02	1.72E-03	3.85E-02
1.35E+00	4.49E-03	9.81E-04	3.86E-04	4.55E-04	2.78E+02	2.51E-03	6.82E-02
1.20E+00	4.04E-03	9.81E-04	3.49E-04	4.09E-04	2.70E+02	2.26E-03	6.22E-02
6.30E-01	5.82E-02	2.77E-03	1.14E-03	1.62E-02	1.75E+03	8.45E-02	2.42E+00
4.99E-01	5.91E-02	2.77E-03	8.99E-04	1.38E-02	1.68E+03	4.83E-02	1.78E+00
1.04E+00	5.40E-02	2.77E-03	2.00E-03	2.44E-02	1.67E+03	1.43E-01	3.40E+00
9.75E-01	6.47E-03	5.63E-04	7.96E-05	1.33E-03	2.27E+02	2.54E-03	3.60E-02
6.93E-01	2.90E-02	2.13E-03	4.51E-04	6.89E-03	5.44E+02	1.16E-02	3.93E-01
6.63E-01	4.31E-02	2.77E-03	1.85E-03	2.20E-02	8.30E+02	7.72E-02	1.71E+00

4.27E-01	5.98E-02	2.77E-03	9.12E-04	1.40E-02	9.73E+02	2.50E-02	9.41E-01
4.38E-01	6.01E-02	2.77E-03	9.16E-04	1.41E-02	1.03E+03	2.57E-02	9.82E-01
6.74E-01	4.43E-02	2.77E-03	1.24E-03	1.60E-02	1.10E+03	8.57E-02	2.04E+00
6.77E-01	5.98E-02	2.77E-03	1.62E-03	2.10E-02	1.05E+03	5.54E-02	1.53E+00
4.64E-01	5.76E-02	2.77E-03	8.37E-04	1.31E-02	1.67E+03	4.93E-02	1.73E+00
8.04E-01	2.53E-02	1.91E-03	4.37E-04	6.44E-03	4.98E+02	1.14E-02	3.56E-01
3.06E+01	1.29E-02	1.98E-02	4.71E-02	1.71E-02	1.74E+03	6.92E-02	3.20E+00
1.09E+01	2.98E-02	2.85E-03	2.64E-02	9.54E-03	3.57E+02	1.92E-02	6.70E-01
1.01E+00	1.35E-03	1.33E-03	3.08E-04	1.09E-04	2.29E+02	2.39E-03	3.35E-02
1.39E+00	1.82E-03	1.62E-03	5.64E-04	2.03E-04	3.02E+02	3.20E-03	6.97E-02
4.68E+00	3.15E-03	8.23E-03	1.04E-02	3.73E-03	7.88E+02	7.45E-03	5.28E-01
1.95E+01	1.13E-02	3.94E-02	3.07E-02	1.18E-02	9.67E+02	1.20E-02	3.47E+00
3.40E+00	1.68E-03	4.93E-03	4.96E-03	1.76E-03	9.84E+02	6.31E-03	3.83E-01
4.65E+00	3.42E-03	5.59E-03	1.04E-02	3.69E-03	1.12E+03	1.68E-02	5.51E-01
5.99E+00	2.59E-03	7.22E-03	8.73E-03	3.10E-03	9.91E+02	8.32E-03	6.38E-01
6.38E+00	3.66E-03	9.63E-03	1.05E-02	3.80E-03	1.62E+03	2.80E-02	8.73E-01
1.46E+00	1.87E-03	1.76E-03	5.76E-04	2.06E-04	3.07E+02	3.30E-03	7.50E-02
5.50E+00	4.10E+00	5.62E-02	5.50E-04	6.06E-02	1.22E+03	5.59E-03	1.54E+00
7.72E-01	2.29E-03	1.33E-03	1.93E-04	2.14E-04	2.27E+02	1.50E-03	2.74E-02
9.44E-01	3.18E-03	1.49E-03	2.83E-04	3.21E-04	2.92E+02	1.87E-03	4.56E-02
9.16E-01	3.04E-03	1.49E-03	2.72E-04	3.07E-04	2.89E+02	1.83E-03	4.36E-02

Sum of emisRate				Pollutant
				PM2.5 Tirewear
RoadType	yearID	FuelType	SourceType	g/mi
Rural Restricted Access	2038	Diesel Fuel	Combination Long-haul Truck	4.39E-03
			Combination Short-haul Truck	3.92E-03
			Intercity Bus	3.44E-03
			Passenger Car	1.15E-03
			Passenger Truck	1.44E-03
			School Bus	2.09E-03
			Single Unit Long-haul Truck	2.46E-03
			Single Unit Short-haul Truck	2.19E-03
			Transit Bus	2.29E-03
			Motor Home	1.86E-03
			Refuse Truck	4.21E-03
			Light Commercial Truck	1.39E-03
		Gasoline	Motorcycle	5.73E-04
			Passenger Car	1.15E-03
			Passenger Truck	1.15E-03
			School Bus	2.08E-03
			Single Unit Short-haul Truck	1.69E-03
			Transit Bus	3.37E-03
			Motor Home	1.86E-03
			Refuse Truck	1.58E-03
			Light Commercial Truck	1.17E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.29E-03
		Ethanol (E-85)	Passenger Car	1.15E-03
			Passenger Truck	1.15E-03
			Light Commercial Truck	1.15E-03
Rural Unrestricted Acces	2038	Diesel Fuel	Combination Long-haul Truck	4.88E-03
			Combination Short-haul Truck	4.36E-03
			Intercity Bus	4.03E-03
			Passenger Car	1.34E-03
			Passenger Truck	1.68E-03
			School Bus	2.44E-03
			Single Unit Long-haul Truck	2.88E-03
			Single Unit Short-haul Truck	2.56E-03
			Transit Bus	2.68E-03
			Motor Home	2.18E-03
			Refuse Truck	4.92E-03
			Light Commercial Truck	1.62E-03
		Gasoline	Motorcycle	6.71E-04
			Passenger Car	1.34E-03
			Passenger Truck	1.35E-03
			School Bus	2.44E-03
			Single Unit Short-haul Truck	1.98E-03

			Transit Bus	3.94E-03
			Motor Home	2.18E-03
			Refuse Truck	1.85E-03
			Light Commercial Truck	1.37E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.68E-03
		Ethanol (E-85)	Passenger Car	1.34E-03
			Passenger Truck	1.34E-03
			Light Commercial Truck	1.34E-03
Urban Restricted Access	2038	Diesel Fuel	Combination Long-haul Truck	4.70E-03
			Combination Short-haul Truck	4.20E-03
			Intercity Bus	3.71E-03
			Passenger Car	1.24E-03
			Passenger Truck	1.55E-03
			School Bus	2.25E-03
			Single Unit Long-haul Truck	2.65E-03
			Single Unit Short-haul Truck	2.37E-03
			Transit Bus	2.47E-03
			Motor Home	2.01E-03
			Refuse Truck	4.54E-03
			Light Commercial Truck	1.50E-03
		Gasoline	Motorcycle	6.19E-04
			Passenger Car	1.24E-03
			Passenger Truck	1.25E-03
			School Bus	2.25E-03
			Single Unit Short-haul Truck	1.82E-03
			Transit Bus	3.64E-03
			Motor Home	2.01E-03
			Refuse Truck	1.71E-03
			Light Commercial Truck	1.27E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.47E-03
		Ethanol (E-85)	Passenger Car	1.24E-03
			Passenger Truck	1.24E-03
			Light Commercial Truck	1.24E-03
Urban Unrestricted Acces	2038	Diesel Fuel	Combination Long-haul Truck	5.58E-03
			Combination Short-haul Truck	4.98E-03
			Intercity Bus	4.60E-03
			Passenger Car	1.53E-03
			Passenger Truck	1.92E-03
			School Bus	2.79E-03
			Single Unit Long-haul Truck	3.29E-03
			Single Unit Short-haul Truck	2.93E-03
			Transit Bus	3.07E-03
			Motor Home	2.49E-03
			Refuse Truck	5.63E-03
			Light Commercial Truck	1.86E-03

Gasoline	Motorcycle	7.67E-04
	Passenger Car	1.53E-03
	Passenger Truck	1.54E-03
	School Bus	2.79E-03
	Single Unit Short-haul Truck	2.26E-03
	Transit Bus	4.51E-03
	Motor Home	2.49E-03
	Refuse Truck	2.12E-03
	Light Commercial Truck	1.57E-03
Compressed Natural Gas (CNG)	Transit Bus	3.07E-03
Ethanol (E-85)	Passenger Car	1.53E-03
	Passenger Truck	1.53E-03
	Light Commercial Truck	1.53E-03

RateUnit

PM2.5 Brakewear g/mi	PM10 Tirewear g/mi	PM10 Brakewear g/mi	PM10 Total Exh g/mi	VOC g/mi	SO2 g/mi	NOx g/mi
1.19E-02	2.93E-02	9.53E-02	2.82E-02	6.16E-02	1.35E-02	1.29E+00
1.08E-02	2.61E-02	8.64E-02	2.49E-02	6.01E-02	1.32E-02	1.24E+00
9.98E-03	2.29E-02	7.98E-02	2.49E-02	6.08E-02	1.36E-02	1.22E+00
1.54E-03	7.64E-03	1.24E-02	2.46E-03	5.55E-03	1.51E-03	2.96E-02
2.32E-03	9.59E-03	1.86E-02	7.82E-03	2.32E-02	4.13E-03	1.91E-01
7.47E-03	1.39E-02	5.97E-02	1.39E-02	5.37E-02	8.84E-03	9.61E-01
7.90E-03	1.64E-02	6.32E-02	1.36E-02	4.70E-02	7.36E-03	6.31E-01
6.82E-03	1.46E-02	5.46E-02	1.34E-02	4.65E-02	7.83E-03	6.46E-01
6.42E-03	1.53E-02	5.13E-02	2.41E-02	5.86E-02	1.23E-02	1.29E+00
5.48E-03	1.24E-02	4.38E-02	1.35E-02	5.32E-02	8.68E-03	7.84E-01
1.10E-02	2.80E-02	8.80E-02	2.81E-02	5.95E-02	1.38E-02	1.29E+00
2.42E-03	9.25E-03	1.94E-02	6.89E-03	2.03E-02	3.67E-03	1.61E-01
1.24E-04	3.82E-03	9.92E-04	3.22E-02	4.78E-01	2.59E-03	8.05E-01
1.54E-03	7.64E-03	1.24E-02	2.28E-03	6.88E-03	1.18E-03	3.24E-02
2.45E-03	7.70E-03	1.96E-02	3.73E-03	1.05E-02	1.64E-03	5.12E-02
7.45E-03	1.39E-02	5.96E-02	3.06E-02	1.86E-01	6.83E-03	5.32E-01
4.86E-03	1.13E-02	3.89E-02	2.27E-02	9.54E-02	6.26E-03	3.33E-01
1.00E-02	2.25E-02	8.02E-02	3.54E-02	2.35E-01	9.21E-03	6.68E-01
5.48E-03	1.24E-02	4.38E-02	3.19E-02	1.64E-01	6.74E-03	4.26E-01
2.54E-03	1.05E-02	2.03E-02	3.51E-02	1.62E-01	1.00E-02	1.55E-01
2.52E-03	7.82E-03	2.02E-02	3.69E-03	1.03E-02	1.64E-03	5.23E-02
6.42E-03	1.53E-02	5.13E-02	3.40E-03	1.03E-01	7.26E-03	1.62E+00
1.54E-03	7.64E-03	1.24E-02	1.43E-03	8.64E-03	1.35E-03	2.79E-02
2.46E-03	7.64E-03	1.96E-02	2.25E-03	1.27E-02	1.84E-03	4.15E-02
2.54E-03	7.64E-03	2.03E-02	2.06E-03	1.19E-02	1.78E-03	3.78E-02
1.67E-02	3.26E-02	1.33E-01	3.04E-02	6.80E-02	1.35E-02	1.33E+00
1.51E-02	2.91E-02	1.21E-01	2.67E-02	6.63E-02	1.32E-02	1.27E+00
1.51E-02	2.68E-02	1.21E-01	2.68E-02	6.80E-02	1.30E-02	1.22E+00
2.50E-03	8.94E-03	2.00E-02	1.99E-03	4.41E-03	1.49E-03	1.84E-02
3.97E-03	1.12E-02	3.17E-02	7.88E-03	2.52E-02	4.12E-03	1.98E-01
1.00E-02	1.63E-02	8.03E-02	1.31E-02	4.92E-02	6.63E-03	7.67E-01
1.13E-02	1.92E-02	9.01E-02	1.41E-02	5.42E-02	6.89E-03	6.34E-01
9.77E-03	1.71E-02	7.82E-02	1.42E-02	5.39E-02	7.37E-03	6.48E-01
9.18E-03	1.79E-02	7.34E-02	2.19E-02	5.32E-02	9.48E-03	1.06E+00
7.97E-03	1.45E-02	6.37E-02	1.42E-02	5.97E-02	7.59E-03	7.43E-01
1.66E-02	3.28E-02	1.33E-01	2.96E-02	6.62E-02	1.32E-02	1.28E+00
4.02E-03	1.08E-02	3.22E-02	6.94E-03	2.18E-02	3.70E-03	1.66E-01
2.17E-04	4.47E-03	1.74E-03	2.22E-02	5.02E-01	2.43E-03	7.54E-01
2.50E-03	8.94E-03	2.00E-02	1.85E-03	5.54E-03	1.17E-03	2.01E-02
4.14E-03	9.01E-03	3.31E-02	2.75E-03	8.01E-03	1.59E-03	3.20E-02
1.00E-02	1.63E-02	8.01E-02	9.89E-03	1.67E-01	5.09E-03	3.78E-01
6.86E-03	1.32E-02	5.49E-02	7.93E-03	9.17E-02	5.76E-03	3.02E-01

1.42E-02	2.63E-02	1.14E-01	2.01E-02	2.33E-01	7.34E-03	5.17E-01
7.97E-03	1.45E-02	6.37E-02	1.02E-02	1.49E-01	5.86E-03	3.77E-01
3.81E-03	1.23E-02	3.05E-02	2.19E-02	1.60E-01	9.68E-03	1.33E-01
4.16E-03	9.15E-03	3.32E-02	2.93E-03	8.18E-03	1.63E-03	3.48E-02
9.18E-03	1.79E-02	7.34E-02	2.25E-03	1.21E-01	5.79E-03	1.26E+00
2.50E-03	8.94E-03	2.00E-02	1.16E-03	7.26E-03	1.33E-03	1.73E-02
4.15E-03	8.94E-03	3.32E-02	1.66E-03	1.01E-02	1.79E-03	2.54E-02
4.17E-03	8.94E-03	3.34E-02	1.63E-03	9.81E-03	1.77E-03	2.41E-02
1.53E-02	3.13E-02	1.22E-01	2.99E-02	6.55E-02	1.35E-02	1.31E+00
1.38E-02	2.80E-02	1.11E-01	2.63E-02	6.39E-02	1.32E-02	1.26E+00
1.26E-02	2.48E-02	1.01E-01	2.61E-02	6.43E-02	1.34E-02	1.22E+00
1.98E-03	8.25E-03	1.58E-02	2.40E-03	5.14E-03	1.52E-03	2.44E-02
2.99E-03	1.04E-02	2.39E-02	8.05E-03	2.44E-02	4.13E-03	1.94E-01
9.21E-03	1.50E-02	7.37E-02	1.46E-02	5.76E-02	8.73E-03	9.68E-01
9.55E-03	1.77E-02	7.64E-02	1.45E-02	5.11E-02	7.62E-03	6.61E-01
8.28E-03	1.58E-02	6.62E-02	1.43E-02	5.05E-02	8.03E-03	6.70E-01
8.10E-03	1.65E-02	6.48E-02	2.51E-02	6.20E-02	1.21E-02	1.29E+00
6.71E-03	1.34E-02	5.37E-02	1.42E-02	5.71E-02	8.59E-03	7.91E-01
1.40E-02	3.03E-02	1.12E-01	2.95E-02	6.30E-02	1.37E-02	1.29E+00
3.10E-03	9.99E-03	2.48E-02	7.05E-03	2.11E-02	3.67E-03	1.62E-01
1.61E-04	4.13E-03	1.29E-03	3.29E-02	4.96E-01	2.54E-03	7.95E-01
1.98E-03	8.25E-03	1.58E-02	2.23E-03	6.39E-03	1.18E-03	2.68E-02
3.16E-03	8.31E-03	2.53E-02	3.68E-03	9.62E-03	1.63E-03	4.28E-02
9.19E-03	1.50E-02	7.35E-02	2.84E-02	1.99E-01	6.87E-03	5.38E-01
5.84E-03	1.22E-02	4.67E-02	2.25E-02	1.04E-01	6.45E-03	3.41E-01
1.26E-02	2.42E-02	1.01E-01	3.37E-02	2.49E-01	9.19E-03	6.70E-01
6.71E-03	1.34E-02	5.37E-02	3.13E-02	1.75E-01	6.78E-03	4.31E-01
3.20E-03	1.14E-02	2.56E-02	3.45E-02	1.67E-01	1.01E-02	1.50E-01
3.24E-03	8.44E-03	2.59E-02	3.59E-03	9.34E-03	1.64E-03	4.35E-02
8.10E-03	1.65E-02	6.48E-02	3.35E-03	1.15E-01	7.24E-03	1.63E+00
1.98E-03	8.25E-03	1.58E-02	1.40E-03	8.15E-03	1.35E-03	2.30E-02
3.16E-03	8.25E-03	2.53E-02	2.22E-03	1.17E-02	1.82E-03	3.45E-02
3.25E-03	8.25E-03	2.60E-02	2.00E-03	1.09E-02	1.77E-03	3.11E-02
2.90E-02	3.72E-02	2.32E-01	3.71E-02	8.28E-02	1.48E-02	1.50E+00
2.61E-02	3.32E-02	2.09E-01	3.23E-02	8.09E-02	1.43E-02	1.43E+00
2.54E-02	3.07E-02	2.03E-01	3.23E-02	8.20E-02	1.41E-02	1.36E+00
4.06E-03	1.02E-02	3.25E-02	2.10E-03	4.41E-03	1.63E-03	1.44E-02
6.42E-03	1.28E-02	5.14E-02	8.95E-03	2.99E-02	4.43E-03	2.28E-01
1.46E-02	1.86E-02	1.17E-01	1.45E-02	5.66E-02	6.94E-03	8.10E-01
1.79E-02	2.19E-02	1.43E-01	1.67E-02	6.80E-02	8.29E-03	7.68E-01
1.55E-02	1.95E-02	1.24E-01	1.67E-02	6.76E-02	8.77E-03	7.75E-01
1.43E-02	2.04E-02	1.15E-01	2.47E-02	5.99E-02	9.21E-03	1.09E+00
1.24E-02	1.66E-02	9.90E-02	1.62E-02	7.43E-02	8.81E-03	8.67E-01
2.76E-02	3.75E-02	2.21E-01	3.60E-02	7.95E-02	1.43E-02	1.43E+00
6.52E-03	1.24E-02	5.21E-02	7.83E-03	2.56E-02	3.99E-03	1.91E-01

3.57E-04	5.11E-03	2.86E-03	2.16E-02	5.70E-01	2.37E-03	6.68E-01
4.06E-03	1.02E-02	3.25E-02	1.94E-03	5.58E-03	1.27E-03	1.57E-02
6.75E-03	1.03E-02	5.40E-02	2.76E-03	7.84E-03	1.71E-03	2.57E-02
1.46E-02	1.86E-02	1.17E-01	7.68E-03	2.07E-01	5.17E-03	3.39E-01
1.06E-02	1.51E-02	8.45E-02	7.14E-03	1.23E-01	6.53E-03	3.13E-01
2.21E-02	3.00E-02	1.77E-01	1.86E-02	2.87E-01	7.38E-03	4.90E-01
1.24E-02	1.66E-02	9.90E-02	8.75E-03	1.93E-01	6.51E-03	3.86E-01
6.06E-03	1.41E-02	4.85E-02	2.23E-02	1.90E-01	1.07E-02	1.38E-01
6.76E-03	1.05E-02	5.41E-02	2.92E-03	8.05E-03	1.75E-03	2.84E-02
1.43E-02	2.04E-02	1.15E-01	2.15E-03	1.68E-01	5.82E-03	1.19E+00
4.06E-03	1.02E-02	3.25E-02	1.22E-03	7.44E-03	1.45E-03	1.35E-02
6.76E-03	1.02E-02	5.41E-02	1.66E-03	1.01E-02	1.92E-03	2.03E-02
6.79E-03	1.02E-02	5.44E-02	1.63E-03	9.85E-03	1.90E-03	1.93E-02

CO	Methane (CH4)	N2O	Benzene	Formaldehyde	CO2 Equivalent	PM2.5 Total Exh	NOx
g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	
3.03E-01	3.96E-02	1.72E-03	4.74E-04	7.98E-03	1.57E+03	2.59E-02	1.29E+00
3.03E-01	3.95E-02	1.72E-03	4.73E-04	7.97E-03	1.54E+03	2.29E-02	1.24E+00
2.95E-01	3.85E-02	1.63E-03	4.61E-04	7.76E-03	1.58E+03	2.29E-02	1.22E+00
9.21E-01	4.47E-03	3.32E-04	5.36E-05	9.03E-04	1.76E+02	2.26E-03	2.96E-02
5.48E-01	2.09E-02	1.26E-03	2.50E-04	4.22E-03	4.82E+02	7.19E-03	1.91E-01
2.91E-01	4.03E-02	1.63E-03	4.82E-04	8.13E-03	1.03E+03	1.28E-02	9.61E-01
2.69E-01	3.91E-02	1.63E-03	4.68E-04	7.89E-03	8.57E+02	1.26E-02	6.31E-01
2.74E-01	3.91E-02	1.63E-03	4.68E-04	7.89E-03	9.12E+02	1.24E-02	6.46E-01
2.95E-01	3.85E-02	1.63E-03	4.61E-04	7.77E-03	1.44E+03	2.22E-02	1.29E+00
2.88E-01	4.01E-02	1.63E-03	4.80E-04	8.08E-03	1.01E+03	1.25E-02	7.84E-01
2.89E-01	3.74E-02	1.63E-03	4.47E-04	7.53E-03	1.61E+03	2.59E-02	1.29E+00
6.10E-01	1.82E-02	1.13E-03	2.18E-04	3.67E-03	4.27E+02	6.34E-03	1.61E-01
1.11E+01	2.46E-02	1.68E-03	2.08E-02	7.57E-03	3.88E+02	2.85E-02	8.05E-01
9.11E-01	1.23E-03	7.86E-04	2.32E-04	8.29E-05	1.77E+02	2.02E-03	3.24E-02
1.24E+00	1.57E-03	8.97E-04	3.69E-04	1.32E-04	2.45E+02	3.30E-03	5.12E-02
3.99E+00	1.47E-03	2.77E-03	4.90E-03	1.70E-03	1.02E+03	2.71E-02	5.32E-01
2.33E+00	9.98E-04	2.66E-03	2.75E-03	9.63E-04	9.38E+02	2.01E-02	3.33E-01
4.74E+00	1.91E-03	2.70E-03	5.87E-03	2.02E-03	1.38E+03	3.13E-02	6.68E-01
3.22E+00	1.19E-03	2.70E-03	3.92E-03	1.35E-03	1.01E+03	2.82E-02	4.26E-01
1.27E+00	6.43E-04	2.66E-03	2.09E-03	6.28E-04	1.50E+03	3.10E-02	1.55E-01
1.16E+00	1.54E-03	9.70E-04	3.56E-04	1.27E-04	2.47E+02	3.26E-03	5.23E-02
6.19E+00	2.13E+00	3.31E-02	2.60E-04	1.67E-02	1.43E+03	3.01E-03	1.62E+00
6.97E-01	2.08E-03	7.86E-04	1.50E-04	1.65E-04	1.75E+02	1.26E-03	2.79E-02
9.35E-01	2.79E-03	8.61E-04	2.27E-04	2.55E-04	2.39E+02	1.99E-03	4.15E-02
8.39E-01	2.55E-03	8.61E-04	2.09E-04	2.33E-04	2.32E+02	1.82E-03	3.78E-02
3.40E-01	4.63E-02	2.05E-03	5.54E-04	9.34E-03	1.58E+03	2.80E-02	1.33E+00
3.39E-01	4.63E-02	2.05E-03	5.54E-04	9.33E-03	1.53E+03	2.46E-02	1.27E+00
3.44E-01	4.73E-02	2.05E-03	5.66E-04	9.53E-03	1.52E+03	2.47E-02	1.22E+00
5.76E-01	3.26E-03	4.18E-04	3.90E-05	6.58E-04	1.74E+02	1.83E-03	1.84E-02
4.14E-01	2.30E-02	1.58E-03	2.75E-04	4.64E-03	4.80E+02	7.25E-03	1.98E-01
2.55E-01	3.97E-02	2.05E-03	4.76E-04	8.02E-03	7.73E+02	1.20E-02	7.67E-01
3.09E-01	4.76E-02	2.05E-03	5.70E-04	9.61E-03	8.03E+02	1.30E-02	6.34E-01
3.14E-01	4.77E-02	2.05E-03	5.71E-04	9.63E-03	8.58E+02	1.31E-02	6.48E-01
2.63E-01	3.84E-02	2.05E-03	4.60E-04	7.75E-03	1.10E+03	2.01E-02	1.06E+00
3.27E-01	4.92E-02	2.05E-03	5.89E-04	9.92E-03	8.84E+02	1.30E-02	7.43E-01
3.37E-01	4.58E-02	2.05E-03	5.48E-04	9.24E-03	1.53E+03	2.73E-02	1.28E+00
4.59E-01	1.98E-02	1.42E-03	2.37E-04	3.99E-03	4.31E+02	6.39E-03	1.66E-01
1.07E+01	2.61E-02	2.12E-03	2.20E-02	8.02E-03	3.65E+02	1.97E-02	7.54E-01
5.70E-01	8.94E-04	9.88E-04	1.71E-04	6.04E-05	1.75E+02	1.63E-03	2.01E-02
7.69E-01	1.08E-03	1.13E-03	2.54E-04	9.00E-05	2.39E+02	2.44E-03	3.20E-02
3.00E+00	1.48E-03	3.48E-03	4.95E-03	1.74E-03	7.63E+02	8.74E-03	3.78E-01
2.26E+00	9.72E-04	3.34E-03	2.71E-03	9.53E-04	8.64E+02	7.02E-03	3.02E-01

3.90E+00	2.21E-03	3.39E-03	6.80E-03	2.39E-03	1.10E+03	1.78E-02	5.17E-01
3.09E+00	1.11E-03	3.39E-03	3.72E-03	1.28E-03	8.78E+02	9.02E-03	3.77E-01
1.25E+00	6.84E-04	3.34E-03	2.19E-03	6.70E-04	1.45E+03	1.94E-02	1.33E-01
7.83E-01	1.12E-03	1.22E-03	2.59E-04	9.19E-05	2.44E+02	2.59E-03	3.48E-02
5.08E+00	2.51E+00	4.17E-02	3.07E-04	1.97E-02	1.17E+03	1.99E-03	1.26E+00
4.36E-01	1.51E-03	9.88E-04	1.14E-04	1.20E-04	1.73E+02	1.02E-03	1.73E-02
5.72E-01	1.92E-03	1.08E-03	1.63E-04	1.73E-04	2.33E+02	1.47E-03	2.54E-02
5.46E-01	1.84E-03	1.08E-03	1.56E-04	1.66E-04	2.30E+02	1.44E-03	2.41E-02
3.24E-01	4.37E-02	1.92E-03	5.23E-04	8.81E-03	1.57E+03	2.75E-02	1.31E+00
3.24E-01	4.36E-02	1.92E-03	5.22E-04	8.80E-03	1.54E+03	2.42E-02	1.26E+00
3.17E-01	4.26E-02	1.83E-03	5.10E-04	8.59E-03	1.56E+03	2.40E-02	1.22E+00
8.50E-01	4.02E-03	3.71E-04	4.82E-05	8.12E-04	1.76E+02	2.21E-03	2.44E-02
5.21E-01	2.22E-02	1.41E-03	2.65E-04	4.47E-03	4.81E+02	7.40E-03	1.94E-01
3.10E-01	4.46E-02	1.83E-03	5.34E-04	9.00E-03	1.02E+03	1.34E-02	9.68E-01
2.89E-01	4.31E-02	1.83E-03	5.16E-04	8.69E-03	8.87E+02	1.33E-02	6.61E-01
2.93E-01	4.31E-02	1.83E-03	5.16E-04	8.70E-03	9.35E+02	1.31E-02	6.70E-01
3.16E-01	4.27E-02	1.83E-03	5.11E-04	8.61E-03	1.41E+03	2.31E-02	1.29E+00
3.06E-01	4.44E-02	1.83E-03	5.31E-04	8.95E-03	1.00E+03	1.30E-02	7.91E-01
3.12E-01	4.14E-02	1.83E-03	4.96E-04	8.36E-03	1.59E+03	2.71E-02	1.29E+00
5.66E-01	1.91E-02	1.26E-03	2.29E-04	3.86E-03	4.28E+02	6.48E-03	1.62E-01
1.11E+01	2.56E-02	1.88E-03	2.16E-02	7.88E-03	3.82E+02	2.91E-02	7.95E-01
8.40E-01	1.10E-03	8.79E-04	2.09E-04	7.45E-05	1.77E+02	1.97E-03	2.68E-02
1.13E+00	1.39E-03	1.00E-03	3.27E-04	1.17E-04	2.44E+02	3.26E-03	4.28E-02
4.22E+00	1.64E-03	3.10E-03	5.48E-03	1.91E-03	1.03E+03	2.52E-02	5.38E-01
2.48E+00	1.13E-03	2.97E-03	3.12E-03	1.10E-03	9.67E+02	1.99E-02	3.41E-01
5.00E+00	2.14E-03	3.01E-03	6.55E-03	2.27E-03	1.38E+03	2.98E-02	6.70E-01
3.41E+00	1.33E-03	3.02E-03	4.40E-03	1.52E-03	1.02E+03	2.77E-02	4.31E-01
1.33E+00	7.10E-04	2.97E-03	2.27E-03	6.96E-04	1.51E+03	3.06E-02	1.50E-01
1.04E+00	1.35E-03	1.08E-03	3.12E-04	1.11E-04	2.45E+02	3.17E-03	4.35E-02
6.51E+00	2.39E+00	3.70E-02	2.92E-04	1.87E-02	1.44E+03	2.97E-03	1.63E+00
6.42E-01	1.87E-03	8.79E-04	1.37E-04	1.48E-04	1.76E+02	1.23E-03	2.30E-02
8.47E-01	2.47E-03	9.63E-04	2.04E-04	2.25E-04	2.37E+02	1.96E-03	3.45E-02
7.48E-01	2.23E-03	9.63E-04	1.86E-04	2.03E-04	2.31E+02	1.77E-03	3.11E-02
3.99E-01	5.98E-02	2.77E-03	7.16E-04	1.21E-02	1.72E+03	3.41E-02	1.50E+00
3.99E-01	5.98E-02	2.77E-03	7.16E-04	1.21E-02	1.67E+03	2.97E-02	1.43E+00
4.01E-01	6.04E-02	2.77E-03	7.23E-04	1.22E-02	1.64E+03	2.97E-02	1.36E+00
5.82E-01	3.13E-03	5.63E-04	3.75E-05	6.32E-04	1.90E+02	1.93E-03	1.44E-02
4.50E-01	2.78E-02	2.13E-03	3.32E-04	5.60E-03	5.16E+02	8.24E-03	2.28E-01
2.69E-01	4.72E-02	2.77E-03	5.65E-04	9.51E-03	8.09E+02	1.33E-02	8.10E-01
3.61E-01	6.03E-02	2.77E-03	7.22E-04	1.22E-02	9.66E+02	1.54E-02	7.68E-01
3.67E-01	6.06E-02	2.77E-03	7.25E-04	1.22E-02	1.02E+03	1.54E-02	7.75E-01
2.78E-01	4.62E-02	2.77E-03	5.53E-04	9.32E-03	1.07E+03	2.28E-02	1.09E+00
3.81E-01	6.25E-02	2.77E-03	7.48E-04	1.26E-02	1.03E+03	1.49E-02	8.67E-01
3.92E-01	5.80E-02	2.77E-03	6.94E-04	1.17E-02	1.66E+03	3.31E-02	1.43E+00
4.90E-01	2.36E-02	1.91E-03	2.83E-04	4.77E-03	4.65E+02	7.20E-03	1.91E-01

1.04E+01	2.99E-02	2.85E-03	2.52E-02	9.18E-03	3.57E+02	1.91E-02	6.68E-01
5.75E-01	8.58E-04	1.33E-03	1.65E-04	5.80E-05	1.91E+02	1.72E-03	1.57E-02
7.53E-01	1.02E-03	1.52E-03	2.38E-04	8.39E-05	2.57E+02	2.44E-03	2.57E-02
3.09E+00	2.04E-03	4.69E-03	6.80E-03	2.42E-03	7.75E+02	6.80E-03	3.39E-01
2.68E+00	1.43E-03	4.50E-03	3.98E-03	1.41E-03	9.79E+02	6.31E-03	3.13E-01
4.14E+00	3.03E-03	4.57E-03	9.30E-03	3.31E-03	1.11E+03	1.65E-02	4.90E-01
3.63E+00	1.62E-03	4.58E-03	5.39E-03	1.89E-03	9.76E+02	7.74E-03	3.86E-01
1.51E+00	9.68E-04	4.50E-03	3.01E-03	9.59E-04	1.60E+03	1.97E-02	1.38E-01
7.76E-01	1.06E-03	1.65E-03	2.44E-04	8.62E-05	2.63E+02	2.58E-03	2.84E-02
5.39E+00	3.48E+00	5.62E-02	4.25E-04	2.72E-02	1.20E+03	1.90E-03	1.19E+00
4.40E-01	1.45E-03	1.33E-03	1.12E-04	1.15E-04	1.89E+02	1.08E-03	1.35E-02
5.59E-01	1.80E-03	1.46E-03	1.55E-04	1.61E-04	2.50E+02	1.47E-03	2.03E-02
5.41E-01	1.73E-03	1.46E-03	1.50E-04	1.55E-04	2.47E+02	1.44E-03	1.93E-02
						2.43E-02	0.00E+00
						1.72E-02	0.00E+00
						9.30E-02	0.00E+00
						4.92E-03	0.00E+00
						2.41E-02	0.00E+00
						2.00E-03	0.00E+00
						2.27E-03	0.00E+00
						2.22E-03	0.00E+00

MBTL EIS -- GRADE CROSSING EMISSIONS INVENTORY -- SUMMARY OF EXHAUST EMISSIONS BY GRADE CROSSING (TONS/YEAR)

Pollutants (tons/year)	2018		2028		2038	
	No Action	Incremental Increase	No Action	Incremental Increase	No Action	Incremental Increase
Criteria Pollutants						
CO	3.28E-02	4.70E-02	3.60E-02	9.37E-01	1.30E-02	2.78E-01
NOx	5.19E-03	7.43E-03	3.62E-03	9.42E-02	1.29E-03	2.74E-02
PM10	6.31E-04	9.03E-04	1.02E-03	2.64E-02	5.17E-04	1.10E-02
PM2.5	2.33E-04	3.34E-04	2.44E-04	6.33E-03	1.07E-04	2.28E-03
SO2	3.19E-05	4.56E-05	5.03E-05	1.31E-03	2.40E-05	5.12E-04
VOC	1.04E-03	1.49E-03	8.72E-04	2.27E-02	3.51E-04	7.48E-03
Hazardous Pollutants						
Acetaldehyde	7.20E-05	1.03E-04	6.05E-05	1.57E-03	2.44E-05	5.19E-04
Acrolein	1.04E-05	1.49E-05	8.72E-06	2.27E-04	3.51E-06	7.48E-05
Benzene	1.34E-05	1.92E-05	1.13E-05	2.93E-04	4.53E-06	9.66E-05
1,3-Butadiene	8.31E-07	1.19E-06	6.98E-07	1.81E-05	2.81E-07	5.99E-06
Ethylbenzene	6.51E-06	9.32E-06	5.47E-06	1.42E-04	2.20E-06	4.69E-05
Formaldehyde	2.26E-04	3.23E-04	1.90E-04	4.93E-03	7.64E-05	1.63E-03
n-Hexane	5.62E-06	8.04E-06	4.72E-06	1.23E-04	1.90E-06	4.05E-05
Toluene	3.12E-05	4.46E-05	2.62E-05	6.80E-04	1.05E-05	2.24E-04
Xylene	3.95E-05	5.65E-05	3.32E-05	8.62E-04	1.33E-05	2.84E-04

MTBL EIS grade xing emission calcs_04132015.xls

Commuter traffic

Assume a mean travel time of 24.1 minutes (http://quickfacts.census.gov/qfd/states/53/53015.html)

Assumed each worker is a single occupant; Used the on-road average emission rate for 2018 MOVES - 35 mph.

Labor	Number					
Phase 1&2		Time (min) - round trip	Speed (miles/hr)	Days/year	miles/year	miles/day
Peak Employees	200	48.2	35	753.0952	4234905	5623.333

Assume a 50/50 Split between gasoline and E-85

Project Year	NOx	PM10	PM2.5	SO2	CO	VOC	CO2	CH4	N2O	CO2eq
2018										
Construction Annual				**T/year**						
Passenger Vehicle - Gas+E-85	5.13E-01	2.16E-01	4.12E-02	1.06E-02	7.38E+00	1.26E-01	1.48E+03	1.57E-02	7.11E-03	1.49E+03
Construction Max Day				**lbs/day**						
Passenger Vehicle - Gas+E-85	1.36E+00	5.75E-01	1.09E-01	2.82E-02	1.96E+01	3.35E-01	3.94E+03	4.16E-02	1.89E-02	3.94E+03

Conversion Factors:

453.59	g/lb
2000	lbs/ton
5280	ft/mile
3.78541	l/gal
24	hrs/day

Global Warming Potentials (GWPs): CO_2 - 1, CH_4 - 25, N_2O - 298

Mobile Source - Moves run for Cowlitz County, WY, 2018
Emission factors for Commuting Vehicles Exhaust

Emission Factors for Commuting Vehicles Emission Factors (gm/mile)												
Project Year	**NOx**	**PM10**	**PM2.5**	**SO2**	**CO**	**VOC**	**CO2**	**CH_4**	**N_2O**	**Benzene**	**Form**	**CO2eq**
2018												
Passenger Gas (at 35mph)	1.61E-01	4.77E-02	1.01E-02	2.14E-03	1.96	3.61E-02	321.38	2.71E-03	1.75E-03	1.19E-03	4.44E-04	321.97
Passenger E-85 (at35 mph)	5.88E-02	4.50E-02	7.59E-03	2.42E-03	1.20	1.80E-02	313.88	4.00E-03	1.30E-03	2.92E-04	3.59E-04	314.37

Commuter traffic

Assume a mean travel time of 24.1 minutes (http://quickfacts.census.gov/qfd/states/53/53015.html)

Assumed each worker is a single occupant; Used the on-road average emission rate for 2018 MOVES - 35 mph.

Labor	Number					
	75	Time (min) - round trip	Speed (miles/hr)	Days/year	miles/year	miles/day
Employees: 5 day/week	14	48.2	35	260	102344.67	
Employees: 7 day/week	61	48.2	35	294	504244.3	
Total					606588.97	

Assume a 50/50 Split between gasoline and E-85 (tons per year)

Project Year	NOx	PM10	PM2.5	SO2	CO	VOC	CO2	CH4	N2O	CO2eq
2018										
Construction Annual				**T/year**						
Passenger Vehicle - Gas+E-85	0.073440066	0.030989402	0.005901277	0.0015225	1.0568848	0.0180747	212.38476	0.0022439	0.00101911	212.74455

Conversion Factors:

453.59	g/lb
2000	lbs/ton
5280	ft/mile
3.78541	l/gal
24	hrs/day

Global Warming Potentials (GWPs)
CO_2 - 1
CH_4 - 25
N_2O - 298

Mobile Source - Moves run for Cowlitz County, WY, 2018
Emission factors for Commuting Vehicles Exhaust

Project Year	NOx	PM10	PM2.5	SO2	CO	VOC	CO2	CH_4	N_2O	Benzene	Form	CO2eq
	Emission Factors for Commuting Vehicles Emission Factors (gm/mile)											
2018												
Passenger Gas (at 35mph)	1.61E-01	4.77E-02	1.01E-02	2.14E-03	1.96	3.61E-02	321.38	2.71E-03	1.75E-03	1.19E-03	4.44E-04	321.97
Passenger E-85 (at35 mph)	5.88E-02	4.50E-02	7.59E-03	2.42E-03	1.20	1.80E-02	313.88	4.00E-03	1.30E-03	2.92E-04	3.59E-04	314.37

Commuter traffic

Assume a mean travel time of 24.1 minutes (http://quickfacts.census.gov/qfd/states/53/53015.html)

Assumed each worker is a single occupant; Used the on-road average emission rate for 2028 MOVES - 35 mph.

Labor	Number					
	135	Time (min) - round trip	Speed (miles/hr)	Days/year	miles/year	miles/day
Employees: 5 day/week	25	48.2	35	260	182758.3333	
Employees: 7 day/week	110	48.2	35	294	909293	
Total					1092051.333	

Assume a 50/50 Split between gasoline and E-85

Project Year	**NOx**	**PM10**	**PM2.5**	**SO2**	**CO**	**VOC**	**CO2**	**CH4**	**N2O**	**CO2eq**
2028										
Construction Annual				**T/year**						
Passenger Vehicle - Gas+E-85	0.037	0.054	0.009	0.002	1.073	0.012	274.24	0.0022	0.0016	274.77

Conversion Factors:

453.59	g/lb
2000	lbs/ton
5280	ft/mile
3.78541	l/gal
24	hrs/day
Global Warming Potentials (GWPs)	CO_2 - 1
	CH_4 - 25
	N_2O - 298

`

Mobile Source - Moves run for Cowlitz County, WY, 2028
Emission factors for Commuting Vehicles Exhaust

	Emission Factors for Commuting Vehicles **Emission Factors (gm/mile)**										
Project Year	**NOx**	**PM10**	**PM2.5**	**SO2**	**CO**	**VOC**	**CO2**	**CH_4**	**N_2O**	**Benzene**	**Form**	**CO2eq**
2028												
Passenger Gas (at 35mph)	3.35E-02	4.54E-02	7.98E-03	1.52E-03	1.01	9.15E-03	228.62	1.35E-03	1.33E-03	3.08E-04	1.09E-04	229.05
Passenger E-85 (at35 mph)	2.74E-02	4.44E-02	7.09E-03	1.75E-03	0.77	1.12E-02	227.01	2.29E-03	1.33E-03	1.93E-04	2.14E-04	227.46

Commuter traffic

Assume a mean travel time of 24.1 minutes (http://quickfacts.census.gov/qfd/states/53/53015.html)

Assumed each worker is a single occupant; Used the on-road average emission rate for 2038 MOVES - 35 mph.

Labor	Number					
	135	Time (min) - round trip	Speed (miles/hr)	Days/year	miles/year	miles/day
Employees: 5 day/week	25	48.2	35	260	182758.3	
Employees: 7 day/week	110	48.2	35	294	909293	
Total					1092051	

Assume a 50/50 Split between gasoline and E-85

Project Year	**NOx**	**PM10**	**PM2.5**	**SO2**	**CO**	**VOC**	**CO2**	**CH4**	**N2O**	**CO2eq**
2038										
Construction Annual				**T/year**						
Passenger Vehicle - Gas+E-85	0.0171	0.0406	0.0078	0.0011	0.4673	0.0048	157.8767	0.0006	0.0010	158.2

Conversion Factors:

453.59	g/lb
2000	lbs/ton
5280	ft/mile
3.78541	l/gal
24	hrs/day
Global Warming Potentials (GWPs):	CO_2 - 1
	CH_4 - 25
	N_2O - 298

Mobile Source - Moves run for Cowlitz County, WY, 2038
Emission factors for Commuting Vehicles Exhaust

Emission Factors for Commuting Vehicles Emission Factors (gm/mile)												
Project Year	**NOx**	**PM10**	**PM2.5**	**SO2**	**CO**	**VOC**	**CO2**	**CH_4**	**N_2O**	**Benzene**	**Form**	**CO2eq**
2038												
Passenger Gas (at 35mph)	2.84E-02	6.75E-02	1.09E-02	1.75E-03	0.78	8.05E-03	262.30	1.06E-03	1.65E-03	2.44E-04	8.62E-05	262.82
Passenger E-85 (at 35 mph)	0.00E+00	0.00E+00	2.00E-03	0.00E+00	0.00	0.00E+00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00

Source	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	HAPS	DPM
				Construction Emissions (tpy) [Maximum per Year]					
COMBUSTION SOURCES									
Equipment (Onsite)	24.6	9.04	2.23	0.95	2.34	1.93	1.93	0.05	2.34
Haul Trucks (Onsite & Offsite)	13.43	2.92	0.585	0.040	0.77	0.63	0.44	0.015	0.77
Passenger Vehicles (Offsite)	0.53	7.46	0.129	0.0107	0.218	0.218	0.042		
Barges (Offsite)	59.04	15.68	1.511	0.028	1.29	1.06	1.06	0.08	1.29
Total Combustion Sources	97.59	35.1	4.46	1.03	4.62	3.84	3.47	0.14	4.40
Total (on-site and off-site)	38.5	19.4	2.9	1.0	3.3	2.8	2.4	0.1	3.1
FUGITIVE SOURCES									
Controlled Fugitive Earthwork	-	-	-	-	12.0	5.87	1.22	-	
Total Fugitive Sources	-	-	-	-	12.0	5.87	1.22	-	
Total - All Construction Sources	97.6	35.1	4.46	1.03	16.6	9.70	4.69	0.14	4.40

Source	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	HAPS	DPM
				Construction Emissions (lb/day) [Maximum daily]					
COMBUSTION SOURCES									
Equipment (Onsite)	229.6	82.9	20.4	8.67	21.5	17.66	17.66	0.42	21.5
Haul Trucks (Onsite & Offsite)	165.22	38.41	7.93	0.48	12.45	10.24	6.29	0.19	12.45
Passenger Vehicles (Offsite)	1.431	20.033	0.349	0.029		0.583	0.113		
Barges (Offsite)	454.7	120.8	11.6	0.21	9.90	8.14	8.14	0.61	9.9
Total Combustion Sources	850.9	262.1	40.3	9.40	43.8	36.6	32.2	1.22	43.8
Total minus barges	396.22	141.33	28.66	9.18	33.94	28.48	24.07	0.61	33.94
	54.7	14.4	3.1	0.2	6.1	5	2.6	0.1	
	284.26	97.29	23.49	8.87	27.59	22.66	20.26	0.52	21.49
FUGITIVE SOURCES									
Controlled Fugitive Earthwork	-	-	-	-	66.7	32.6	6.8	-	
Total Fugitive Sources	-	-	-	-	66.7	32.6	6.80	-	
Total - All Construction Sources	850.9	262.1	40.3	9.40	110.5	69.2	39.0	1.22	43.8

Facility Only (Material Handling, Maintenance and On-site Equipment) Pollutant Emissions (tpy)

Source	NOx	CO	VOC	SO2	TSP	PM10	PM2.5	HAPs	DPM
FUGITIVE SOURCES									
Coal Transfer (except piles):									
Material Handling	-	-	-	-	5.25	1.84	0.28	-	-
Coal Piles:									
Wind Erosion	-	-	-	-	1.08	0.92	0.14	-	-
Material Handling	-	-	-	-	2.62	0.92	0.14	-	-
MOBILE SOURCES									
Maintenance/Operations Equipment:									
Combustion	4.36	1.42	0.36	0.19	0.38	0.31	0.31	7.15E-03	0.38
Total - onsite	4.36	1.42	0.36	0.19	9.33	3.99	0.87	7.15E-03	0.38

					On-Site Ship and Train Pollutant Emissions (tpy)				
Source	**NOx**	**CO**	**VOC**	**SO2**	**TSP**	**PM10**	**PM2.5**	**HAPs**	**DPM**
Trains:									
Combustion (On-site)	11.57	4.00	0.48	1.42E-02	0.30	0.25	0.24	4.26E-02	0.21
Fugitive (On-site)	-	-	-	-	2.10	1.79	0.27	-	-
Ships:									
Combustion (On-site)	23.3	65.9	15.3	4.52	1.27	1.05	1.02	7.58E-02	0.56
Total - transport	34.8	69.9	15.8	4.54	3.68	3.08	1.53	3.75E-02	0.77

					Total Pollutant Emissions (tpy)				
Source	**NOx**	**CO**	**VOC**	**SO2**	**TSP**	**PM10**	**PM2.5**	**HAPS**	**DPM**
FUGITIVE SOURCES									
Coal Transfer (except piles):									
Material Handling	-	-	-	-	5.25	1.84	0.28	-	-
Coal Piles:									
Wind Erosion	-	-	-	-	1.08	0.92	0.14	-	-
Material Handling	-	-	-	-	2.62	0.92	0.14	-	-

MOBILE SOURCES									
Maintenance/Operations Equipment:									
Combustion	4.36	1.42	0.36	0.19	0.38	0.31	0.31	7.15E-03	0.38
Trains:									
Combustion (Off-site)	17.5	7.6	0.60	2.70E-02	0.45	0.37	0.36	0.08	0.45
Fugitive (Off-site)	-	-	-	-	0.94	0.80	0.12	-	-
Combustion (On-site)	11.6	4.00	0.48	1.42E-02	0.30	0.25	0.24	4.26E-02	0.21
Fugitive (On-site)	-	-	-	-	2.10	1.79	0.27	-	-
Ships:									
Combustion (Off-site)	24.8	37.9	14.1	3.04	2.17	1.78	1.64	3.25E-02	0.00
Combustion (On-site)	23.3	65.9	15.3	4.52	1.27	1.05	1.02	0.08	0.56
Total - All Sources, Onsite and Offsite	81.5	116.9	30.9	7.79	16.6	10.0	4.53	0.24	1.61

Table O-1. Principal List of Toxic Air Contaminants[a] Speciation Profiles for Gasoline, Diesel and Distillate Fuel Combustion Sources

Pollutant		Weight Percent						
	CAS Number	TOG Profile No. 2116	TOG Profile No. 504	TOG Profile No. 818	PM_{10} Profile No. 112	PM_{10} Profile No. 114	PM_{10} Profile No. 119	PM_{10} Profile No. 400
Acetaldehyde	75070	0.25	—	7.4	—	—	—	—
Acrolein	107208	0.12	—	—	—	—	—	—
Benzene	71432	2.2	2.1	2.0	—	—	—	—
1,3 butadiene	106990	0.48	—	—	—	—	—	—
Formaldehyde	50000	1.4	0.10	15	—	—	—	—
Xylenes	1210	4.3	1.1	1.0	—	—	—	—
Naphthalene	91203	0.04	0.07	0.085	—	—	—	—
n-Hexane	110543	1.4	1.6	0.16	—	—	—	—
Propylene	115071	2.7	4.6	2.6	—	—	—	—
Toluene	108883	5.1	2.2	1.5	—	—	—	—
Arsenic	7440382	—	—	—	0.54	0.54	—	—
Cadmium	7440439	—	—	—	0.05	0.05	—	—
Lead	7439921	—	—	—	0.55	0.55	—	0.003
Manganese	7439965	—	—	—	—	—	—	0.05
Mercury	7439976	—	—	—	—	—	—	—
Nickel	7440020	—	—	—	0.05	0.05	—	0.05
Styrene	100425	0.11	—	—	—	—	—	—
Sulfates	9960	—	—	—	25	25	15	45
Vanadium	7440622	—	—	—	—	—	0.55	—
Hexavalent Chromium	18540299	—	—	—	0.027	0.027	—	0.0025
Zinc	7440666	—	—	—	0.55	0.55	—	0.05
Applicable Emission Sources:		Motor Vehicles – - gasoline	Ship main engines – residual or distillate oil	Ship aux. engines, tugboats, construction equipment– diesel fuel	Ship main engines – distillate oil	Ship aux. engines – diesel fuel	Tugboats – engine, construction equipment – diesel fuel	Motor Vehicles – vehicles - gasoline

Notes:

[a] Toxic air contaminants cumulatively contributing less than 0.1 percent to the total cancer risk, chronic hazard index, or acute hazard index are not included.

TOG – total organic gas; CAS – Chemical Abstract Service

VOC is equal to TOG + methane + ethane

Source: CARB (2015), speciation profiles for organic gases and particulate matter. Available for download at: http://www.arb.ca.gov/ei/speciate/speciate.htm#specprof

List of Hazardous Air Pollutants

NAME
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1-Dimethylhydrazine
1,2,4-Trichlorobenzene
1,2-Dibromo-3-chloropropane
1,2-Diphenylhydrazine
1,2-Epoxybutane
1,2-Propylenimine (2-Methyl aziridine)
1,3-Butadiene
1,3-Dichloropropene
1,3-Propane sultone
1,4-Dichlorobenzene
1,4-Dioxane (1,4-Diethyleneoxide)
2,2,4-Trimethylpentane - Original HAP list has incorrect CAS# 580841
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
2,4-D, salts and esters
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,4-Toluene diisocyanate
2-Acetylaminofluorene
2-Chloroacetophenone
2-Nitropropane
3,3'-Dichlorobenzidene
3,3'-Dimethoxybenzidine
3,3-Dimethylbenzidine
4,4'-Methylene bis(2-chloroaniline)
4,4'-Methylenedianiline
4,6-Dinitro-o-cresol, and salts
4-Aminobiphenyl
4-Dimethylaminoazobenzene (Dimethyl aminoazobenzene)
4-Nitrobiphenyl
4-Nitrophenol

Volatile Organic Compounds and Hazardous Air Pollutants

Acetaldehyde
Acetamide
Acetonitrile
Acetophenone
Acrolein
Acrylamide
Acrylic acid
Acrylonitrile
Allyl chloride
Aniline
Antimony compounds
Arsenic compounds (inorganic including arsine)
Asbestos
Benzene (including benzene from gasoline)
Benzidine
Benzotrichloride
Benzyl chloride
Beryllium compounds
beta-Propiolactone
Biphenyl
bis(2-Ethylhexyl)phthalate (DEHP)
bis(Chloromethyl)ether
Bromoform
Cadmium compounds
Calcium cyanamide
Captan
Carbaryl
Carbon disulfide
Carbon tetrachloride
Carbonyl sulfide
Catechol
Chloramben
Chlordane
Chlorine
Chloroacetic acid
Chlorobenzene
Chlorobenzilate
Chloroform
Chloromethyl methyl ether
Chloroprene
Chromium compounds
Cobalt compounds
Coke oven emissions
Cresols/cresylic acid (isomers and mixture)
Cumene
Cyanide compounds
DDE (p,p'-DDE) - CAS# 3547044 in original list
Diazomethane

Dibenzofuran
Dibutyl phthalate
Dichloroethyl ether (bis(2-Chloroethyl)ether)
Dichlorvos
Diethanolamine
Diethyl sulfate
Dimethyl formamide
Dimethyl phthalate
Dimethyl sulfate
Dimethylcarbamoyl chloride
Epichlorohydrin (l-Chloro-2,3-epoxypropane)
Ethyl acrylate
Ethyl carbamate (Urethane)
Ethyl chloride (Chloroethane)
Ethylbenzene
Ethylene dibromide (Dibromoethane)
Ethylene dichloride (1,2-Dichloroethane)
Ethylene glycol
Ethylene imine (Aziridine)
Ethylene oxide
Ethylene thiourea
Ethylidene dichloride (1,1-Dichloroethane)
Fine mineral fibers
Formaldehyde
Glycol ethers - Note the glycol ether ethylene glycol monobutyl ether (EGBE or butyl cellosolve solvent, CAS # 111762), was delisted 11/29/04)
Heptachlor
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Hexamethylene diisocyanate
Hexamethylphosphoramide
Hexane (n-Hexane)
Hydrazine
Hydrochloric acid
Hydrogen fluoride (Hydrofluoric acid)
Hydroquinone
Isophorone
Lead compounds
Lindane (all isomers)
m-Cresol (cresol isomer)
m-Xylene (xylene isomer)
Maleic anhydride
Manganese compounds
Mercury compounds

Methanol
Methoxychlor
Methyl bromide (Bromomethane)
Methyl chloride (Chloromethane)
Methyl chloroform (1,1,1-Trichloroethane)
~~Methyl ethyl ketone~~ (~~2-Butanone~~) - Delisted 12/13/05
Methyl hydrazine
Methyl iodide (Iodomethane)
Methyl isobutyl ketone (Hexone)
Methyl isocyanate
Methyl methacrylate
Methyl tert-butyl ether (MTBE)
Methylene chloride (Dichloromethane)
Methylene diphenyl diisocyanate (MDI) - Current candidate for delisting
N,N-Dimethylaniline
Naphthalene
Nickel compounds
Nitrobenzene
N-Nitrosodimethylamine
N-Nitrosomorpholine
N-Nitroso-N-methylurea
o-Anisidine
o-Cresol (cresol isomer)
o-Toluidine
o-Xylene (xylene isomer)
p-Cresol (cresol isomer)
p-Phenylenediamine
p-Xylene (xylene isomer)
Parathion
Pentachloronitrobenzene (Quintobenzene)
Pentachlorophenol
Phenol
Phosgene
Phosphine
Phosphorus
Phthalic anhydride
Polychlorinated biphenyls (Aroclors)
Polycylic organic matter (includes dioxins and furans)
Propionaldehyde
Propoxur (Baygon)
Propylene dichloride (1,2-Dichloropropane)
Propylene oxide
Quinoline
Quinone
Radionuclides (including radon)
Selenium compounds

Styrene
Styrene oxide
Tetrachloroethylene (Perchloroethylene)
Titanium tetrachloride
Toluene
Toluene-2,4-diamine
Toxaphene (chlorinated camphene)
Trichloroethylene
Triethylamine
Trifluralin
Vinyl acetate
Vinyl bromide
Vinyl chloride
Vinylidene chloride (1,1-Dichloroethylene)
Xylenes (isomers and mixture)

MILLENNIUM BULK TERMINALS–LONGVIEW SEPA ENVIRONMENTAL IMPACT STATEMENT

SEPA COAL TECHNICAL REPORT

COAL DUST EMISSIONS, COAL SPILLS ANALYSIS, AND SULFUR DIOXIDE AND MERCURY EMISSIONS ANALYSIS

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April 2016

ICF International. 2016. *Millennium Bulk Terminals—Longview, SEPA Environmental Impact Statement, SEPA Coal Technical Report.* April. (ICF 00264.13.) Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

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SULFUR DIOXIDE AND MERCURY EMISSIONS ANALYSIS

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Acronyms and Abbreviations

$\mu g/m^2$	micrograms per square meter
$\mu g/m^3$	microns per cubic meter
AERMOD	AMS/EPA Regulatory Model
Applicant	Millennium Bulk Terminals—Longview, LLC
ASIL	acceptable source impact level
BNSF	BNSF Railway Company
CO	carbon monoxide
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
g	gram
g/m^2/month	grams per square meter per month
g/m^2/year	grams per square meter per year
GCTM	global chemical transport modeling
Hg	mercury
Hg^0	mercury in elemental form
Hg^{II}	gas-phased oxidized mercury
IPM	Integrated Planning Model
km	kilometer
mg/km^2-year	milligrams per square kilometer per year
mph	miles per hour
MT/year	metric tons per year
NAAQS	National Ambient Air Quality Standards
ng/m^3	nanograms per cubic meter
NO_2	nitrogen oxides
O_3	ozone
O-M	observed-to-modeled comparison
OH	hydroxyl radical
PAHs	polycyclic aromatic hydrocarbons
pg/m^3	picograms per cubic meter
PHS	Priority Habitats and Species
PM10	particles with a mean diameter of less than 10 microns
PM2.5	particles with a mean diameter of less than 2.5 microns
RCW	Revised Code of Washington
Reynolds facility	Reynolds Metal Company facility
SO_2	sulfur dioxide
SWCAA	Southwest Clean Air Agency
TSP	total suspended particulates
UP	Union Pacific Railroad
WAC	Washington Administrative Code

Project Description

This technical report assesses the potential coal impacts (coal dust, coal spills, and sulfur dioxide and mercury emissions) of the proposed Millennium Bulk Terminals—Longview project (Proposed Action) and No-Action Alternative.

Project Description

Millennium Bulk Terminals—Longview, LLC (Applicant) proposes to construct and operate a coal export terminal in Cowlitz County, Washington, along the Columbia River (Figure 1). The coal export terminal would receive coal from the Powder River Basin in Montana and Wyoming and the Uinta Basin in Utah and Colorado via rail, then load and transport the coal by ocean-going ships via the Columbia River and Pacific Ocean to overseas markets in Asia. The coal export terminal would be capable of receiving, stockpiling, blending, and loading coal by conveyor onto ships for export. Construction of the coal export terminal would begin in 2018. For the purpose of this analysis, it is assumed the coal export terminal would operate at full capacity in 2028.

The following subsections present a summary of the Proposed Action and No-Action Alternative. For detailed information on these alternatives, see the Washington State Environmental Policy Act (SEPA) Alternatives Technical Report (ICF International 2016).

Proposed Action

The Proposed Action would develop a coal export terminal on 190 acres (project area). The project area is located within an existing 540-acre area currently leased by the Applicant at the former Reynolds Metals Company facility (Reynolds facility), and land currently owned by Bonneville Power Administration. The project area is adjacent to the Columbia River in unincorporated Cowlitz County, Washington near Longview city limits (Figure 2).

The Applicant currently and separately operates, and would continue to separately operate, a bulk product terminal on land leased by the Applicant. Industrial Way (State Route 432) provides vehicular access to the Applicant's leased land. The Reynolds Lead and the BNSF Spur, both operated by Longview Switching Company,[1] provide rail access to the Applicant's leased area from a point on the BNSF Railway Company (BNSF) main line (Longview Junction, Washington) located to the east in Kelso, Washington. Ships access the Applicant's leased area via the Columbia River and berth at an existing dock (Dock 1) operated by the Applicant in the Columbia River.

[1] Longview Switching Company is jointly owned by BNSF Railway Company (BNSF) and Union Pacific Railroad (UP).

Figure 1. Project Vicinity

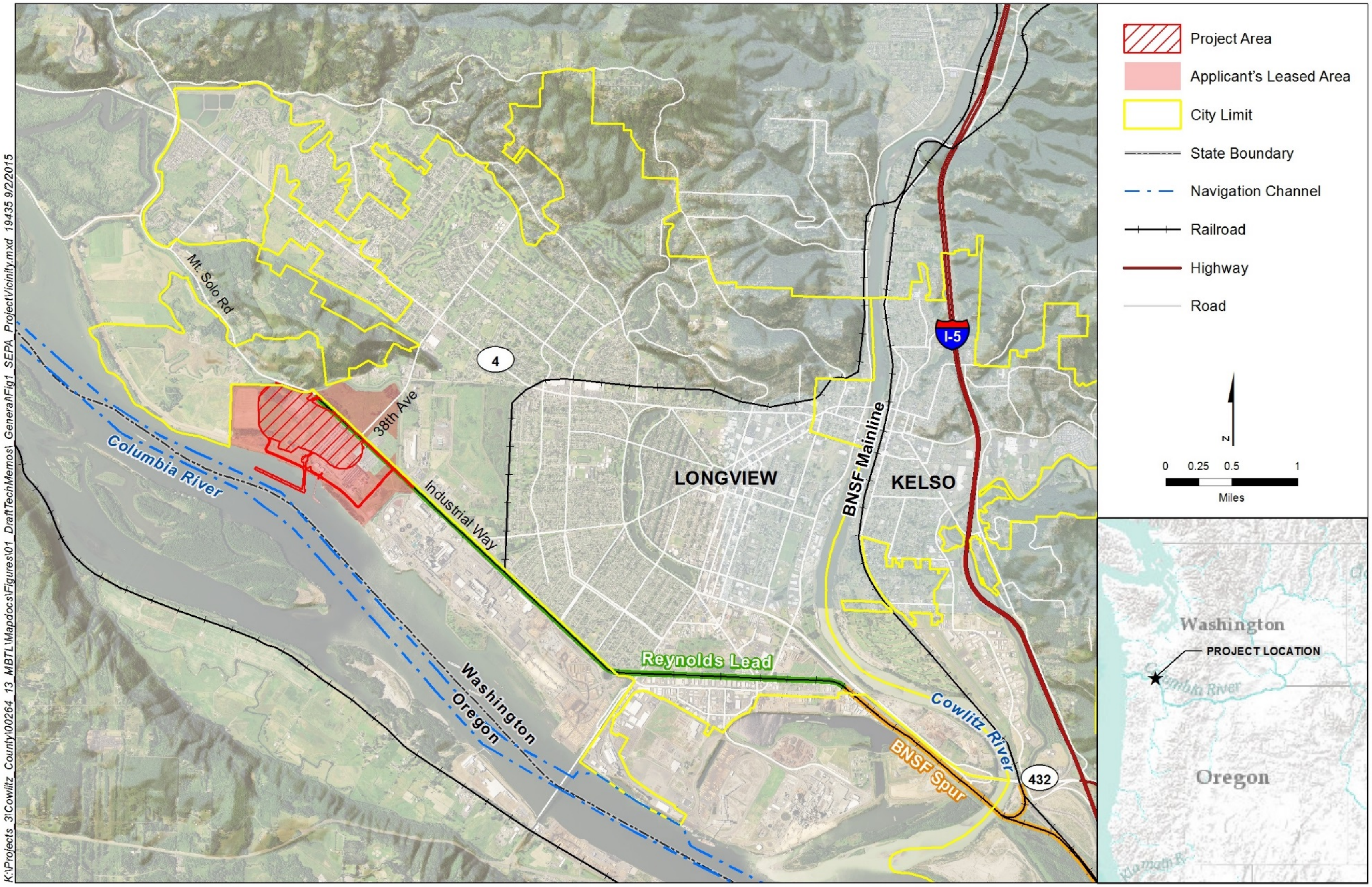
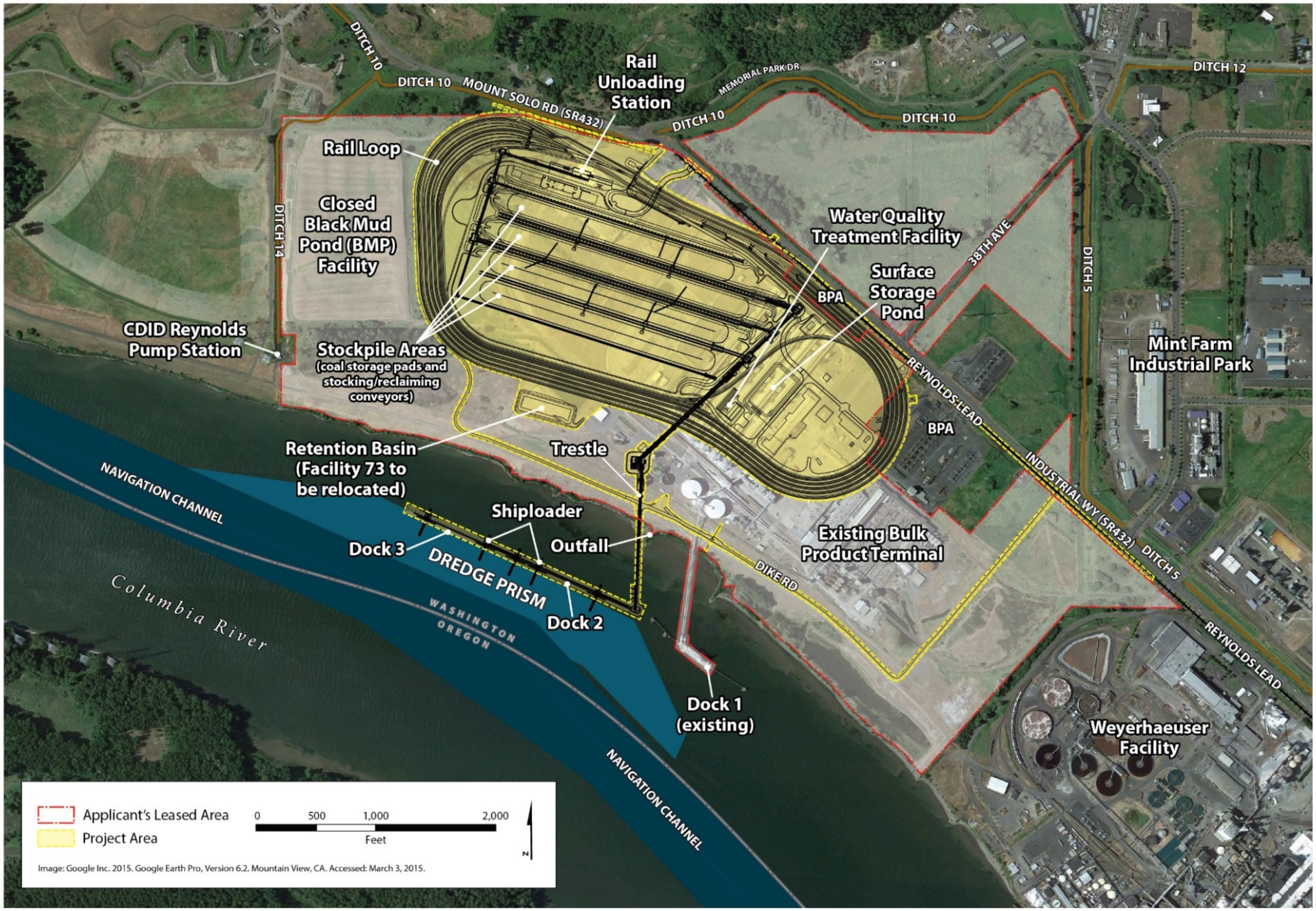


Figure 2. Proposed Action



Under the Proposed Action, BNSF or Union Pacific Railroad (UP) trains would transport coal in rail cars from the BNSF main line at Longview Junction, Washington, to the project area via the BNSF Spur and Reynolds Lead. Coal would be unloaded from rail cars, stockpiled and blended, and loaded by conveyor onto ocean-going ships at two new docks (Docks 2 and 3) on the Columbia River for export.

Once construction is complete, the Proposed Action would have an annual throughput capacity of up to 44 million metric tons.[2] The coal export terminal would consist of one operating rail track, eight rail tracks for the storage of rail cars, rail car unloading facilities, stockpile areas for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks 2 and 3), and ship-loading facilities on the two docks. Dredging of the Columbia River would be required to provide access to and from the Columbia River navigation channel and for berthing at the two new docks.

Vehicles would access the project area from Industrial Way (State Route 432). Ships would access the project area via the Columbia River and berth at one of the two new docks. Terminal operations would occur 24 hours per day, 7 days per week. The coal export terminal would be designed for a minimum 30-year period of operation.

No-Action Alternative

Under the No-Action Alternative, the proposed export terminal would not be constructed. Current operations of the bulk product terminal, which include the storage and transport of alumina and up to 150,000 metric tons per year of coal. Importing of alumina would continue and increase in the project area using Dock 1. The Applicant could expand the existing bulk product terminal onto the 190-acre project area, developing storage and shipment facilities to bulk product terminal operations. Coal and alumina would continue to be stored, transferred, and shipped. Additional bulk product transfers activities involving products such as calcine pet coke, coal tar pitch, cement, fly ash, and sand or gravel could also be pursued, and new or revised permits could be required. These operations would involve storage and upland transfer of bulk products, which would use existing or new buildings. Construction of new buildings could involve demolition and replacement of existing buildings and new or modified permits. Any new construction would be limited to uses allowed under existing Cowlitz County development regulations and federal and state permits.

[2] A metric ton is the U.S. equivalent to a tonne per the International System of Units, or 1,000 kilograms or approximately 2,204.6 pounds.

Coal Dust Emissions

Chapter 1
Introduction

This chapter assesses potential coal dust exposure resulting from the proposed Millennium Bulk Terminals—Longview project Proposed Action and No-Action Alternative. This chapter describes the regulatory setting, establishes the method for assessing potential coal dust impacts, presents the historical and current conditions in the study area, and assesses potential impacts.

1.1 Regulatory Setting

Regulations, statutes, and guidelines that apply to consideration of potential coal dust in the environment are summarized in Table 1.

Table 1. Regulations, Statutes, and Guidelines Applicable to Coal Dust

Regulation, Statute, Guideline	Description
Federal	
National Environmental Policy Act (42 USC 4321 et seq.)	Requires the consideration of potential environmental effects. NEPA implementation procedures are set forth in the President's Council on Environmental Quality's Regulations for Implementing NEPA (49 CFR 1105).
Clean Air Act and Amendments	As amended in 1970, 1977, and 1990, requires EPA to develop and enforce regulations to protect the public from air pollutants and their health impacts.
National Ambient Air Quality Standards	Specifies the maximum acceptable ambient concentrations for seven criteria air pollutants: CO, O_3, NO_2, SO_2, lead, PM10 and PM2.5, and. Primary NAAQS set limits to protect public health, and secondary NAAQS set limits to protect public welfare. Geographic areas where concentrations of a given criteria pollutant exceed a NAAQS are classified as nonattainment areas for that pollutant.
State	
Washington State Environmental Policy Act (WAC 197-11, RCW 43.21C)	Requires state and local agencies in Washington to identify potential environmental impacts that could result from governmental decisions.
Washington State General Regulations For Air Pollution Sources (WAC 173-400) and Washington State Clean Air Act (RCW 70.94)	Establishes the rules and procedures to control or prevent the emissions of air pollutants. Provide the regulatory authority to control emissions from stationary sources, reporting requirements, emissions standards, permitting programs, and the control of air toxic emissions.
Local	
Southwest Clean Air Agency (SWCAA 400)	Regulates stationary sources of air pollution in Clark, Cowlitz, Lewis, Skamania, and Wahkiakum Counties.
Cowlitz County SEPA Regulations (Cowlitz County Code 19.11)	Provide for the implementation of SEPA in Cowlitz County.

Regulation, Statute, Guideline	Description
Notes: EPA = U.S. Environmental Protection Agency; CO = carbon monoxide; O_3 = ozone; NO_2 = nitrogen oxides; SO_2 = sulfur dioxide; PM2.5 = particulate matter up to 2.5 micrometers in size; PM10 = particulate matter up to 10 micrometers in size; NAAQS = National Ambient Air Quality Standards; WAC = Washington Administrative Code; RCW = Revised Code of Washington; SWCAA = Southwest Clean Air Agency	

In occupational settings (such as coal mines), exposure to airborne coal dust is regulated by agencies such as the Occupational Safety and Health Administration and the Mine Safety and Health Administration. In nonoccupational settings (such as outdoor exposures) exposure to coal dust in combination with all other types of particulate matter and dust in the ambient air is regulated by the U.S. Environmental Protection Agency (EPA). The federal regulation that applies to particulate matter is a part of the National Ambient Air Quality Standards (NAAQS). These standards apply to particle sizes with diameter of less than 10 microns (PM10) and particles with a mean diameter of less than 2.5 microns (PM2.5) (40 Code of Federal Regulations 50). The NAAQS were established under the authority of the Clean Air Act to protect human health, including sensitive populations such as children and the elderly, with a margin of safety.

There are no federal or state guidelines or standards in the United States that identify acceptable levels of ambient dust deposition levels. The source most commonly cited on the question of levels of dust deposition for nuisance is the New Zealand Ministry of Environment document *Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions* (New Zealand Ministry of Environment 2001). This study cites acceptable level of dust deposition and identifies two trigger levels for dust nuisance impacts[3] above current background levels.

- 4.0 grams per square meter per month (g/m^2/month) for industrial or sparsely populated locations. This equates to an approximate visible layer of dust on outdoor furniture or window sills.
- 2.0 g/m^2/month for sensitive residential locations.

A highly visible dust, such as black coal dust, will cause visible soiling at lower levels than other types of dust. British Columbia, Canada, has a less stringent maximum desirable level for average dustfall in a residential area of 5.1 g/m^2/month and for nonresidential areas of 8.7 g/m^2/month (British Columbia Ministry of Environment 2014).

1.1.1 BNSF Coal Dust Requirements

Per the BNSF Coal Loading Rule,[4] BNSF has imposed a tariff (a schedule of shipping rates and requirements) that requires coal shippers in Wyoming and Montana to control coal dust emissions from rail cars. One method allowed by the tariff is to use one of topper agents (surfactants) that, along with shaping the load profile, have been shown to reduce average coal dust emissions by at least 85%. This is most commonly done by loading coal cars with a modified loading chute that produces a rounded profile of the top of the coal load. This shaped profile limits the loss of coal dust from wind while the train is moving.

[3] Refers to the level of dust deposition that affects the aesthetics, look, or cleanliness of surfaces but not the health of humans and the environment.

[4] For more information, see http://www.bnsf.com/customers/what-can-i-ship/coal/coal-dust.html

In addition to the shaped profile, topper agents (i.e., surfactants) are applied to the surface of the coal mound to limit coal dust loss. The topper agent must be applied before leaving the coal mine area. In addition, in 2014, BNSF constructed and began operating a surfactant spray facility along its main line in Pasco, Washington, where coal trains traveling west along the main line route through the Columbia River Gorge are sprayed with a topper agent to lessen potential coal dust release from rail cars. The Safe Harbor provision in BNSF's Coal Loading Rule identifies five acceptable topper agents and application rates that BNSF states have been shown to reduce coal dust losses by at least 85% when used in conjunction with coal load profiling. A shipper can use any of the five approved topping agents.[5]

1.2 Study Area

The study area for direct impacts is the project area. The study area for indirect impacts differs for each co-lead agency. The indirect impacts study areas are as follows.

- **Cowlitz County and Ecology.** The area along the Reynolds Lead and BNSF Spur up to 1,000 feet from the rail line.
- **Ecology only.** The area along the rail routes for Proposed Action-related trains on BNSF main line routes in Washington State up to 1,000 feet from the rail line.

[5] For more information, see http://www.bnsf.com/customers/what-can-i-ship/coal/include/dust-toppers.xls

Chapter 2
Existing Conditions

This chapter describes the methods for assessing the existing conditions and determining impacts, and the existing conditions in the study area as they pertain to coal dust emissions.

2.1 Methods

This section describes the methods used to characterize existing conditions and assess the potential impacts of the Proposed Action and No-Action Alternative on coal dust emissions.

2.1.1 Data Sources

The following sources of information were used to identify the potential impacts of the Proposed Action and No-Action Alternative on coal dust in the study area.

- *Millennium Coal Export Terminal, Longview, Washington Environmental Report Air Quality. Appendix L – Air Quality Modeling Analysis* (URS Corporation 2015).
- *Final Report Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains Goonyella, Blackwater and Moura Coal Rail Systems Queensland Rail Limited* (Connell Hatch 2008: 41).
- *Duralie Extension Project, Air Quality Assessment* (Heggies 2009).
- *Analysis of Carry-Back at the RG Tanna Coal Terminal (Draft), Exploration & Mining* (Commonwealth Scientific and Industrial Research Organisation 2007).
- *Diesel particulate matter and coal dust from trains in the Columbia River Gorge, Washington State* (Jaffe et al. 2015).
- *Inorganic composition of fine particles in mixed mineral dust– pollution plumes observed from airborne measurements during ACE-Asia* (Maxwell-Meier et al. 2004).
- Information from the Applicant about anticipated coal handling and transfer activities in the project area.
- Information from the SEPA Rail Transportation Technical Report (ICF International and Hellerworx 2016) on the rail routes of Proposed Action-related trains through Washington State.

Operations of the Proposed Action would result in coal dust emissions from the handling and transfer of coal related to rail unloading, ship loading, conveyor transfer and coal-pile storage. Coal transfers would occur in enclosed areas (e.g., rotary coal car dump facility, conveyors) and unenclosed areas (e.g., coal storage piles).

Over the last 10 years, air quality monitoring studies have collected information on the deposition and ambient concentration levels of coal dust associated with coal train operations. These studies have been conducted in various locations, including Australia, Canada, and the United States (though none in Washington State). However, the available documentation from these studies often does not provide information on all factors that affect coal dust emissions from trains. Also, there are many differences between the Australian coal trains, which have been studied the most extensively, and U.S. coal trains. Some of these limitations of the Australian studies are as follows.

- Size of the coal rail car (Australia cars have about a 30% smaller surface area).
- Distance over which the coal is transported (coal through Washington is coming from greater distances).
- Shaping of the coal (often not described in Australian studies).
- Application and type of topping agent (surfactant) to minimize coal dust emissions (often not described in Australian studies).
- Higher humidity (more frequent rainfall and cooler conditions in Washington State).

2.1.2 Impact Analysis

The following describes the impact analysis methods for the coal export terminal and for Proposed Action-related coal trains.

2.1.2.1 Coal Export Terminal

Coal dust emissions sources were assessed for their potential air quality impacts using the AMS/EPA Regulatory Model (AERMOD) Version 14134.

The potential for coal dust emissions from the coal export terminal and impacts on the area surrounding the coal export terminal were estimated using AERMOD Version 14134. AERMOD was used because impacts would be localized, and the model is designed to estimate emissions for multiple point, area, and volume sources in simple and complex terrain, and uses hourly local meteorological data. In addition, AERMOD estimates the deposition of particulates (such as coal dust) using information on the particulates' emissions rate and particle sizes.

The modeling estimated the near-field coal dust deposition impacts from coal dust emissions at planned full operational capacity of the coal export terminal. Table 2 summarizes the sources of coal dust emissions and their estimated annual average emissions rates that were used in the analysis.

Table 2. Coal Dust Total Suspended Solids Emissions Rates at Maximum Throughput

Operation	Annual Average TSP Emissions Rate (tons per year)
Coal pile wind erosion	1.08
Coal pile development and removal	2.62
Ship transfer and conveyors	5.25
Train unloading	0.91
Total	**9.86**

Notes:
TSP = total suspended particulates

Coal dust emissions were characterized as three source types: volume, area and line sources. Coal transfer operations were characterized as volume sources, which included eight transfer towers, a rotary rail dump, surge bins work points, and two conveyors to load coal onto the ships with emissions rates estimated based on EPA AP-42, Section 13.2.4. Area sources are used to model low-level ground releases. The four coal piles were modeled as area sources with the emissions estimated following the EPA AP-42, Section 13.2.5 approach. The coal dust emissions from tandem rotary unloaders that would unload the coal were modeled as a volume source with emissions estimated following the EPA AP-42, Section 13.2.5 approach. Weyerhaeuser's Mint Farm meteorological station was used in the analysis for the years 2001 to 2003. This station is located approximately 0.5 mile southeast of the project area.

In general the modeling approach built on the approach in the *Millennium Coal Export Terminal, Longview, Washington Environmental Report Air Quality. Appendix L – Air Quality Modeling Analysis* (URS Corporation 2015) which provides further details on the air quality modeling. The changes applied here included modeling for the deposition of the coal particles and a more conservative assumption about the effectiveness of full enclosures and spray/fogging for conveyors. A 95% reduction effectiveness was assumed for the enclosed conveyor and spray/fogging systems, which is consistent with a similar facility's draft permit from the Oregon Department of Environmental Quality (2013).

No information was available on the particle size distribution for Powder River Basin or Uinta Basin coal for particle sizes smaller than 65 microns that would be received at the coal export terminal; however data were available from 11 coal mines in Australia (Katestone 2009). The coal type with the highest near-field deposition, from the Moranbah North mine, was used in the Applicant's deposition analysis, as shown in Table 3.

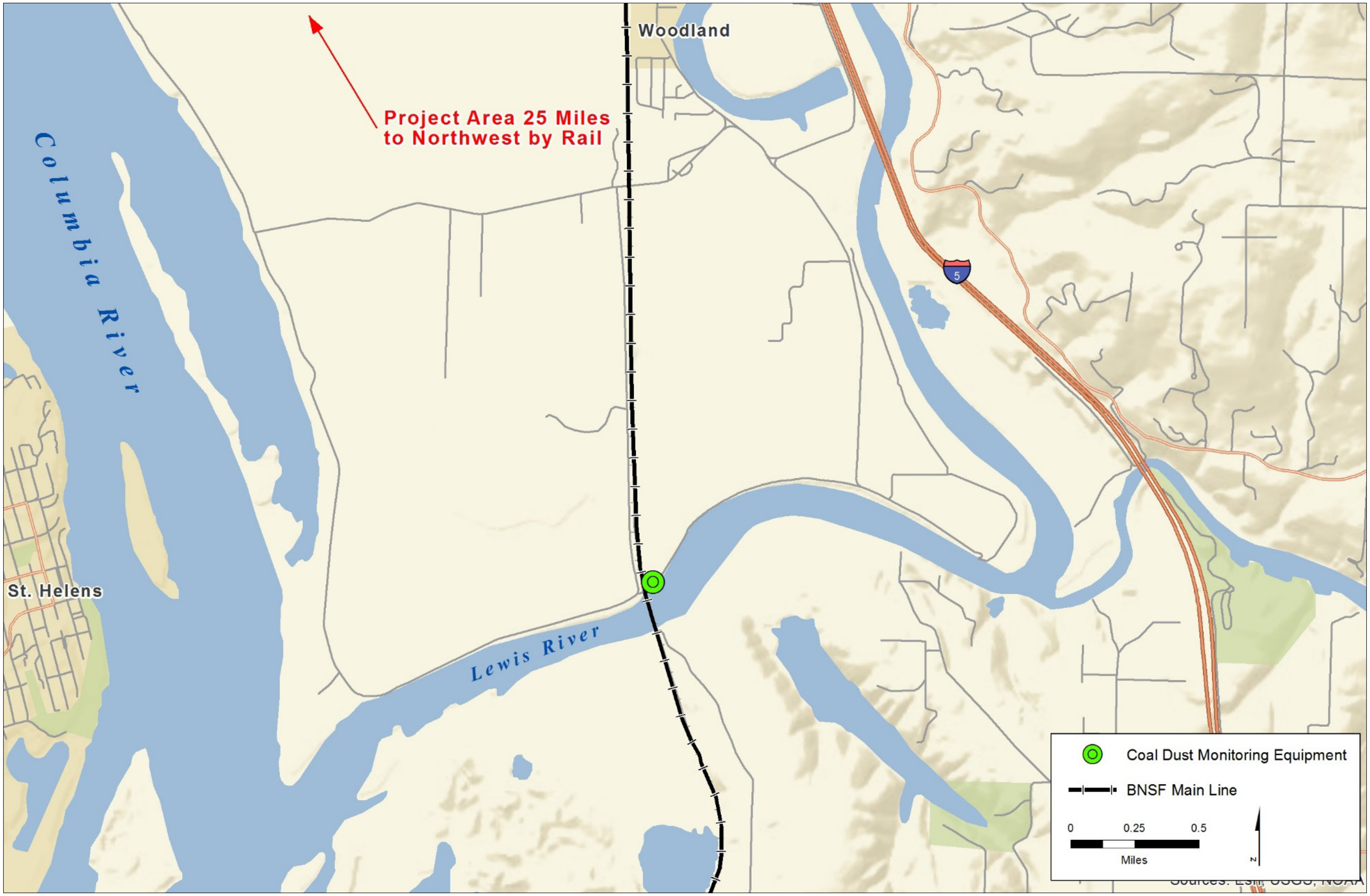
Table 3. Particle Size Distribution for Coal Dust Deposition Analysis

	Mean Mass Diameter Size Range (microns)					
	65–42.5	**42.5–30**	**30–20**	**20–10**	**10–3.75**	**3.75–0.5**
Mass Fraction	0.143	0.147	0.196	0.245	0.218	0.051

2.1.2.2 Coal Trains

As part of this analysis, a field study to collect data on coal dust emanating from passing coal trains was undertaken. Appendix A contains a detailed report on the study including the sampling program, laboratory analysis, quality assurance, and results. The objective of the sampling program was to collect coal dust data at a location in Cowlitz County under conditions that were conducive to coal dust emissions from passing coal trains. Data collected during the first 2 weeks in October 2014, were suitable to allow a small but representative sample to be collected to improve knowledge regarding coal dust emissions and improve the reliability of the assessment of potential impacts. This analysis used the data collected during the field study to evaluate coal train emissions estimates based on studies done in Australia, to verify their applicability to similar projects in the United States, and to evaluate the potential future impacts from the increased transport of coal to the coal export terminal via rail. Because only a limited number of coal trains travel to the Applicant's leased area per week and travel at low speeds, a sampling network was deployed in southern Cowlitz County along the BNSF main line just north of the Lewis River where several loaded coal trains passby per day (Figure 3).

Figure 3. Coal Dust Monitoring Site Location



Data collected at the site included:

- Continuous airborne particulate matter using a size-segregating laser-based optical scattering technique with data recorded at a 10-second time resolution. Measurements were made at the anticipated downwind (east) side of the tracks.
- Short-term particulate matter deposition using deposition plates on both sides of the tracks that sampled during triggered events with a train passage.
- Short-term airborne particulate matter on both sides of the tracks using impaction sampling techniques triggered during selected train passages.
- Integrated 24-hour airborne particulate matter using filter-based techniques with measurements primarily focused on the anticipated downwind (east) side of the tracks.
- Meteorological measurements of wind speed, wind direction, temperature, humidity and solar radiation at a 30-second time resolution to document the conditions during the sampling events.
- Train speed and video recording (documenting the number of coal cars, etc.)

To determine the coal particle concentrations from the collected samples, analytical methods were developed to evaluate the coal particle concentrations in the three different types of measurements and collection devices: fallout of particles (deposition plates for approximately 20 microns and larger); airborne concentrations in the optical microscopy size range (Air-O-Cell slit impaction cassettes 3 to 100 microns); and particles in the "respirable" size range (less than 3 microns). All data collected during the measurement program were processed and validated prior to using in the coal dust analysis.

A total of 23 coal trains were observed during the study period (October 2014) and samples were obtained for 22 of the trains.[6] Of the 22 coal train sample sets collected, 11 where submitted to the laboratory for full analyses, along with two noncoal freight trains for comparison. Prior to the start of the study period, it was verified with the receivers of the coal trains (TransAlta Power Plant near Centralia and Westshore Terminals in British Columbia, Canada) originated in the Powder River Basin and surfactant was applied at the mine. At the time of this study the BNSF Pasco spray station was not yet operational and no additional surfactant material was being applied to the coal.

To improve the reliability of the impact assessment, results from the coal dust monitoring study were used to compare with the air dispersion and emissions modeling using the information observed at the air quality monitoring site (e.g., meteorology, train speed, number of coal cars). Findings from the comparison of modeled data to monitored data were then used to adjust the emissions estimates to produce the best fit with the observed data. The revised emissions estimates were then adjusted to reflect the projected activity levels along the rail line during full operation and the impact assessed.

Air quality modeling was performed using AERMOD for the periods when wind direction was clearly across the tracks and when a complete set of deposition plates and impaction samplers were recorded at the site. This resulted in four periods (sample sets 6, 21, 22 and 25) in which suitable measurements were made to use with the model.

[6] The other data were not analyzed because the train came to a complete stop on the section of track being studied.

A key input to the modeling is the emissions factor used to characterize the amount of coal dust from moving, fully loaded coal rail cars. The approach used the equation reported in the Connell-Hatch study (Connell-Hatch 2008). This equation has since been used in a number of environmental impact assessments in Australia (GHD 2012; Heggies 2009).

The emissions factor for the rate of coal dust emitted (total suspended particulate [TSP]-sized) is expressed in metric units of grams (g) of TSP per kilometer (km) of rail per metric ton of coal moved as follows.

$$\text{Emissions Factor (loaded coal train)} = 0.0000378(V)^2 - 0.000126(V) + 0.000063$$

where V is the speed of the train (km/h)

This equation was developed from the analysis of coal dust loss (without mitigation) and a minimum air velocity needed for particle lift-off from a wind tunnel study over a variety of wind speeds. The approach assumed no significant rainfall and so likely represents an overestimate for western Washington State. This emission factor was further adjusted by 1.34 to account for the larger-sized rail cars used to transport coal in the United States (44.12 square meters) versus those used in Australia (30.37 square meters) (Connell-Hatch 2008). Each loaded rail car was estimated to hold 122 tons of coal and an 85% emission reduction effectiveness[7] was applied based on best practice of shaping the coal for transport by rail to minimize fugitive emissions and the application of a topping agent at the mine. Emission rates were also estimated for the unloaded train based on a study (Commonwealth Scientific and Industrial Research Organisation 2007) of the amount of coal carry-back found in returning rail cars. The worst-case coal carry-back found in that study was 0.14 ton per car and that value was used in this assessment for the empty rail cars. Emissions rates for each operational setting were calculated and used in the AERMOD dispersion model using representative meteorological data.

2.1.3 Impact Analysis Approach

The study measured the fugitive emissions of coal from the passing trains with a set of air samplers on each side of the tracks to measure the upwind "background" concentrations and deposition, and the downwind concentrations and deposition—the difference being the contributions of the passing trains. A variety of sampling techniques captured the specific emissions from the coal train hauling activities. Short-term measurements using deposition plates, impaction samplers, and continuous particulate matter measurements were used to resolve individual train events, while longer averaging intervals of particulate matter (24-hour) were collected using filter-based collection media to help relate the more standard methods of measurement to the shorter-term type sampling (train event). During the study period, high time resolution meteorological measurements were made to capture wind flow and document the upwind and downwind environment during each train passing. The meteorological measurements also provided needed data on temperature, humidity, transport and atmospheric stability that were used in the coal train modeling.

For operations of the proposed coal export terminal, air quality modeling was performed for the sources of coal dust (transfer handling of the coal from rail to storage piles, fugitive emissions from coal storage piles, transfer and handling of coal from piles to ship).

[7] BNSF tariffs require shippers to control coal dust emissions through use of load profiling and application of an approved topping agent or other measures to reduce emissions by at least 85 percent (BNSF Price List 6041-B and Appendices A and B, issued September 19, 2011).

For the transport of the coal via rail to the coal export terminal, air quality modeling was conducted based on the coal dust emissions estimated from a moving train with some adjustments in the emission rates based on the air quality monitoring study.

2.2 Existing Conditions

The existing environmental conditions related to coal dust exposure in the study area are described below.

2.2.1 Applicant's Leased Area

The existing bulk product terminal in the Applicant's leased area currently receives 1 to 2 coal trains per week, consisting of 25 to 30 coal rail cars. Coal is stored in silos in the Applicant's leased area, adjacent to the project area, and transferred via truck to the Weyerhaeuser facility, located 1 mile to the southeast. Because the coal is stored in silos and the number of coal rail cars, coal dust emissions are estimated to be small and confined almost entirely within the Applicant's leased area.

2.2.2 Cowlitz County

Approximately two loaded coal trains per day, consisting of approximately 125 cars, typically operate along the BNSF main line northbound in Cowlitz County (Western Organization of Resource Councils 2014).

Cowlitz County is classified as an attainment area or unclassified for both PM10 and PM2.5. Of these two pollutants only PM2.5 is currently being monitored. The PM2.5 monitoring station located at Olympic Middle School is a neighborhood-scale site, affected primarily by smoke from home heating. It is considered representative of the Longview-Kelso area and is used for curtailment calls[8] during the home heating season. The estimated 24-hour design value in 2014 was 18 micrograms per cubic meter ($\mu g/m^3$) (Washington State Department of Ecology 2015). While not a reference instrument, it is considered a strong indicator of the relative PM2.5 concentration of the Longview-Kelso area. Air quality in other locations of Cowlitz County is generally as good as or better than in the Longview-Kelso area.

The most recent national air toxic assessment found that Cowlitz County has an overall inhalation cancer risk of 34 cancers per million, which is slightly lower than the state average of 43 per million and below the national average of 50 per million.[9] (U.S. Environmental Protection Agency 2011)

2.2.3 Washington State

Currently, 2 to 4 coal trains per day operate within Washington State, typically consisting of approximately 125 rail cars, mainly along the BNSF main line (Western Organization of Resource Councils 2014, The Herald of Everett Washington 2013). Coal dust emissions associated with the operations of these trains occurs mostly along the BNSF main line routes because of the high

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[8] When meteorological conditions indicate the probability that PM 2.5 levels are likely to exceed EPA standards, the Department of Ecology and Local Air Authorities are authorized to issue a burn ban or other restriction.

[9] The national air toxic assessment did not include diesel particulate matter in the risk assessment as EPA believes the cancer potency risk factor has to large of uncertainty to provide meaningful results.

operating speeds of the trains. Most of the coal dust deposition, as well as the highest concentration of coal dust in the air, occurs within the railroad right-of-way.

The following paragraphs describe the existing air quality conditions for the route that would be used for the proposed project (for westbound-loaded trains and eastbound-unloaded trains).

Air quality along the rail route in eastern Washington State from Spokane to Pasco is generally good. Spokane is a maintenance area for carbon monoxide, but has not had an exceedance of the carbon monoxide standard in over 10 years. From spring through fall in this region of the Columbia Plateau, high winds can combine with dry weather conditions to create dust storms that can lead to extremely high levels of PM10. The state monitors for PM2.5 along this route but in general, the monitoring is below the state's goal of keeping concentrations below 20 $\mu g/m^3$, well below the PM2.5 NAAQS of 35 $\mu g/m^3$.

Air quality through the Columbia Gorge is also generally good, the primary concern being visibility impairment and regional haze issues, with these issues occurring at much lower concentration levels than for health effects. Air quality from Vancouver north to Longview is generally good with PM2.5 being the pollutant of most concern. Readings are generally well below the state's goal of keeping concentrations below 20 $\mu g/m^3$.

The rail route between Tacoma and Auburn over the Cascades via Stampede Pass passes through the only PM2.5 maintenance area in the state, the Tacoma-Pierce County PM2.5 maintenance area. The primary cause of poor air quality in the nonattainment area is residential wood burning during periods with colder-than-average temperatures and low wind speeds. The area east of Auburn does experience some of the highest ozone levels in Western Washington but are below the NAAQS.

Air quality from Stampede Pass through Ellensburg to Yakima and back to Pasco is generally good but recent monitoring data has shown a high fraction of the PM2.5 concentration to be nitrates in the Yakima region. In Yakima, much of the PM2.5 comes from wood burning with highest levels in the wintertime due to increased wood burning and stagnate conditions. Up to one-fourth of PM2.5 may be in the form of nitrate during the wintertime (Washington State Department of Ecology 2014). In addition, air quality in the Ellensburg area has, in recent years, shown that residents breathe unhealthy levels of PM2.5 2 to 3 weeks each year (Washington State Department of Ecology 2013).

Regarding hazardous air pollutants, the most recent national air toxic assessment (U.S. Environmental Protection Agency 2011) showed cancer risks were highest in the highest population centers along the rail route (Vancouver and Spokane) with the inhalation cancer risk of up to 500 cancers per million population. Cancer risk in the smaller communities (Kelso-Longview, Yakima, and Pasco) was up to 300 cancers per million for the smaller communities. Most of the rail route, however, has cancer risks of less than 75 cancers per million.

2.2.4 Coal Dust Monitoring

As described in Section 3.1.3, *Impact Analysis*, 23 coal trains were observed during the study period and samples were obtained for 22 of the trains. Of the 22 sample sets collected, 11 where submitted to the laboratory for full analyses, along with two noncoal freight trains for comparison (Table 4). The other sample sets where not analyzed for several reasons; the most common being that the train came to a complete stop on the section of track being studied.

Key findings from the coal dust monitoring study (Appendix A) were:

- Coal-like particle deposition amounts were 350 micrograms per square meter ($\mu g/m^2$) upwind and 1,140 $\mu g/m^2$ downwind on average per coal train, based on the upwind/downwind deposition plates located 15 meters from the track. Based on the collected data, this increase in mass appears to be fugitive coal dust emissions from the coal cars passing, as coal-like concentrations for deposition plates collected during noncoal train passage were notably very low (averaging 25 $\mu g/m^2$).
- The maximum increase in the 24-hour PM-2.5 concentration from coal dust associated with the passing of two (2) unit coal trains traveling at an average speed of 41.5 mph in Cowlitz County at 40-m downwind was 1.33 $\mu g/m^3$. In a recent study by Jaffe et al (2015), where $PM_{2.5}$ monitoring data was collected in the Columbia River Gorge, the authors reported the maximum increase observed during the study in the 2-minute average $PM_{2.5}$ concentration of 232 $\mu g/m^3$ from the passage of a single coal train traveling at 44.5 mph located 20-m from the rail line. These results are generally consistent with the results found in the T&B Systems study when the 2-minute average $PM_{2.5}$ concentration is expressed in terms of the regulatory averaging period as the average increase in $PM_{2.5}$ concentration over 24 –hours for two coal trains per day would be:

$$\left(2\frac{trains}{day}\right)x\left(2\frac{min}{train}\right)*\frac{232\ \mu g/m^3}{60\frac{min}{hr}*\frac{24hr}{day}} = 0.65\ \mu g/m^3$$

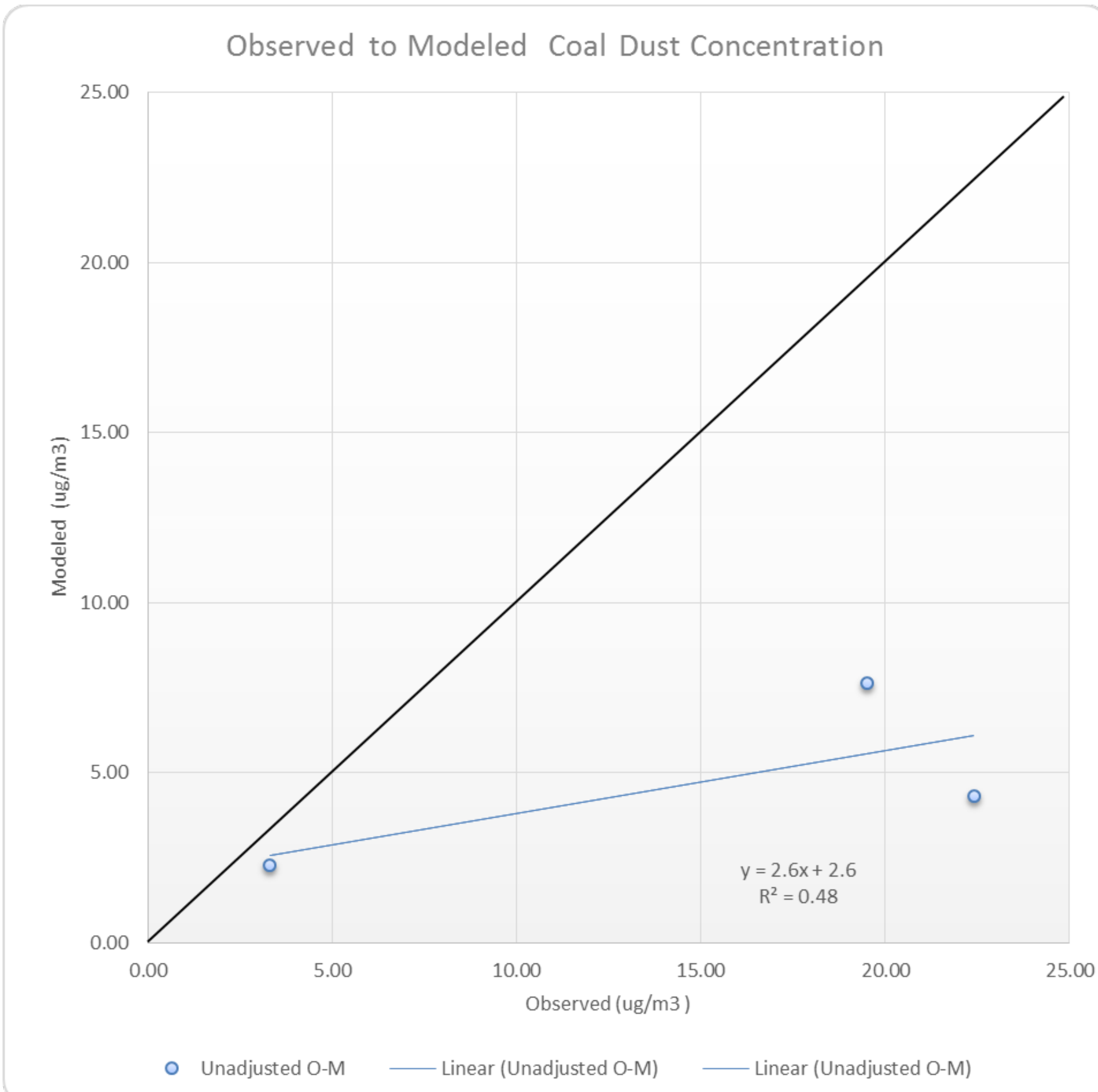
Table 4. Coal Trains for Coal Deposition, Concentration, and Particle Size Analysis

Sample Set	Date	Arrival Time Depart Time	Passage Time	Speed (mph)	Cars		Total	Est. Train Length (miles)	Comments
					Coal	Other			
1	10/1/2014	18:30:17 18:32:16	0:01:59	40	126		130	1.3	
3	10/2/2014	17:53:33 17:55:07	0:01:34	53	119		123	1.4	Stopped sampling 1 minute after train passage because of road traffic
6	10/3/2014	10:22:34 10:24:48	0:02:14	38	125		129	1.4	Sampled for 107 cars
12	10/5/2014	16:04:36 16:06:49	0:02:13	37	124		128	1.4	
13	10/6/2014	4:25:01 4:26:54	0:01:53	44	122		126	1.4	
15	10/6/2014	17:57:20 17:59:05	0:01:45	41	126		130	1.2	
18	10/8/2014	5:00:14 5:01:54	0:01:40	43	125		129	1.2	
21	10/10/2014	5:22:42 5:24:21	0:01:39	43	124		129	1.2	
22	10/10/2014	7:30:22 7:32:07	0:01:45	40	125		129	1.2	
24	10/12/2014	12:58:01 12:59:34	0:01:33	48	122		126	1.2	New sample configuration
25	10/13/2014	9:47:54 9:49:48	0:01:54	43	125		129	1.4	New sample configuration
7	10/3/2014	16:29:18 16:31:05	0:01:47	46		112	115	1.4	Freight train
14	10/6/2014	16:13:18 16:15:03	0:01:45	38		111	114	1.1	Freight train

- Air concentrations of coal-like particles, measured from the impaction samplers downwind from the track for periods with "winds across the tracks" averaged 16.5 μg/m³ during the approximate 2-minute coal train passage, compared to 0.6 μg/m³ from similarly placed upwind samplers.[10]

Modeling results are shown in Figure 4 for the original observed-to-modeled comparison (O-M) and the 1:1 ratio between observed and modeled. Using a best fit linear regression to these datapoints suggests that the coal dust emissions reduction effectiveness is 61% rather than 85%. Subsequent modeling of coal trains all used an estimated emissions reduction effectiveness of 61% in estimating coal dust emission rates.

Figure 4. Coal Dust Emissions Adjustment Curve Based on Observed to Modeled Coal Dust Concentrations



[10] Iron-oxide concentrations measured during this same time period averaged 11.3 μg/m³ on the downwind side and 1.5 μg/m³ on the upwind side. The origin of the iron oxide is mostly likely from train wheels grinding against steel rails. This may contribute additional particulate matter to the near field air concentration, as well as deposition.

Chapter 3
Impacts and Mitigation

This chapter describes the impacts of coal dust exposure that would result from the Proposed Action.

3.1 Impacts

This section describes the coal dust impacts that could result from the Proposed Action and No-Action Alternative. Potential coal dust emissions impacts from the Proposed Action are described below.

3.1.1 Construction: Direct Impacts

Construction of the Proposed Action would not include any coal-handling activities. No impacts from coal dust would occur during construction.

3.1.2 Operations: Direct Impacts

As stated previously, the assessment for the Proposed Action was modeled using the AERMOD dispersion model. This included coal dust handling from the rail unloading, loading onto vessels, and wind erosion emissions from the coal piles.

3.1.2.1 Site-Specific Operations Impacts—Deposition

To assess the coal dust deposition impacts from the on-site operations was conducted based on full production activity levels at the coal export terminal. Table 5 presents these deposition amounts and shows both the estimated maximum annual coal dust deposited, based on a 3-year modeling period, and the estimated maximum monthly deposition, along with a comparison to the New Zealand dust deposition trigger level for sensitive areas. A sensitive area typically has significant residential development, whereas, a sparsely populated rural area may be relatively insensitive to some discharges. In a highly sensitive residential area, deposition rates greater than 2.0 g/m^2/month, above background concentration, may cause nuisance. The estimated maximum monthly coal dust deposition amounts would be below the trigger level for sensitive areas.

Table 5. Estimated Maximum Annual and Monthly Coal Dust Deposition—Project Area

Location	Maximum Annual Deposition (g/m^2/year)	Maximum Monthly Deposition (g/m^2/month)	New Zealand Trigger Level for Sensitive Areas (g/m^2/month)
Fence line	1.88	0.31	2.0

Notes:
g/m^2/year = grams per square meter per year; g/m^2/month = grams per square meter per month

The estimated maximum coal dust deposition from coal export terminal operations would be below the trigger level for sensitive areas. The highest estimated monthly deposition amounts would be near Mt. Solo Road, as shown in Figure 5.

The spatial extent of the estimated maximum annual coal dust deposition near the coal export terminal is shown in Figure 6, which shows the maximum annual deposition in the vicinity of the coal export terminal. This shows that within a few thousand feet of the coal export terminal, the annual cumulative deposition of coal dust is estimated to be less than 0.1 g/m^2.

3.1.3 Operations: Indirect Impacts—Particulate and Deposition

3.1.3.1 Cowlitz County

Reynolds Lead and BNSF Spur

To assess the coal dust air quality and deposition impacts from only coal train operations, separate air quality dispersion modeling using AERMOD was conducted based on an average speed of 10 miles per hour (mph) for coal trains along the Reynolds Lead and BNSF Spur and the planned activity level of an average of eight loaded and eight unloaded coal trains per day. Results are presented in Table 6 showing the estimated maximum coal dust concentration (including background) relative to the PM10 and PM2.5 standard at 100 feet from the rail line. The closest maximum model residential receptor is located 180 feet on the north side of the rail line. These estimated concentrations are below the NAAQS standards. Further distances would experience even lower concentrations as concentrations decrease by about 50% another 160 feet from the rail line.

Figure 5. Estimated Maximum Monthly Coal Deposition (g/m²/month) in the Vicinity of the Project Area

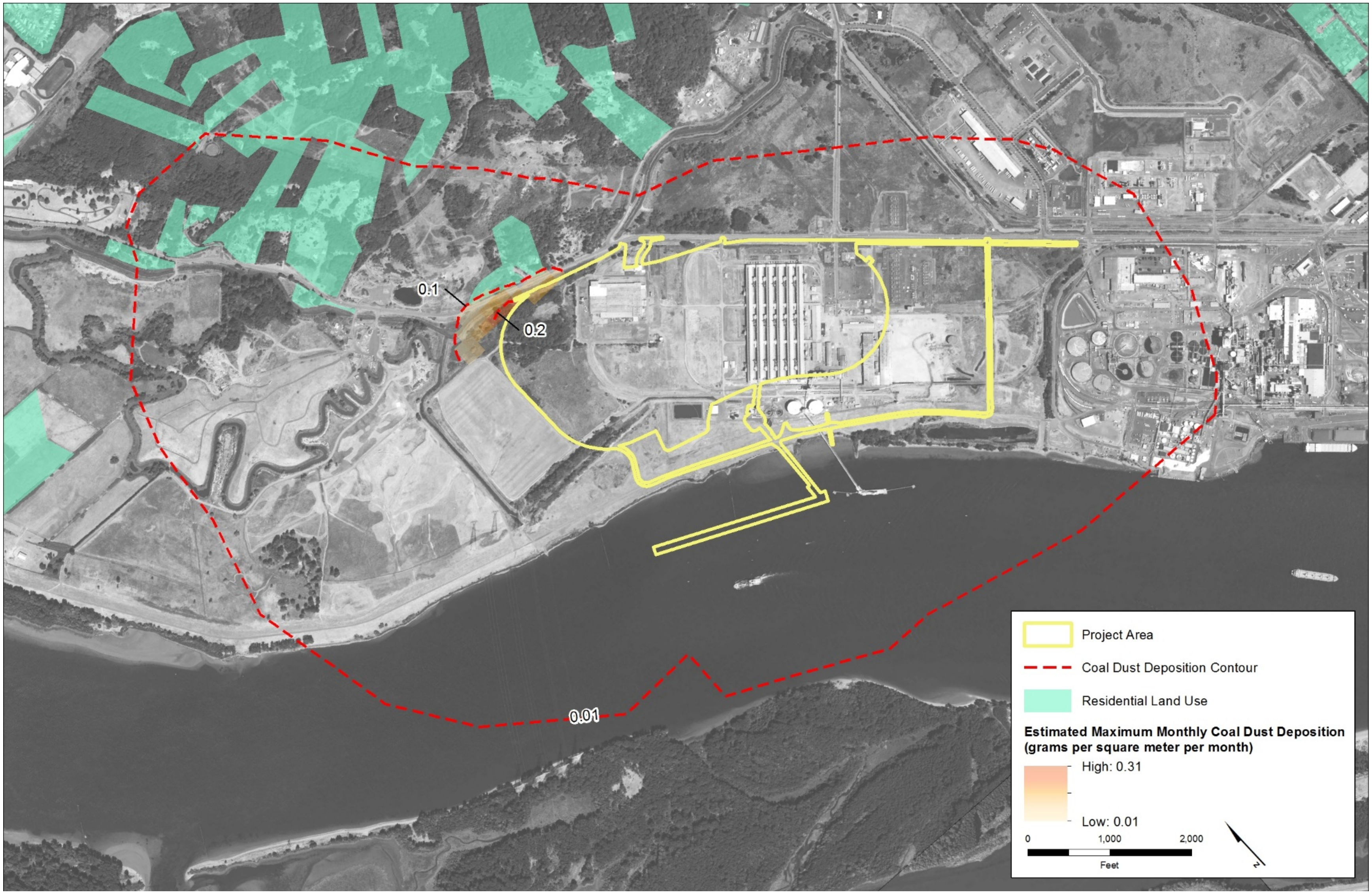


Figure 6. Estimated Maximum Annual Coal Deposition (g/m^2/year) in the Vicinity of the Millennium Bulk Terminal

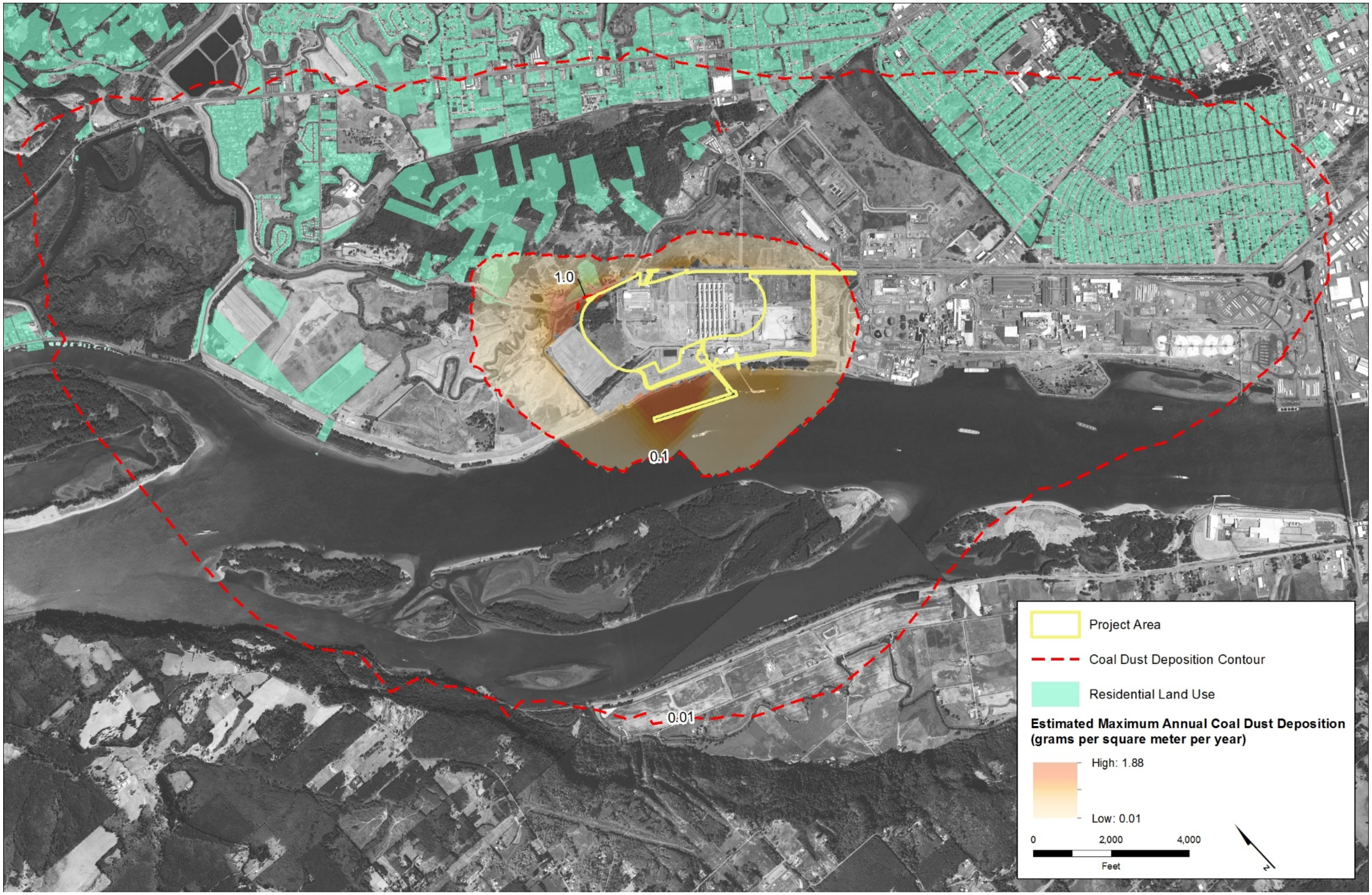


Table 6. Estimated Maximum PM10 and PM2.5 Concentrations 100 Feet from Rail Line—Reynolds Lead and BNSF Spur

Pollutant	Averaging Period	Maximum Modeled Impact (µg/m³)	Background[a] (µg/m³)	Total Concentration (µg/m³)	NAAQS (µg/m³)
PM10	24 hour[b]	0.28	28.0	28.3	150
PM2.5	24 hour[c]	0.05	16	16.05	35
	Annual[d]	0.01	5.3	5.31	12

Notes:

[a] Background concentrations are monitoring design values from Northwest International Air Quality Environmental Science and Technology Consortium (2015).

[b] The PM10 24-hour modeled impact is 3-year average of the high 2nd high concentration.

[c] The PM2.5 24-hour modeled impact is the 3-year average of the 98th percentile of the daily maximum concentrations.

[d] Modeled impact is the high 2nd high over the 3 modeled years.

NAAQS = National Ambient Air Quality Standards; µg/m³ = micrograms per cubic meter

The same modeling approach was used to determine the coal dust TSP deposition. Table 7 reports the results for the estimated maximum increase in deposition from coal train rail operations for the closest maximum modeled residential receptor (a distance of 180 feet from the rail line). Modeling indicates that the maximum monthly deposition would occur during July, but the highest-estimated monthly deposition would be below the New Zealand trigger level for sensitive receptors.

Table 7. Estimated Maximum and Average Monthly Coal Dust Deposition—Reynolds Lead and BNSF Spur

Material	Distance (feet)	Average Maximum Monthly Deposition (g/m²/month)	Maximum Monthly Deposition (g/m²/month)	New Zealand Trigger Level for Sensitive Receptors (g/m²/month)
Coal Dust	180	0.013	0.017	2.0
Coal Dust	340	0.006	0.008	2.0

Notes:

g/m²/month = grams per square meter per month

BNSF Main Line in Cowlitz County

To assess potential coal dust air quality and deposition impacts from coal trains traveling to the coal export terminal on the BNSF main line, air quality modeling was conducted based on an average 50 mph speed on the BNSF main line near Woodland and Kalama, Washington. Table 8 presents the results that show the maximum coal dust concentration (including background) at 50 and 100 feet in comparison with the PM10 and PM2.5 standards. Estimated concentrations are higher than those estimated for the Reynolds Lead and BNSF Spur because of the higher train speeds on the BNSF main line that enhance the entrainment (dust lift-off) of coal particles from the open rail cars. However, in all cases, these concentrations remain below the NAAQS.

Table 8. Estimated Maximum PM10 and PM2.5 Concentrations 50 and 100 Feet From Rail Line—BNSF Main Line, Cowlitz County

Pollutant	Averaging Period	Distance from Rail Line (feet)	Modeled Impact (μg/m³)	Background[a] (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)
PM10	24 hours[b]	50	30.0	28.0	58.0	150
		100	23.0	28.0	51.0	150
PM2.5	24 hours[c]	50	4.5	21.0	25.5	35
		100	3.8	21.0	24.8	35
	Annual[d]	50	2.1	5.9	8.0	12
		100	1.7	5.9	7.6	12

Notes:
[a] Background concentrations are monitoring design values for Woodland, Washington (Northwest International Air Quality Environmental Science and Technology Consortium 2015).
[b] The PM10 24-hour modeled impact is 3-year average of the high 2nd high concentration.
[c] The PM2.5 24-hour modeled impact is the 3-year average of the 98th percentile of the daily maximum concentrations.
[d] Modeled impact is the annual average over the 3 modeled years.
μg/m³ = micrograms per cubic meter

The same modeling approach was used to estimate coal dust TSP deposition along the BNSF main line in Cowlitz County. The results show the estimated increase in deposition from the coal train traffic to the project area at distances of 50, 100, and 150 feet from the rail line (Table 9). The deposition amounts are higher than the Reynolds Line because of the higher train speeds. Estimated maximum monthly deposition would occur during January. The estimated maximum monthly deposition is above the New Zealand trigger level for sensitive areas at 100 feet.[11]

Table 9. Estimated Maximum and Average Monthly Coal Dust Total Suspended Particulate Deposition—BNSF Main Line, Cowlitz County

Material	Distance (feet)	Average Maximum Monthly Deposition (g/m²/month)	Maximum Monthly Deposition (g/m²/month)	New Zealand Trigger Level for Sensitive Areas as Receptors (g/m²/month)
Coal Dust	50	2.2	3.1	2.0
Coal Dust	100	1.4	2.3	2.0
Coal Dust	150	0.98	1.8	2.0

Notes:
g/m²/month = grams per square meter per month

Table 10 compares the maximum trace element concentrations found in coal dust for the coal trains operating along the BNSF main line location with their respective acceptable source impact levels (ASILs). The fraction of trace elements found in coal is based on the maximum fraction of these elements found in two Powder River Basin coal beds (Stricker et al. 2007) in combination with the coal dust air quality modeling. All of the predicted maximum concentrations of these trace elements

[11] These modeled results are comparable to those found during recent monitoring conducted by Corporation of Delta (2014) that reported coal dust deposition amounts ranging from 2 to 10 g/m²/month (July 2013, April 2014, and October 2014) for an average of six 125-car loaded coal trains passing each day at an average speed of 35 mph (Brotherston pers. comm). The dust fall monitor was located 66 feet from the BNSF main line.

in coal dust are less than their respective ASILs. Chromium (VI) is likely substantially lower than as shown in the table as the percent of chromium as chromium (VI) was conservatively assumed to be the same as coal fly ash, which is a post-combustion coal residual. This process is known to substantially increase the percentage of chromium as chromium (VI) (Stam et al. 2011).

Table 10. Maximum Concentrations of Trace Elements Compared with Acceptable Source Impact Levels—BNSF Main Line, Cowlitz County

Substance[a]	Maximum Concentration (μg/m³)	ASIL (μg/m³)	Averaging Time	Percentage of ASIL (%)
Arsenic and inorganic arsenic compounds	0.000062	0.000303	Annual	21
Beryllium and compounds	0.000007	0.000417	Annual	1.8
Cadmium and compounds	0.000002	0.000238	Annual	0.7
Chromium (VI)[b]	0.0000047	0.00000667	Annual	71
Cobalt as metal dust and fume	0.00013	0.1	24 hour	0.1
Copper, dusts and mists	0.0015	100	1 hour	0.002
Lead compounds	0.000038	0.0833	1 year	0.046
Manganese dust and compounds	0.00093	0.04	24 hour	2.3
Mercury, aryl and inorganic	0.000005	0.09	24 hour	0.005
Nickel and compounds	0.000031	0.0042	Annual	0.74
Selenium compounds	0.000065	20	24 hour	0.0003
Vanadium compounds	0.000732	0.2	24 hour	0.37
Crystal silica (PM4 -respirable) daily average	0.94[c]	3.0	8 hour	31

Notes:

[a] The fraction of trace elements found in coal is based on the maximum fraction of these elements found in two Powder River Basin coal beds (Stricker et al. 2007) in combination with the coal dust air quality modeling

[b] Chromium (VI) is likely substantially lower than as shown in the table because the percent of chromium as chromium (VI) was conservatively assumed to be the same as coal fly ash, which is a post-combustion coal residual. Combustion is known to substantially increase the percentage of chromium as chromium (VI) (Stam et al. 2011).

[c] Based on analysis of coal dust sample from field program. Total crystal silica fraction in coal dust is the sum of the crystal silica quartz and silicate fractions.

ASIL = acceptable source impact level; μg/m³ = micrograms per cubic meter

3.1.3.2 Washington State

To assess the coal dust air quality and deposition impacts in other locations in the state, air quality modeling was performed for a train moving at an average speed of 50 mph for the loaded coal train along the main line running in a southwest-northeast orientation in Eastern Washington[12] using Moses Lake meteorological data. Results are presented in Table 11 showing the maximum coal dust concentration (including background) relative to the PM10 and PM2.5 standard. The maximum concentrations occur at a distance of 100 feet. These concentrations fall off by 50% another 100 feet away from the rail line. These concentrations plus background are all below the NAAQS standards.

[12] This is the general orientation of the main rail line running from the Tri-Cities to Spokane.

Table 11. Estimated Maximum PM10 and PM2.5 Concentrations 100 Feet From Rail Line—BNSF Main Line, Washington State (Outside Cowlitz County)

Pollutant	Averaging Period	Modeled Impact (μg/m³)	Background[a] (μg/m³)	Total Concentration (μg/m³)	NAAQS (μg/m³)
PM10	24 hour[b]	24.2	101	125	150
PM2.5	24 hour[c]	2.8	24.2	27.0	35
	Annual[d]	0.92	8.9	9.82	12

Notes:
[a] Background for PM10 is the maximum high second high 24-hour average over the 3-year period (2012–2014) from Kennewick or Spokane. The background PM2.5 from the Spokane monitor from the 2012–2014 period.
[b] The PM10 24-hour modeled impact is 3-year average of the high 2nd high concentration.
[c] The PM2.5 24-hour modeled impact is the 3-year average of the 98th percentile of the daily maximum concentrations.
[d] Modeled impact is the annual average over the 3 modeled years based on Moses Lake meteorological data (2010–2012).
μg/m³ = micrograms per cubic meter

The same modeling approach was used to determine the coal dust TSP deposition in eastern Washington (Table 12). The results show the increase in deposition from the coal train rail operations located about 100 feet from the rail line. Maximum monthly deposition occurs during December. The monthly deposition is well below the New Zealand trigger level for most sensitive areas. The maximum concentration of trace metals would be less than that found in Cowlitz County, which did not show concentrations above the ASIL.

Table 12. Estimated Maximum and Average Monthly Coal Dust Deposition—BNSF Main Line, Washington State (Outside Cowlitz County)

Material	Distance (feet)	Average Maximum Monthly Deposition (g/m²/month)	Maximum Monthly Deposition (g/m²/month)	New Zealand Trigger Level for Sensitive Areas (g/m²/month)
Coal Dust	100	0.71	0.86	2.0
Coal Dust	200	0.26	0.50	2.0

Notes:
g/m²/month = grams per square meter per month

3.2 No-Action Alternative

Under the No-Action Alternative, the Applicant would not construct the Proposed Action and impacts related to coal dust from construction and operation of the Proposed Action would not occur. The Applicant would continue with current and future operations in the project area. The project area could be developed for other industrial uses, including an expanded bulk product terminal or other industrial uses. The Applicant has indicated that, over the long term, it would expand the existing bulk product terminal and develop new facilities to handle more products such as calcine petroleum coke, coal tar pitch, and cement. Petroleum coke transfer would have minimal coal dust emissions because the material is stored in a building and the transfer from vessel occurs through vacuum unloader.

3.3 Mitigation

Based on the findings in this technical report, the co-lead agencies (Cowlitz County and Washington State Department of Ecology) developed potential Applicant mitigation measures. In addition, the Applicant has committed to voluntary measures to mitigate potential impacts. The SEPA Draft Environmental Impact Statement (EIS) presents these mitigation measures.

Chapter 4
References

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Coal Spills Analysis

Chapter 1
Introduction

1.1 Regulatory Setting

There are no known statutes, regulations, or guidelines at the federal, state, or local level that are specific to spills of elemental unprocessed coal. However, there could be federal, state, or local requirements (e.g., permits) that may be required for clean-up activities related to a coal spill after-the-fact, depending on the location and extent of the coal spill, and nature of the response and clean-up actions. Any spill into a jurisdictional waterbody would likely be treated as an unauthorized discharge under the federal Clean Water Act and the state Water Pollution Control Act and clean-up activities would be permitted after-the-fact. Federal, state, or local requirements (e.g., permits) could be required for clean-up activities related to a coal spill, depending on the location and extent of the spill, and nature of the response and clean-up actions. Any coal spill into a jurisdictional waterbody would likely be treated as an unauthorized discharge under the federal Clean Water Act and the state Water Pollution Control Act.

1.2 Study Area

The coal spill study area includes the project area where coal handling would occur, including the dock areas where coal would be loaded onto ships in the Columbia River. The coal spill study area also includes areas along the rail line corridor(s) in Cowlitz County and Washington State where trains would operate, transporting coal to the coal export terminal; coal transport to the coal export terminal would likely follow the BNSF and UP routes described for loaded coal trains in the SEPA Rail Transportation Technical Report (ICF International and Hellerworx 2016). The size and extent of a coal spill cannot be predicted and would depend on various factors such as location of the incident (dock or railway), train speed, surrounding topography, adjacent structures, and characteristics of the adjacent natural and aquatic environment (e.g., terrestrial vegetation and habitat types, lentic (still) or lotic (flowing) surface waters.

This is a qualitative evaluation of coal spills and the study area focuses on the aquatic (e.g., surface waters and wetlands), terrestrial (e.g., vegetation/habitat), and built environments because these could be affected most directly by spilled coal.

Chapter 2
Existing Conditions

Descriptions of existing conditions relative to terrestrial and aquatic habitats and species, and the built environment for the Proposed Action can be found in the SEPA Vegetation Technical Report (ICF International 2016a), SEPA Surface Water and Floodplains Technical Report (ICF International 2016b), SEPA Fish Technical Report (ICF International 2016c), SEPA Wildlife Technical Report (ICF International 2016d), SEPA Land and Shoreline Use Technical Report (ICF International 2016e), and SEPA Water Quality Technical Report (ICF International 2016f).

The existing conditions in the rail line study area is described for two areas: Cowlitz County and those portions of Washington State beyond Cowlitz County.

2.1 Cowlitz County

The environment within Cowlitz County can be broken down into three broad categories: (1) aquatic habitats (i.e., rivers, streams, surface waters, and wetlands); (2) terrestrial habitats (i.e., deciduous and coniferous forests, and disturbed areas); and (3) the various built environments associated with rural, residential, agricultural, commercial, and industrial areas.

2.1.1 Aquatic Environments

Aquatic environments in Cowlitz County include surface waters (e.g. streams, rivers, wetlands) that are intersected by or adjacent to the rail line. These surface waters are important components of the natural environment, providing habitat for fish, wildlife, and vegetation. Major rivers in the study area include the Columbia River, Cowlitz River, Kalama River, North Fork Lewis River, and Toutle River, and there are also many smaller streams, such as Ostrander Creek, Salmon Creek, and Mill Creek, most of which are tributaries to the Columbia River. These rivers and streams are known to, or have the potential to, support various species of fish, including salmonids, such as Chinook salmon, chum salmon, coho salmon, sockeye salmon, pink salmon, steelhead, and bull trout. Steelhead and coho salmon spawning habitat has been identified at the Kalama River rail crossing (Washington Department of Fish and Wildlife 2015a). Five of these salmonid species are federally protected under the Endangered Species Act: Chinook salmon, chum salmon, coho salmon, steelhead, and bull trout. Eulachon, a small anadromous fish, and green sturgeon are also federally protected under the Endangered Species Act and are found in rivers and streams in the study area. Critical habitat is designated in several study area streams for Chinook salmon, chum salmon, steelhead, bull trout, and eulachon. Other fish, amphibian, and reptile species may also utilize surface waters in the study area, such as the Pacific pond turtle, Dunn's salamander, western toad, leopard dace, and Pacific lamprey.

Wetlands are also an aquatic environment of concern in the study area. The National Wetland Inventory (U.S. Fish and Wildlife Service 2015) maps wetlands along much of the rail study area within Cowlitz County, with higher concentrations where the rail is closer to the Columbia River and outside of developed areas (e.g., outside the cities of Kalama and Longview, and agricultural areas). Noted higher wetland concentrations occur south of the confluence of the Cowlitz River with the Columbia River and around the confluence of the Kalama River with the Columbia River. Wetlands mapped along the rail line include Palustrine[13] Emergent, Palustrine Scrub Shrub, and Palustrine Forested wetlands, with various hydrologic regimes. Wetlands provide habitat that can support a variety of wildlife species, including birds, mammals, amphibians, and reptiles. A review of Washington Priority Habitats and Species (PHS) data (Washington Department of Fish and Wildlife 2015b) indicates several large areas of waterfowl concentrations and cavity nesting ducks associated with various wetland habitats. Species identified with these habitat areas include downy woodpeckers, green backed herons, great horned owl, short eared owl, goldeneyes, and wood ducks. Waterfowl concentrations in the southern part of Cowlitz County in the rail study area (just north of the North Fork Lewis River) include dusky and cackling Canada geese, tundra swans, and sandhill cranes; this area provides seasonal migration habitat for these species.

2.1.2 Terrestrial Environments

The terrestrial environment along the rail line includes a mix of natural habitats (forest, shrub, herbaceous upland), disturbed and developed areas (i.e., rural and urban areas), and agricultural areas. South of Longview and the confluence of the Cowlitz and Columbia Rivers, terrestrial vegetation and wildlife habitat conditions improve compared to the more industrial and urban character of the cities of Longview and Kelso, with some forested areas, wetlands, and ash mounds (associated with the eruption of Mount St. Helens in 1980 and subsequent dredging of the Cowlitz River to remove the mud and ash from the river). South of the Kalama River near the town of Kalama, terrestrial conditions again revert to more industrial and urban land uses. From the town of Kalama south to Martin Island, habitat conditions revert back to areas of forests and wetland areas interspersed with rural development. From Martin Island south to the Cowlitz-Clark County line, the BNSF rail corridor intersects primarily agricultural land and rural development, with the exception of the city of Woodland, which has some commercial, urban, and residential development.

Representative wildlife in the study area may include black-tailed deer, red fox, coyote, raccoon, striped skunk, beaver, Oregon and grey-tailed vole, red-tailed hawk, Cooper's hawk, Canada geese, mallard and northern pintail ducks, great blue heron, white-breasted nuthatch, chipping sparrow, and a variety of amphibians and reptiles (Commission for Environmental Cooperation 2011). A review of PHS data (Washington Department of Fish and Wildlife 2015b) for terrestrial habitats indicates small areas of oak woodlands in a few places along the rail line; species associated with this habitat include various woodpeckers, migrant birds, reptiles, invertebrates, and the western gray squirrel (Washington Department of Fish and Wildlife 1998). In addition, two osprey point locations are mapped within 300 feet of the rail line; no further information is provided (Washington Department of Fish and Wildlife 2015b). No designated critical habitat for federally protected species under the jurisdiction of the U.S. Fish and Wildlife Service is mapped in the terrestrial environment in the vicinity of the rail line corridor(s) potentially used to transport coal.

2.1.3 Built Environment

The built environment in the rail line study area in Cowlitz County consists of structures and infrastructure associated with urban, rural, and commercial/industrial land uses. More developed areas occur around Longview, Kalama, and Woodland, and are dominated by industrial facilities and residential neighborhoods. Less-developed rural areas are found in-between these more urbanized

[13] Palustrine wetlands are inland wetlands which generally lack flowing water, contain ocean-derived salts in concentrations of less than 0.5 parts per thousand (ppt), and are non-tidal.

areas. Structures include housing, commercial and industrial buildings, and associated infrastructure such as roads, bridges, and transmission and utility lines.

2.2 Washington State

Washington State beyond Cowlitz County has various and substantially different types of natural and built environmental conditions. Beyond Cowlitz County, the BNSF rail corridor (rail study area) primarily travels through three ecoregions, including the Cascades, Eastern Cascades Slopes and Foothills, and Columbia Plateau (Commission for Environmental Cooperation 2006), which is the largest ecoregion the rail study area passes through. In general, similar categories for the natural and built environment are applicable at the state-wide scale (i.e., natural [aquatic and terrestrial] environments and built environments).

2.2.1 Aquatic Environment

The aquatic environment in Washington beyond Cowlitz County includes many rivers and streams that are intersected or adjacent to the rail corridor. Many rivers and streams in the rail study area in Clark and Skamania Counties support or have the potential to support the same fish species described for Cowlitz County, as well as similar amphibian and reptile species. However, east of Skamania County (e.g., Klickitat and Benton Counties) the ecological conditions transition to the drier climate of the Columbia Plateau in Eastern Washington (i.e., east of the Cascade Mountains). As a result, smaller tributary streams originating in this ecoregion are generally ephemeral; most summer precipitation is evaporated or transpired, leaving little water for streamflow (Commission for Environmental Cooperation 2011). These conditions may be one factor limiting potential fish distribution. For example streams that support salmonids are much less prevalent in the drier region of eastern Washington compared to western Washington (Washington Department of Fish and Wildlife 2015a). Wetlands occur in the Columbia Plateau, but many have been drained and altered (Commission for Environmental Cooperation 2011).

2.2.2 Terrestrial Environment

The vast majority of the rail study area beyond Cowlitz County is within the Columbia Plateau ecoregion (Commission for Environmental Cooperation 2011). This ecoregion has dry desert and steppe climates, marked by hot, dry summers and cold winters, and consists of shrub-steppe vegetation communities. Vegetation is typically dominated by sagebrush, bitterbrush, bluebunch, needle- and thread-, Idaho fescue, and Sandberg's bluegrass. Numerous annual and perennial flowers often grow in the spaces between the shrubs and bunchgrass. Shrub-steppe historically dominated the landscape of the ecoregion, but much of it has been degraded, fragmented, and isolated from other similar habitats due to conversion to croplands (Washington Department of Fish and Wildlife 2015c).

Representative wildlife of the Columbia Plateau include mule deer, pronghorn antelope (last reintroduced in 2011 at the Yakama Indian Reservation), coyote, black-tailed jackrabbit, ground squirrels, American kestrel, golden eagle, red-tailed hawk, western meadowlark, savanna sparrow, western diamondback rattlesnake, greater sage-grouse, sage sparrows, sage thrashers, and pygmy rabbits, in addition to many other birds, mammals, reptiles, and insects (Commission for Environmental Cooperation 2011 and Washington Department of Fish and Wildlife 2015c). Shrub-steppe communities can also support federally protected species, including the pygmy rabbit and Spalding's catchfly, and the Washington Department of Fish and Wildlife also considers shrub-steppe a priority habitat under the PHS program.

The Cascades and Eastern Cascade Slopes and Foothills ecoregions make up a smaller area intersected by the rail study area and mostly coincide with Clark, Skamania, and Klickitat Counties. Typical vegetation in the Cascades ecoregion at lower elevations include Douglas fir, western hemlock, western red cedar, big leaf maple, and red alder; representative wildlife includes black-tailed deer, black bear, coyote, beaver, river otter, pileated woodpecker, and northern goshawk. Typical vegetation in the Eastern Cascades Slopes and Foothills ecoregion includes open forests of ponderosa pine and some lodgepole pine, with sagebrush and steppe vegetation at lower elevations. Representative wildlife species in this ecoregion include black bear, black-tailed deer, mule deer, cougar, wolverine, coyote, yellow bellied marmot, bald and golden eagles, Cooper's hawk, and osprey (Commission for Environmental Cooperation 2011). PHS data (Washington Department of Fish and Wildlife 2015b) indicate various priority habitats and species along the rail line study area, including talus slope and cliffs/bluffs habitats, bald eagle concentrations and breeding areas, and western pond turtle regular occurrence areas.

2.2.3 Built Environment

The built environment in the rail study area in Washington (beyond Cowlitz County) consists of structures and infrastructure associated with urban, rural, agricultural, and industrial land uses. More developed areas occur along the southern BNSF corridor around Ridgefield, Vancouver, Stevenson, Camas, Washougal, Kennewick, Walla Walla, Richland, Pasco, and Spokane, while to the north more developed ares include Tacoma, Seattle, Everett, Wenatchee, and Yakima. These areas are dominated by a mix of commercial, industrial, and residential land uses. Less-developed rural areas are found in-between these urban areas. Structures include housing, industrial buildings, commercial buildings, and associated infrastructure such as roads, bridges, and transmission and utility lines.

Chapter 3
Impacts and Mitigation

3.1 Impacts

Large-scale coal spills from operation of the coal export terminal and trains transporting coal to the facility could potentially affect the aquatic, terrestrial, and built environments. Such an event could occur as a result of a train incident (collision and/or derailment) or to a lesser extent during coal handling at the coal export terminal that occurs outside the rail loop (i.e., trestle and docks). Potential effects on the natural environment from a coal spill would likely be more pronounced during a train incident compared to a spill occurring in the confines of the coal export terminal for two reasons: (1) the absence of terrestrial and aquatic environments within the already developed project area compared to the presence of various terrestrial and aquatic resources along the rail line throughout the state, and (2) the amount of coal that could be spilled during operations at the coal export terminal would likely be relatively low when compared to a spill resulting from a train incident or derailment. Additionally, coal would be contained within the rail loop during operations. The magnitude of the potential impact from a coal spill on the aquatic, terrestrial, and built environments would depend on the location of the spill, the volume of the spill, and success of efforts to contain and clean-up the spill.

A coal spill during operations of the coal export terminal could occur. Direct impacts resulting from a spill during coal handling at the coal export terminal would likely be relatively minor because the amount of coal that could be spilled during operations would be relatively small and because of the absence of terrestrial and aquatic environments that exist within the areas to be developed and the contained nature of the coal export terminal and features of the terminal (e.g., fully enclosed belt conveyors, transfer towers, and shiploaders).

Further, it is unlikely that coal handling within the upland portions of the project area would result in a spill of coal that would affect the Columbia River as the rail loop and stockpile areas would be contained, and other areas adjacent to the coal export terminal are separated from the Columbia River by an existing levee, which would prevent coal from being conveyed from upland areas adjacent to the rail loop to the Columbia River. Coal could be spilled during ship loading operations; however, such a spill would require human error or equipment malfunction and would be expected to result in a limited release of coal into the environment due to safeguards to prevent such operational errors resulting in a spill. These include start-up alarms, dock containment measures (i.e., containment "gutters" placed beneath the docks to capture water and other materials that may fall onto and through the dock surface) to contain spillage/rainfall/runoff, and enclosed shiploaders.

The potential impact of a coal spill from train operations is directly related to the probability of a train incident occurring. A train incident (collision/derailment) risk analysis was developed by ICF International (2016g) to estimate the number of train incidents that could potentially occur during coal transport (i.e., loaded coal trains) within Cowlitz County and Washington State. In Cowlitz County, the predicted number of loaded coal train incidents is approximately one every 2 years. The predicted number of loaded coal train incidents within Washington State is approximately five per year (ICF International 2016g).

Not every incident of a loaded coal train would necessarily result in a rail car derailment and/or a spill of coal. A train incident could involve just one or two rail cars or multiple rail cars, and could include derailment in certain circumstances. Not all of the coal cars that may derail in any train incident would necessarily result in some or all of their contents spilling, depending on the nature of the incident (i.e., size of train, speed of the train, terrain where incident occurs). A broad range of spill sizes, from a partial rail car to multiple rail cars, could potentially occur from loaded unit coal trains as the result of a train incident (ICF International 2016g).

In addition, containment and clean-up efforts for coal spills associated with both operations and rail transport factor significantly into the ultimate fate of a coal release and its potential impact on the environment. It is assumed that coal spills in the terrestrial and built environments would be easier to contain and clean up than if such spills were to occur in the aquatic environment because coal would be on the ground surface and visible, response time would be more swift, and clean-up equipment would likely have easier access to the spill site. The impacts from unintended or coal releases on the aquatic, terrestrial, and built environments are described in the context of the train incident risk analysis and the containment and clean-up measures to remove the spilled coal.

3.1.1 Aquatic Environments

Coal is transported over land and water throughout the world. However, there is little existing literature and research regarding the effects of unburnt coal on the aquatic environment.

The most comprehensive literature review on the potential impacts of unburnt coal in the aquatic environment was conducted by Ahrens and Morrisey (2005). Their review summarized the potential physical and chemical (toxicity) effects of unburnt coal released into the aquatic environment; the following summarizes these effects and draws heavily from their review.

3.1.1.1 Physical Effects

In sufficient quantities, coal can have measurable physical effects on aquatic organisms and habitats similar to suspended and deposited sediments (which are well documented). The potential physical effects of increased coal in the aquatic environment are likely to dominate over potential toxic chemical effects (see below) of coal (Ahrens and Morrisey 2005). The physical effects of coal on aquatic organisms and the aquatic environment can include abrasion, smothering, diminished photosynthesis, alteration of sediment texture and stability, reduced availability of light, temporary loss of habitat, and diminished respiration and feeding for aquatic organisms. The magnitude of these potential impacts would depend on the amount and size of coal particles suspended in the water and settling on the bed/organisms (which will, in turn, depend on rate of flow and patterns of water movement), duration of coal exposure, and existing water clarity (Ahrens and Morrisey 2005). Therefore, depending on the circumstances of a coal spill and the existing conditions of a particular aquatic environment (e.g. lake, stream, wetland), the physical effects on aquatic organisms and habitat from introduced coal could vary significantly and range from no perceptible impact (i.e., relatively small spill followed by rapid and complete clean-up) to more severe impacts that could include reduced growth, reproduction, and abundance; elevated mortality; and altered population and community structure (i.e., large spill that impacts significant habitat and/or species with prolonged and more invasive clean-up effort).

Similarly, clean-up of coal released into the aquatic environment could result in temporary impacts to habitat, such as smothering, alteration of sediment composition, temporary loss of habitat, and diminished respiration and feeding for aquatic organisms. The time required for recovery of the aquatic environment and resources would depend upon the extent and duration of clean-up efforts and the environment in which the incident occurred. For benthic organisms, such as macroinvertebrates, recolonization rates of temporarily disturbed benthic habitats range from 30 to 45 days (National Marine Fisheries Service 2003). Aquative vegetation would likely require more time to recolonize benthic habitats temporarily disturbed by clean-up efforts, with the durations dependent upon site-specific conditions (i.e., water depth, water clarity, water velocity, substrate type).

3.1.1.2 Chemical Effects (Toxicity)

Some research suggests that the bioavailability of contaminants in coal is limited, and that at levels of coal contamination at which estimates of bioavailable concentrations of contaminants might give cause for concern, the acute physical effects are likely to be more harmful than the chemical effects (Ahrens and Morrisey 2005). However, the variable chemical properties of coal and the aquatic environment in which it might occur, may give rise to circumstances in which contaminant mobility and bioavailability is enhanced. Coal can be a source of acidity, salinity, trace metals, polycyclic aromatic hydrocarbons (PAHs), and chemical oxygen demand (a measure of organic pollutants found in water), and interactions between coal and water could result in the alteration of pH and salinity, release of trace metals and PAHs, and an increase in chemical oxygen demand. However, if and how much these alterations occur in the aquatic environment and whether the alterations are significant enough to be potentially toxic to aquatic organisms depends on many factors, notably the type of coal, the relative amount of time the coal is exposed to water and broken down, dilution, buffering, and bioavailability.

Because of these unknown factors it is difficult to evaluate specifically what would happen in the event of a coal spill in the aquatic environment. For example, the acidity-generating potential of coal is largely a function of sulfur content, with sulfur-rich coals generally producing low pH levels in water and sulfur-poor coal generally producing more pH-neutral water (Ahrens and Morrisey 2005). The low pH of sulfur-rich coal further favors dissolution and release of metal ions such as iron, copper, manganese, chromium, and zinc compared to sulfur-poor coal (Anderson and Youngstrom 1976 in Ahrens and Morrisey 2005).[14]

Coal from the Powder River basin and Uinta Basin are low-sulfur coal. However, to provide a sense of the worst-case, more sulfur-rich coal is considered in the context of impacts to water quality. In general, how sulfur-rich coal could affect the aquatic environment largely depends on the context in which the coal is present. In the context of a coal stockpile at an export terminal that is exposed to rain water, the leachate generated from sulfur-rich coal could result in stormwater runoff with low pH levels and metal ion concentrations that could potentially be released into the environment if not contained and treated prior to discharge (operation of the coal export terminal would require a federal and state permit for any discharge of stormwater from the facility; effluent would be required to meet state and federal water quality criteria). In the context of coal released into a large flowing river like the Columbia River (e.g., from train derailment or during ship loading), acidity could be immediately buffered by the river's naturally occurring bicarbonate concentrations, which

[14] It should be noted that the coal export terminal would primarily handle western U.S. coal from the Powder River Basin, and to a lesser extent the Uinta Basin; the sulfur content of coal from these basins is poor—the lowest sulfur content from U.S. domestic sources (Grette Associates, LLC 2014). This suggests that there would be a much lower acidity-generating potential (i.e., low pH levels) and lower potential metal release in the aquatic environment.

would limit the release of metals, potentially resulting in imperceptible changes in the aquatic environment. Further, if any metals were released, their concentrations would likely be diluted by the river's velocity and discharge volumes. In this scenario, any negative impacts on aquatic organisms, assuming chemicals were bioavailable, would likely be localized and kept in the immediate vicinity of the coal. In smaller streams and lakes, the impact could be more pronounced, but the extent of any impact would depend on site-specific conditions as well as the amount of coal released into the system.

Despite the variable factors and uncertainty of potential effects of coal spilled into the aquatic environment, some research suggests that under certain conditions chemicals released from coal could interfere with metabolizing enzymes and metal detoxification proteins, destabilize and increase permeability of membranes, and bioaccumulate in the tissue of aquatic organisms (Ahrens and Morrisey 2005). Whether there would be any measurable impact would depend on a variety of factors, but could potentially result in reduced growth, reproduction, and abundance; elevated mortality; and altered population and community structure (Ahrens and Morrisey 2005).

Depending on the circumstances of an coal spill and the existing conditions of a particular aquatic environment (e.g., stream, lake, wetland), the chemical effects on aquatic organisms and habitats could vary significantly and range from no perceptible impact to more severe impacts. A recent coal train derailment and coal spill in Burnaby, British Columbia, in 2014, and subsequent clean-up and monitoring efforts provide some insight into the potential impact of coal spilled on the aquatic environment (i.e., Silver Creek and Burnaby Lake). Phase one of the effort involved removing as much coal as possible from the terrestrial and aquatic environment; a total of approximately 143 tonnes of mixed coal, organic and mineral fines were removed using a vacuum-truck system and hand tools (Borealis Environmental Consulting 2015). Some coal was left in place in the stream and lake because it was considered impractical to remove additional coal without concomitant removal of significant volumes of native substrate and potential disturbance of riparian habitats. Post clean-up water quality and biota studies were then conducted to determine the potential short- and long-term impacts from the residual coal that remained in the aquatic environment. The study included four major elements: water quality, sediment quality, sediment leachate toxicity, and bioaccumulation potential. The study's summary results state that water quality was generally consistent with provincial and/or federal guidelines protective of aquatic life. Sediment concentrations of three metals and PAHs exceeded sediment guidelines, which indicated a potential for adverse effects on aquatic biota, requiring additional laboratory toxicity tests regarding the bioavailability of these metals and PAHs. The toxicity test results determined all samples to be nontoxic to all species tested (fish, invertebrate, and algae), except at one sample site, which yielded marginal effects on the survival of benthic macroinvertebrates. The bioaccumulation potential results indicated no potential at any sample site, except for one sample site where PAHs present have the slight potential to accumulate in benthic invertebrates in that sample area. The overall conclusion of the weight-of-evidence evaluation was that there are potentially minor impacts in the coal spill study area, and that these impacts are restricted to a very small localized area of the stream and lake. Further, no additionalmitigation was recommended (as any removal of residual coal mixed with sediments was determined to pose a greater risk to environmental receptors); it was not anticipated that higher trophic levels would experience any adverse effects; and impacts beyond the spatial extent of the area assessed would be unlikely (Borealis Environmental Consulting 2015).

3.1.2 Terrestrial Environments

Coal released as the result of a spill into the terrestrial environment could physically damage and smother vegetation and terrestrial habitat. The potential for this impact within the confines of the coal export terminal would be low because of the developed nature of the coal export terminal, which has little to no existing vegetation or suitable terrestrial habitat, and containment measures which would already be in place during operations. Vegetation and terrestrial habitat immediately adjacent to the rail line would be susceptible to impacts from a coal spill, but the area adjacent to the rail line is generally disturbed from rail right-of-way maintenance (i.e., routine mowing and trimming of vegetation), and provides little high quality habitat and vegetation diversity, as well as higher incidences of nonnative plant species. There would be a greater risk of affecting more natural and undisturbed vegetation and habitats if a coal spill were to occur beyond these maintained areas or the rail right-of-way. Herbaceous vegetation would be more susceptible to damage and smothering from a coal spill compared to more rigid, woody vegetation like shrubs and trees, which would be able to better withstand the weight and force of a coal spill, depending upon the magnitude of the spill. The magnitude of potential impacts would depend on the size (volume) and extent (area) of the coal spill.

The physical impact of coal spilled on vegetation would range from minor plant damage to complete loss of vegetation, at least until assumed restoration measures would be implemented. Some plant species may be more sensitive to these impacts than others, and a coal spill could create an opportunity for nonnative plants to thrive and outcompete damaged native plants, although nonnative plants would likely sustain similar damage. Coal dust associated with a coal spill could also cover vegetation, resulting in reduced light penetration and photosynthesis, which could lead to reduced vegetation density and plant diversity. More tolerant plant species could benefit from decreased competition, particularly nonnative species that could outcompete native species. The magnitude of potential coal dust impact would depend on duration of exposure, tolerance of vegetation, and aggressiveness of nonnative species.

Ground disturbance related to clean-up of coal spilled during operations may further impact vegetation by either removing or further damaging it. Any pieces of residual coal that might remain on the ground after a clean-up effort could leach chemicals from exposure to rain, which could damage or kill vegetation. However, if this were to occur, the impact area would generally be highly localized and limited to the extent of the spill, and unlikely to disrupt the overall plant ecosystem.

Coal spilled into the terrestrial environment could also affect wildlife that may be in the area during a coal spill. It is unlikely that wildlife would be present within the confines of the coal export terminal due to the lack of vegetation and suitable habitat in the developed facility, presence of surrounding facility fences that would limit wildlife movement, and presence of humans and machinery during operations. Wildlife present along the rail line during a train incident or derailment, and that are unable to escape the area, could be harmed by direct physical contact if rail cars derail. Depending on the size of the coal spill, wildlife could sustain injuries from blunt force trauma as the rail car derails and coal is spilled, and if the spill is severe enough, could smother and die. Smaller and less mobile species would be at a higher risk than larger and more mobile species. However, it is anticipated that most wildlife would have already moved out of the immediate area along the track because of the relatively loud sounds and vibrations generated from oncoming and passing trains.

3.1.3 Built Environment

Coal spills in the built environment could potentially affect structures in the event of a large and concentrated coal spill associated with a train incident and/or derailment; however, more likely impacts on the built environment would include the potential disruption and delay of traffic, reduced access to business and services, and disruption of utility services. Although clean-up of coal in the built environment would likely commence immediately and access to the spill would be relatively uninhibited, there could be some delays and detours for vehicles, bicyclists, and pedestrians. Access to businesses, industries, services, and first responders could also be blocked or restricted. These impacts would likely be short-term and temporary burdens until removal and clean-up efforts were completed. The magnitude of these impacts would depend on the location and extent of a coal spill.

3.2 Mitigation

Based on the findings in this technical report, the co-lead agencies (Cowlitz County and Washington State Department of Ecology) developed potential Applicant mitigation measures. The SEPA Draft EIS presents these mitigation measures.

Chapter 4
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Sulfur Dioxide and Mercury Emissions Analysis

Chapter 1
Introduction

This chapter assesses the potential impacts in Washington State resulting from the combustion of Millennium Bulk Terminals–Longview coal exported to Asia and combusted in Asia. The air pollutants that could potentially impact Washington State, given the distant location, are emissions of mercury (Hg) and sulfur dioxide (SO_2). These pollutants are chemically transformed, deposited, and, in some cases, re-emitted[15].

Mercury is mostly (53%) released to the atmosphere in elemental form (Hg^0), with another 37% released as gas-phased oxidized mercury (Hg^{II}), and 10% as particle bound mercury. Hg^0 is oxidized to Hg^{II} by ozone and hydroxyl radical (OH) in the atmosphere; however, this process is relatively slow, and, because Hg^0 is relatively insoluble in water and has a low deposition velocity, it stays in the atmosphere for long periods of time. Hg^{II} is lost from the atmosphere through wet and dry deposition; however, in cloudy regions Hg^{II} can be reduced back to Hg^0; thus, a portion of the Hg^{II} Particle-bound mercury is rapidly removed from the atmosphere through deposition and is found only close to the source.

The process for SO_2 entering the atmosphere is similar to mercury's process. The atmospheric chemistry responsible for the conversion of SO_2 to particulate sulfate is primarily through the oxidation of SO_2 by the hydroxyl radical in the absence of clouds or fog. The rate of this conversion process increases with both increasing temperature and relative humidity. The conversion of SO_2 to sulfate via aqueous solution chemistry in clouds and fog is more complex and dependent on several variables, including concentrations of the principal oxidants (hydrogen peroxide and ozone), ammonia, droplet size, and composition. The speed of the reaction can vary from less than 1% SO_2 converted per hour to a maximum of about 10% converted per hour at high temperature and relative humidity. Competing with the conversion to sulfate is the removal process that includes loss to cloud droplets, rainout, and washout and loss to sea salt aerosols at the ocean's surface.

Because this chemical transformation and removal process of Hg and SO_2 is complicated, the best approach for assessing the impacts is through chemical transport modeling.

1.1 Assessment Approach

The objective of this assessment is to determine how much of the mercury and sulfate levels that would be found over Washington State could be attributable to the mercury and sulfur emitted from coal combustion in Asia (from coal that passed through the coal export terminal). The assessment was conducted in a four-step process.

1. Conduct a literature review of the current state of the science for the air monitoring and modeling of SO_2 and Hg in the Pacific Northwest.

[15] Chemically transformed meaning the pollutants interact with other chemicals in the atmosphere to form other air pollutants. Deposited meaning the pollutant is deposited to the earth surface. Re-emitted meaning pollutants which are first deposited to the surface of the earth but are later re-emitted to the atmosphere due mostly to changes in meterological or physical oceanic conditions.

2. Use the best understanding of the source-to-receptor relationship from the global chemical transport modeling (GCTM) that has been done to date and apply those findings to answer the objective of this study.
3. To apply the findings from the GCTM, compare the emission inventory for mercury and SO_2 used in the modeling with the projected air emissions of mercury and SO_2 in Asia (China, Japan, South Korea, Hong Kong, and Taiwan) for each of the five incremental scenarios completed using the Integrated Planning Model (IPM). This model was used to conduct the coal market assessment. Finally, identify the impacts from a long-range transport episode and on an annual basis.
4. Based on the literature review and emission inventory uncertainties, provide an upper bound on the mercury and SO_2 attributable to coal that passed through the coal export terminal.

This report discusses each of these four steps and presents the findings from this assessment. Because the two pollutants' (SO_2 and mercury) chemical fate and behavior in the atmosphere is very different, the final part of the report addresses mercury and SO_2 separately.

1.2 Overview of Methods for Mercury and SO_2 Assessment

This section provides an overview of the methods for the mercury and SO_2 assessment.

1.2.1 Literature Review

This step involved identifying, gathering, and reviewing peer-reviewed literature published in the past 15 years on the fate and transport of mercury and SO_2 emissions injected into the atmosphere from Asian countries where coal would be burned and any impact analyses completed to assess the impacts of the emissions in the Pacific Northwest of the United States and British Columbia, Canada. The best understanding of the fate and transport of those emissions would be used in assessing the fraction of the coal consumed and the impact in Washington State using a GCTM used to determine impacts in the Pacific Northwest.

1.2.2 Emission Inventory, GCTM, and Concentration Estimate

To determine the concentration or deposition amounts over Washington State from coal consumed, the emission source strength for each country of interest was collected as used in the fate and transport GCTM. The resulting concentration or deposition from the GCTM modeling was then adjusted for the projected country emissions for when the Applicant would become operational relative to the GCTM baseline modeling year. Finally, the projected concentration or deposition were adjusted for the fractional amount of coal to country emissions. This is expressed mathematically in the equation below and then simplified in the following step.

$$X_{tt} = X_{00} \times \frac{EA_{tt}}{EA_{00}} \times \frac{EA_{MTBL,tt}}{EA_{tt}},$$

Which simplifies to:

$$X_{tt} = X_{00} \times \frac{EA_{MTBL,tt}}{EA_{00}} \qquad \text{(Equation 1)}$$

Where *tt* is the forecast year, 00 is the baseline year of the GCTM modeling, *X* is the concentration or deposition at the representative location, *EA* is East Asia SO_2 or mercury emissions from all sources, and *MBTL* is the SO_2 or mercury emission from Proposed Action-related coal.

1.2.3 Application to the Five Coal Market Assessment Scenarios

Each emission rate (mercury or SO_2) for the five SEPA Coal Market Assessment Technical Report (ICF International 2016) scenarios was applied to future years of the five IPM scenarios for three future years (2025, 2030, and 2040) when the coal export terminal would be operational. Estimates of the concentrations and deposition are determined for each scenario on an annual and episodic bases. More information about the scenarios can be found in the SEPA Coal Market Assessment Technical Report.

1.2.4 Uncertainty

Based on the literature review on uncertainty an upper-bound estimate was developed on the possible coal combustion impact on mercury and sulfate concentration and deposition impact in Washington State. This is explained in the following sections.

Chapter 2
Mercury Assessment

Over 40 peer-review publications were found during the literature review, which spanned approximately the past 15 years. The studies included mercury emission inventories, emission projections, coal consumption in Asia, air monitoring studies in the Pacific Northwest and British Columbia, and global transport chemical modeling studies focused on assessing the fate and transport from Asia to North America. Also included in the assessment is the United Nations Environment Programme Global Mercury Assessment (United Nations Environment Programme 2013) report, which contains the most recent estimate of global mercury emissions.

The following discusses the nature of the emissions of mercury, how those pollutants behave and change in the atmosphere, and the form of those pollutants once they reach Washington State. This discussion is followed by a description of the papers most relevant to this study, with emphasis on the key findings from those papers as used in developing the impact assessment for the coal burning.

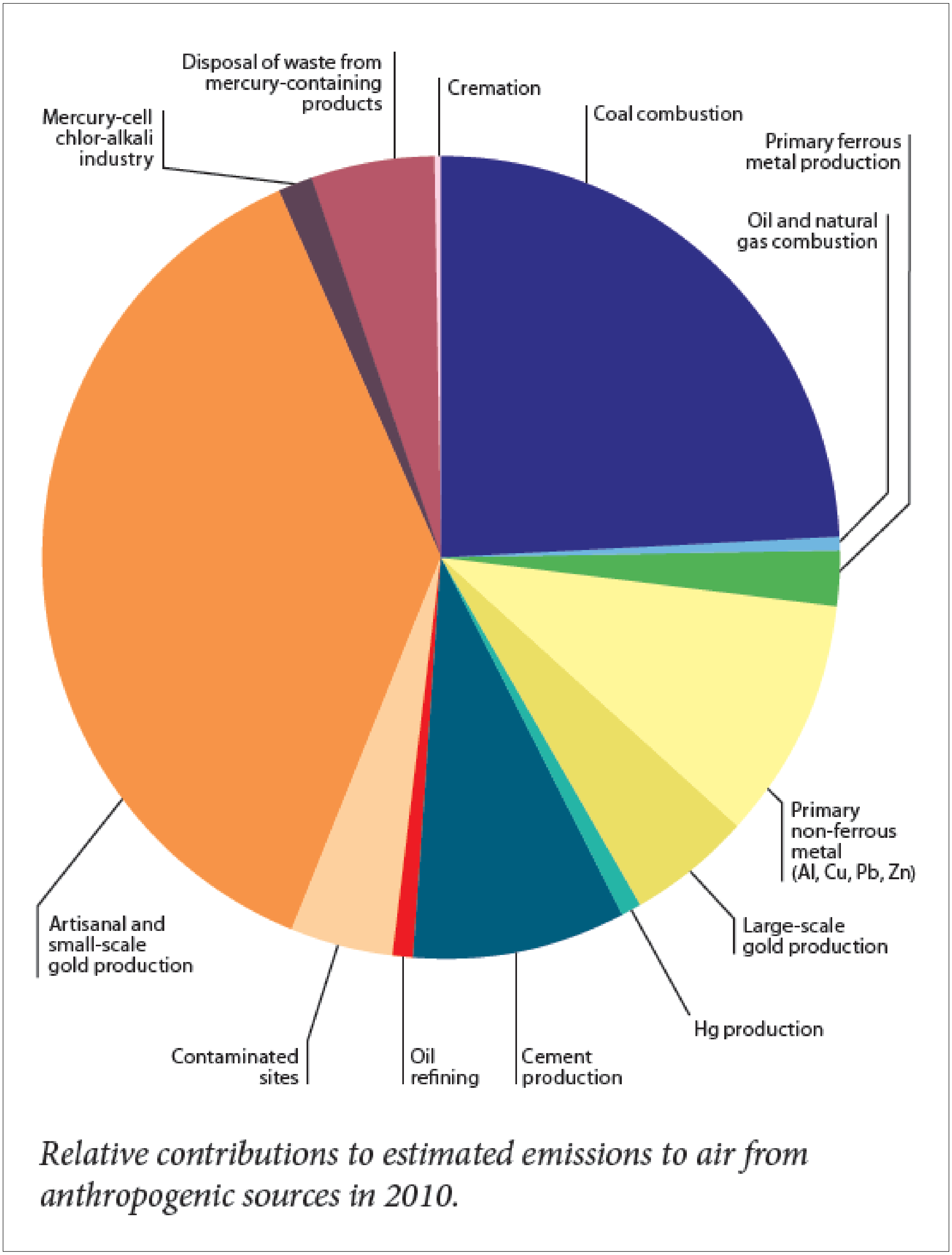
2.1 Introduction

Mercury is a naturally occurring element and is found throughout the world. There are many natural sources of mercury that emit mercury into the atmosphere, including the weathering of mercury-containing rocks, volcanoes when they erupt, and geothermal activity. Most recent models of the flow of mercury through the environment (United Nations Environment Programme 2013) find that natural sources account for about 10% of the annual mercury emission.

Anthropogenic sources of mercury emissions account for about 30% of the total amount of mercury entering the atmosphere each year. Globally, the largest source of emissions within this category is from artisanal and small-scale gold mining (estimated at 37%), followed by coal combustion (24%). The next largest sources are from the primary production of non-ferrous metals (aluminum, copper, lead, and zinc) and cement production. These sources together account for about 80% of the annual anthropogenic emission of mercury. Figure 7 shows the estimated emissions by anthropogenic source category.

The third category of mercury emissions is re-emissions, which account for about 60% of the mercury emitted to the air annually. Mercury previously deposited from air onto soils, surface waters, and vegetation from past emissions can be emitted back to the air. Re-emission is a result of the conversion of inorganic and organic forms of mercury to elemental mercury, which is volatile and therefore readily returns to the air. Mercury may be deposited and re-emitted many times as it cycles through the environment.

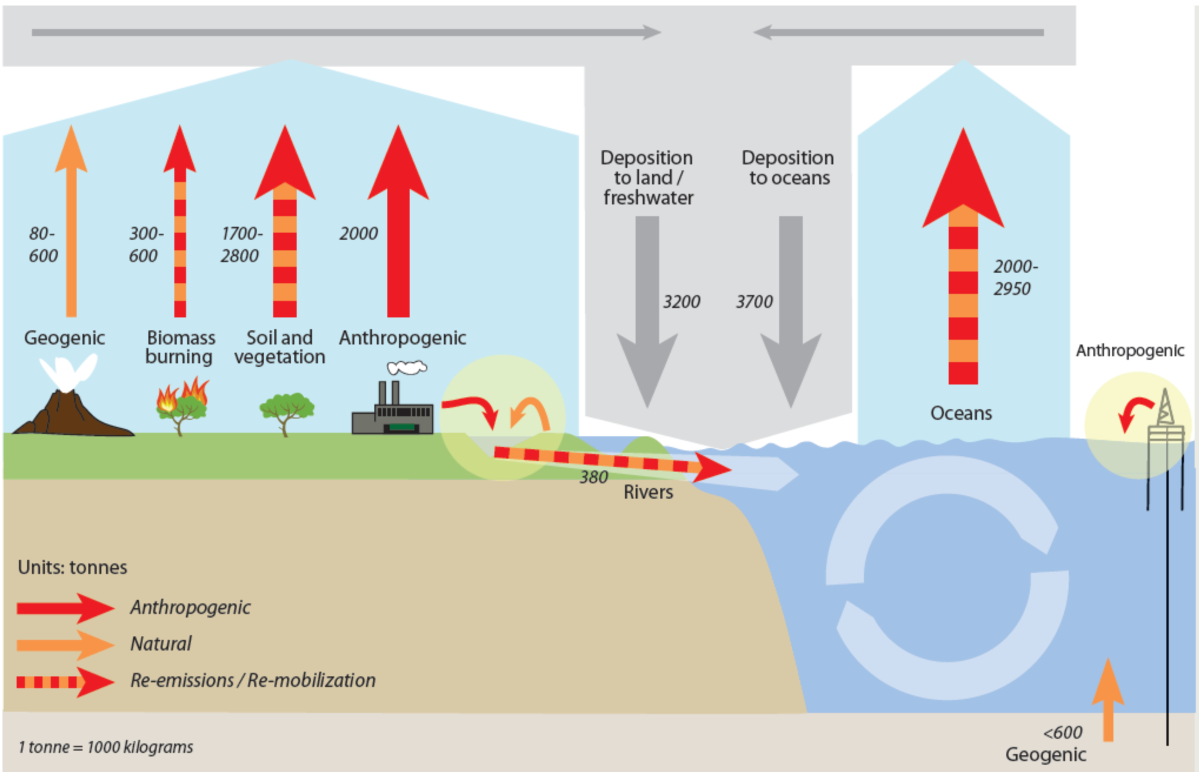
Figure 7. Anthropogenic Mercury Emissions Source Contribution



Source: United Nations Environment Programme 2013.

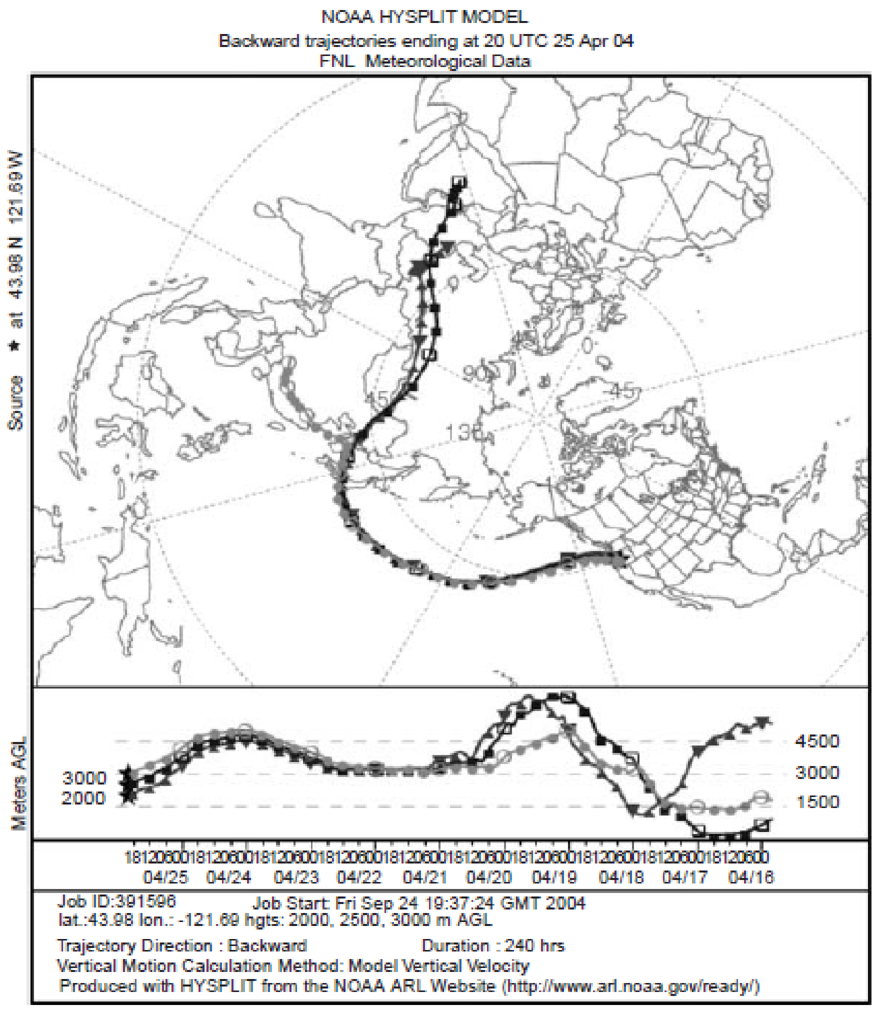
Re-emitted mercury should not be considered a natural source—it may originally have been either natural or anthropogenic, but by the time it is re-emitted, its specific origin cannot be identified other than from atmospheric modeling. Estimating re-emission rates is done using global modeling approaches based on data of atmospheric levels of mercury and an understanding of chemical transformations and other processes that affect how mercury moves between air, land, and water. The models act to balance the amount of mercury in circulation at any given time consistent with observational data. This analysis conservatively assumes that the re-emitted mercury is all anthropogenic. Figure 8 shows the current global mercury emission cycle.

Figure 8. Global Mercury Cycle (metric tons/year)



Source: United Nations Environment Programme 2013.

Figure 9. HYSPLIT Back-Trajectory for the Mount Bachelor Observatory Episode(April 25, 2004)



Mercury is largely released in its elemental form, which has a lifetime in the atmosphere of between 6 and 24 months, and therefore can be transported globally. The speciation of mercury has been further studied by Pacyna et al. (2006). Across industries about 53% of mercury in gases is Hg^0, 37% is Hg^{II}, and 10% is particle bound mercury. This is important as the latter two phases of mercury have much shorter lifetimes—on the order of days or weeks—which means they are deposited locally close to the source.

2.2 Studies and Findings

A number of observational studies have examined the long-range transport of Asian mercury emissions to North America (Jaffe et al. 2003, 2005; Weiss-Penzias et al. 2006). Weiss-Penzias et al. found that total mercury (elemental + reactive and particle) over the period from March 28 to May 19, 2004, at Mount Bachelor, Oregon (44.0° N, 121.7° W) had periods where the air mass originated from East Asia, with an average increase in total mercury during these periods of 0.16 nanograms per cubic meter (ng/m^3) attributable to emissions from northern China, Korea, and Japan. This was based on the analysis of thousands of back trajectories using the National Oceanic and Atmospheric

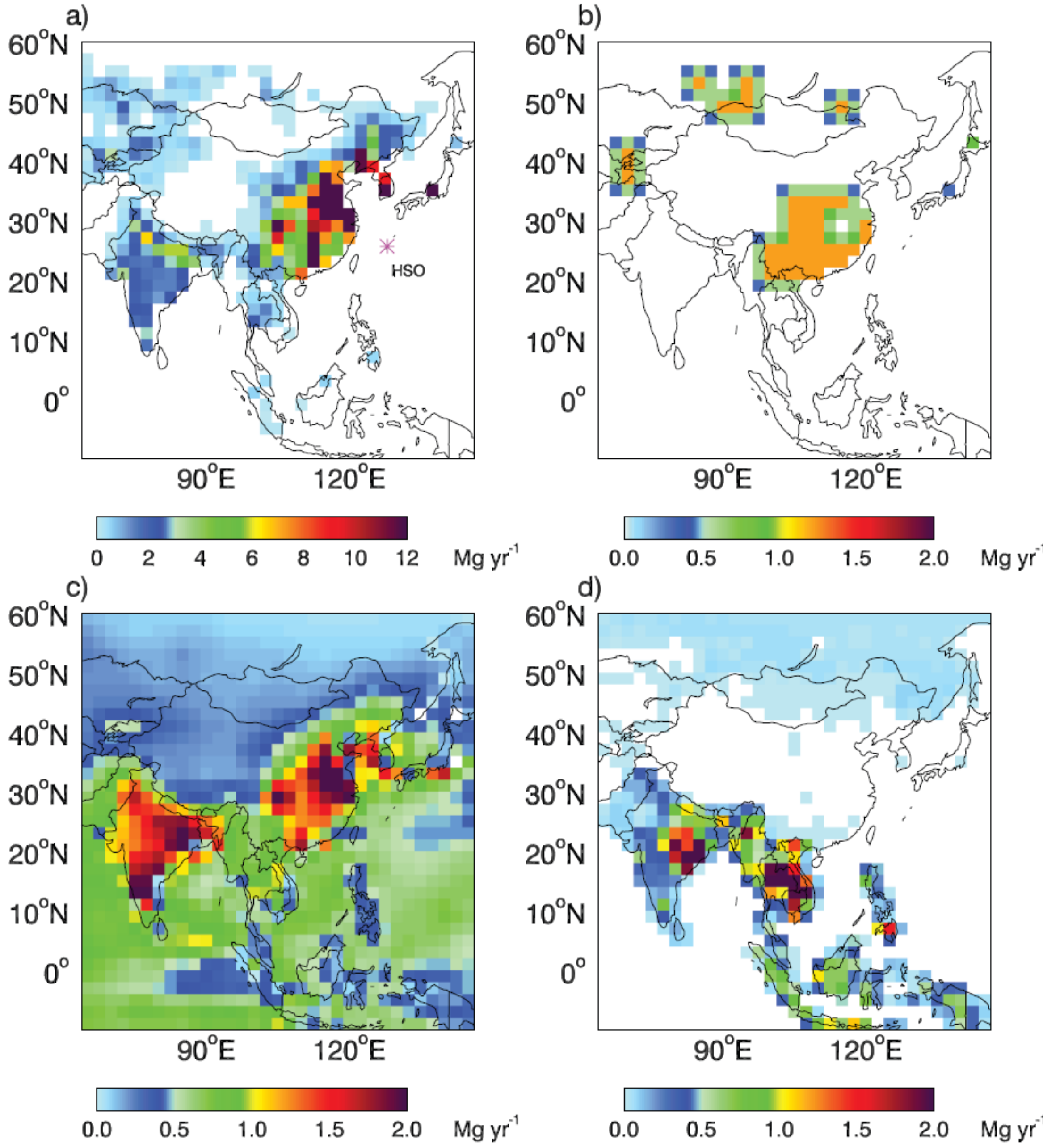
Administration's HYSPLIT trajectory model and mercury-to-carbon monoxide measurement ratios. Two pollution events within this time period were examined in detail, which showed that travel time from East Asia to the Pacific Northwest was about ten days. Back-trajectories for the April 25, 2004, episode at several elevations above and below the Mount Bachelor site elevation, along with back-trajectories for the same date on the corners of a 1° x 1° box around the Mount Bachelor location and at multiple elevations, all showed similar flow from East Asia (Figure 9).

Because of the large amount of coal consumed in East Asia, which is projected to increase, and because studies show long-range transport from East Asia to North America is a frequent occurrence, several global modeling studies have been conducted to explore the impact of mercury emissions from East Asia on North America. The first such assessment was presented by Seigneur et al. (2004), who reported that Asian mercury emission emissions were estimated to contribute between 5 and 36% of the total mercury deposition in the United States. The most extensive modeling study of East Asian mercury emission impacts on the Pacific Northwest was conducted by Strode et al. (2008). That study included both global modeling of mercury and an observational analysis and comparison of the models' findings using the Mount Bachelor monitored mercury data.

The GCTM used in this study was the GEOS-Chem global tropospheric chemistry model (Atmospheric Chemistry Modeling Group 2015). The model was run for the meteorological year 2004 with a model horizontal resolution of 2° latitude by 2.5° longitude. Hourly output from the model was extracted from the grid boxes corresponding to Mount Bachelor. The model includes emission, transport, deposition, and chemistry and is coupled to an ocean mixed layer. The model includes mercury entering the ocean mixed layer through deposition or ocean mixing whereby it is converted in the ocean to elemental mercury and then emitted to the atmosphere through gas-exchange, or it can be lost to the deep ocean through mixing and sinking of particles.

The model simulation includes global emissions from anthropogenic sources (Pacyna et al. 2006; Wilson et al. 2006), biomass burning, and natural emissions plus re-emissions from land and ocean. Figure 10 shows the distribution of anthropogenic, land, and biomass burning emissions over Asia (defined here as 9°S–60°N, 65°–146°W). For this region, anthropogenic emissions are 610 metric tons per year (MT/year) of Hg^0, 380 MT/year of Hg^{II}, and 100 MT/year of particle Hg. Natural emissions of 100 MT/year Hg are located primarily in southeast China. Land re-emissions of 310 MT/year Hg are distributed throughout the region, with large emissions from southeast China and India. All sources of Hg emissions are needed for evaluating the modeling results. At the Mount Bachelor Observatory, the mean model total Hg concentration was 1.61 ± 0.09 ng/m^3. This compared to an observed mean of 1.53 ± 0.19 ng/m^3, yielding a mean model bias of just 5% for total mercury. In addition to identifying the source of emissions, the GCTM tagged emissions from biomass burning, land, and ocean emissions as well as anthropogenic emissions by region. For Asia, anthropogenic mercury includes both direct emission from Asia and also ocean re-emission for previously deposited Asian anthropogenic mercury.

Figure 10. Distribution of Annual Asian Mercury Emissions (milligrams per year) from (a) Anthropogenic, (b) Natural, (c) Land Re-emission + Ocean Emission, and (d) Biomass Burning Used in the GEOS-Chem Model

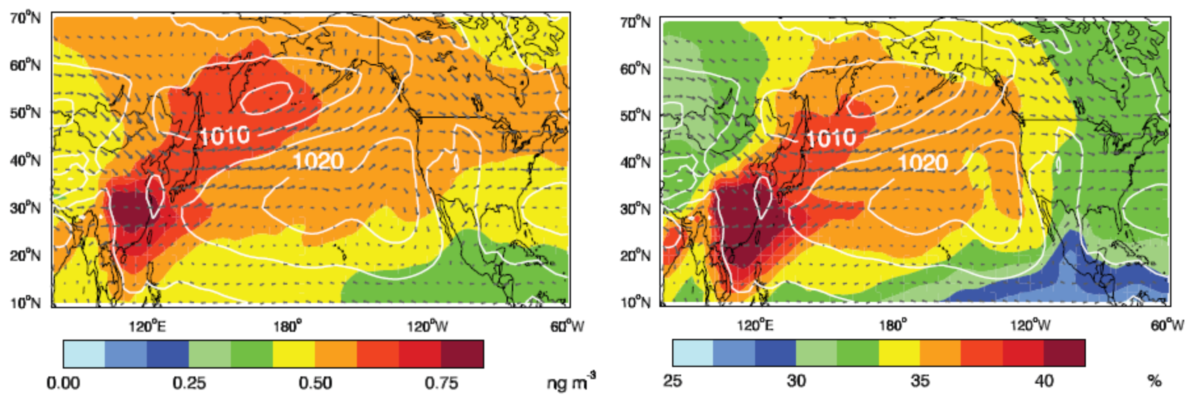


Source: Strode et al. (2008)

The model results showed that the Asian anthropogenic percent contribution to Hg^0 at Mount Bachelor shows little variability between seasons, with an Asian anthropogenic contribution of 18% in spring (0.29 ng/m^3 for Hg^0 and 0.015 ng/m^3 for Hg^{II}) and in the annual average. This source-to-receptor relationship is value applied to determine the contribution of the Proposed Action using Equation 1. The modeling results also show that the largest Asian Hg^0 contribution occurred on April 28, when the Asian sources accounted for 41% of Hg^0 (1.18 ng/m^3). Additionally, the modeling study showed that the regional contribution of Hg^{II} deposition (wet and dry) at Mount Bachelor was 14% (~ 2,900 milligrams per square kilometer per year (mg/km²-year) from Asian anthropogenic emissions. Finally, the model shows that mercury reaches the Mount Bachelor location only in the form of Hg^0 and Hg^{II}; therefore, the following focuses only on these two forms of mercury.

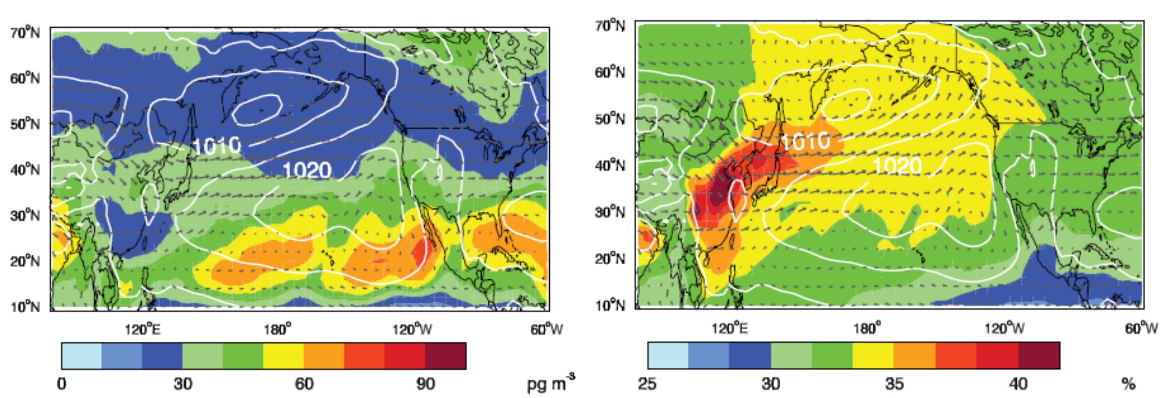
The general trans-Pacific transport of mercury from Asia to North America is shown in Figure 11. The different mechanisms by which Asian Hg^0 reaches North America affect the latitudinal distribution of their contributions. Hg^0 is transported to the northeast from Asia with the prevailing winds. Consequently, the Asian influence is largest over Alaska, western Canada, and the northwestern United States. The relative contribution of Asian emissions to the Hg^0 concentration is no more than 36%.

Figure 11. Maps of March–May 2004 Concentrations and Relative Percentage of Asian Hg^0



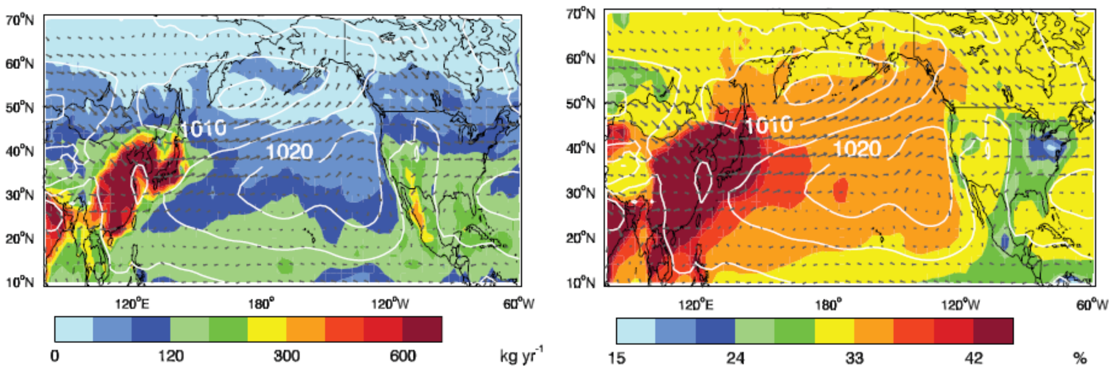
In contrast, Asian emissions influence North American Hg^{II} concentrations from oxidation of the global Asian Hg^0 pool within the atmosphere, rather than by direct transport of Hg^{II} from the emission source. The Asian Hg^{II} contribution is largest at low latitudes where high oxidant concentrations and descending dry air lead to higher concentration levels of Hg^{II} (Figure 12).

Figure 12. Maps of March–May 2004 Concentrations and Relative Percentage of Asian HgII



Asian Hg^{II} deposition follows a similar pattern to Asian Hg^{II} concentration as both wet and dry deposition depend on Hg^{II} concentrations (Figure 13).

Figure 13. Maps of March–May 2004 Concentrations and Relative Percentage of Asian Total Hg Deposition



2.3 Application of the GCTM to the Coal Market Assessment Scenarios

For each of the five SEPA Coal Market Assessment Technical Report (ICF International 2016) scenarios (IPM scenarios), emissions of mercury for 2025, 2030, and 2040 were used in Equation 1 as the defining the Proposed Action's emission source strength ($EA_{MBTL,tt}$). The development methodology for the mercury emissions is described in the IPM modeling. The baseline year emission rate for the GCTM modeling was the year 2000. GCTM modeled concentration and deposition results (X_{00}) are available for just anthropogenic Hg^0 and Hg^{II}, so that each contribution to total Hg can be reported. However, X_{00} is based on total Asian Hg emissions, which includes additional Asian countries where Proposed Action-related coal would not be consumed. Thus, rather than using the total Asian anthropogenic emissions, which total approximately 610 MT/year for Hg^0 and 380 MT/year for Hg^{II}, this study used a more conservative emission total for just the countries that would potentially consume the Proposed Action-related coal: Japan, Korea, China (includes Hong Kong), and Taiwan. The total Hg emission (as found in Pacyna et al. 2006) for these countries was 408 MT/year for Hg^0 and 285 MT/year for Hg^{II}. This conservatively assumes that only Asian emissions from these countries contribute to the portion of Asian mercury in Washington State. The X_{00} is based on the modeled concentrations as reported for Mount Bachelor, which lies within the same grid box as the Proposed Action.

2.3.1 Results from Scenario Comparison

To estimate the episodic concentration it was conservatively assumed that during an episode all of the impact in Washington State from Asia only occurs in the country with Proposed Action-related coal mercury emissions. This greatly increases the scaling ratio and conservatively estimates the episodic mercury impact.

Table 13 shows annual and episodic concentrations from Proposed Action-related coal for the proposed action minus the No Action by year starting in 2025 for Hg^0, Hg^{II}, and total Hg. Overall the differences between the three scenarios relative to the base case are relatively small, with the maximum total Hg ranging from 0.57 to 0.69 picograms per cubic meter (pg/m^3) and the maximum episodic ranging from 2.8 pg/m^3 for the lower bound to 3.7 pg/m^3 for the 2015 Energy Policy scenario. In all cases the concentration is flat over the first 5 years and then increases by 30 to 67% by 2040. In all cases elemental mercury (Hg^0) is the dominate form of Hg. Strode et al. (2008) found the annual average Asian-originated Hg^0 for Mount Bachelor was 0.29 ng/m^3 or 290 pg/m^3 in 2000. Assuming that overall growth in coal burning is balanced with reductions in mercury emissions due to application of control technology implemented under the 2013 Minamata Convention on Mercury the fraction of Hg^0 exposure in Washington State from the Proposed Action in 2040 would be less than 0.3%. Similarly, the Hg^{II} annual average for Mount Bachelor is 150 pg/m^3 and the maximum Proposed Action-related concentration is 0.047 pg/m^3 or a little less than 0.1%. The episodic maximum shows substantially higher concentrations over the annual average; still, the maximum contribution of the Proposed Action of 3.4 pg/m^3 relative to the episodic Hg^0 at Mount Bachelor of 1,180 pg/m^3 is a contribution of less than 0.3%.

Table 14 shows the annual Hg deposition amounts associated with Proposed Action-related coal combustion over Washington State for the proposed action minus the No Action by year starting in 2025. In the first 5 years the deposition amounts are approximately the same across all scenarios except the upper bound scenario, which is higher. All show an increase in mercury deposition by 2040 with a maximum deposition amount of 9.2 milligrams per year per square kilometer (mg/yr-km^2). This amount represents less than 0.4% of the total Asian-sourced mercury deposition over Washington State as estimated by Strode et al. (2008) at 2,900 mg/yr-km^2.

2.3.2 Uncertainty

As with any estimate of impacts a level of uncertainty is inherent in the analysis. The largest source of uncertainties comes from the global estimates of mercury emissions to the air. These stem from various sources, including the availability of information on activity levels, but mainly from the lack of information concerning the mercury content of some raw materials and the validity of the assumptions regarding processes and technologies used to reduce mercury emission releases. However, recent methods used to produce the global inventory for 2010 (United Nations Environment Programme 2013) were compared with a number of national inventories and emissions reported under other systems covering the same period, and in general the level of agreement was found to be good. Other studies have also reported the average uncertainty associated with anthropogenic industrial emission of mercury at ±30% (Pirrone et al. 2010). In the Pacyna et al. (2006) study, the accuracy of the emission inventory was estimated by source categories as: fuel combustion ±25%, various industrial process ±30%, and waste disposal a factor of 2–5. Note that the dominant emissions are from fuel combustion and industrial processes.

Historically, Asian emissions have been most uncertain from China given the uncertainties in activity levels due partly to the rapid changes, type, and amount of coal combusted and level of controls. However, the recent work of Zhang et al. (2015) using a probabilistic process-based approach based on information of the mercury content in fuel and raw materials, the production process, and Hg removal efficiencies obtained from field tests yielded more accurate emission estimates and lowered uncertainties. They estimate total mercury emissions from China at 356 MT/year or about 40% lower than the number used in the GTCM modeling. The study also included was better understanding of the spatial allocation of those emissions.

Another source of uncertainty is the chemistry in the atmospheric transport model. The largest uncertainty in the atmospheric mercury models is the chemical mechanism used to determine how mercury changes forms in the air. Improved experimental data will help improve model performance by making sure that the correct reactions are simulated. The processes that lead from deposition to re-emission also need to be better understood. Advances in this area are showing improvement, with model results becoming closer to estimates based on experimental data (United Nations Environment Programme 2013). However these chemical transformation uncertainties are, in general, less than the emission inventory uncertainties.

Given these uncertainties the mercury impacts in Washington State would be within ±50% of the estimates presented earlier and could be further reduced if GCTM modeling were specifically performed to assess the impacts for the countries expected to import the coal from the proposed export terminal, by using the most recent Asian mercury inventories and applying the advances in understanding atmospheric mercury chemistry.

Table 13. Annual and Episodic Hg Concentration in Washington State as Elemental (Hg^0) and Oxidized Mercury (Hg^{II}) from Proposed Action-related Coal (pg/m^3)

Hg^0	2025	2030	2040	Hg^{II}	2025	2030	2040	Hg^{Tot}	2025	2030	2040
Past Conditions (2014): Proposed Action minus No Action											
Annual	0.39	0.39	0.63	Annual	0.029	0.029	0.046	Annual	0.41	0.41	0.67
Episodic	2.1	2.1	3.4	Episodic	0.15	0.15	0.25	Episodic	2.2	2.2	3.6
Lower Bound: Proposed Action minus No Action											
Annual	0.39	0.39	0.53	Annual	0.029	0.029	0.039	Annual	0.41	0.41	0.57
Episodic	2.1	2.1	2.8	Episodic	0.15	0.15	0.21	Episodic	2.2	2.2	3.0
Upper Bound: Proposed Action minus No Action											
Annual	0.49	0.49	0.64	Annual	0.036	0.036	0.047	Annual	0.52	0.52	0.69
Episodic	2.0	2.0	2.6	Episodic	0.15	0.15	0.19	Episodic	2.1	2.1	2.8
2015 Energy Policy: Proposed Action minus No Action											
Annual	0.39	0.39	0.64	Annual	0.029	0.029	0.047	Annual	0.41	0.41	0.69
Episodic	2.1	2.1	3.4	Episodic	0.15	0.15	0.25	Episodic	2.2	2.2	3.7

Table 14. Annual Hg^{II} Deposition Amounts in Washington State from Proposed Action-related Coal ($mg/yr\text{-}km^2$)

2025	2030	2040
Past Condititons (2014): Proposed Action minus No Action		
5.5	5.5	9.0
Lower Bound: Proposed Action minus No Action		
5.5	5.5	7.6
Upper Bound: Proposed Action minus No Action		
7.0	7.0	9.2
2015 Energy Policy: Proposed Action minus No Action		
5.5	5.5	9.2

Chapter 3
Sulfur Dioxide Assessment

Over two dozen peer-review publications were found during the literature review, which spanned approximately the past 15 years. The studies included SO_2 emission inventories, emission projections, coal consumption in Asia, air monitoring studies in the Pacific Northwest and across the United States for impacts associated with the long-range transport of Asian SO_2 emissions, and global transport chemical modeling studies focused on assessing the fate and transport from Asia to North America.

The following discusses the nature of the SO_2 emissions, how SO_2 behaves and changes in the atmosphere, and its form once it reaches Washington State. This discussion is followed by a description of the papers most relevant to this study, with emphasis on the key findings from those papers as used in developing the impact assessment for coal combustion related to the Proposed Action.

3.1 Introduction

Worldwide natural sources of SO_2 make up about one-quarter to one-third of the global budget. The primary sources are volcanoes and the atmospheric oxidation of oceanic dimethyl sulfide, with a small additional fraction from wildfires (Intergovernmental Panel on Climate Change 2001). Anthropogenic SO_2 emissions originate chiefly from fossil fuel combustion, with coal combustion the largest source, representing about 53% of all anthropogenic sources of SO_2 globally. Other important anthropogenic sources of SO_2 include the burning of petroleum products for both transportation and industrial process (26%) and the smelting of metals (9%). In China, the country with the highest SO_2 emission rates, coal combustions is responsible for about 84% of the total SO_2 emissions (Ohara et al. 2007).

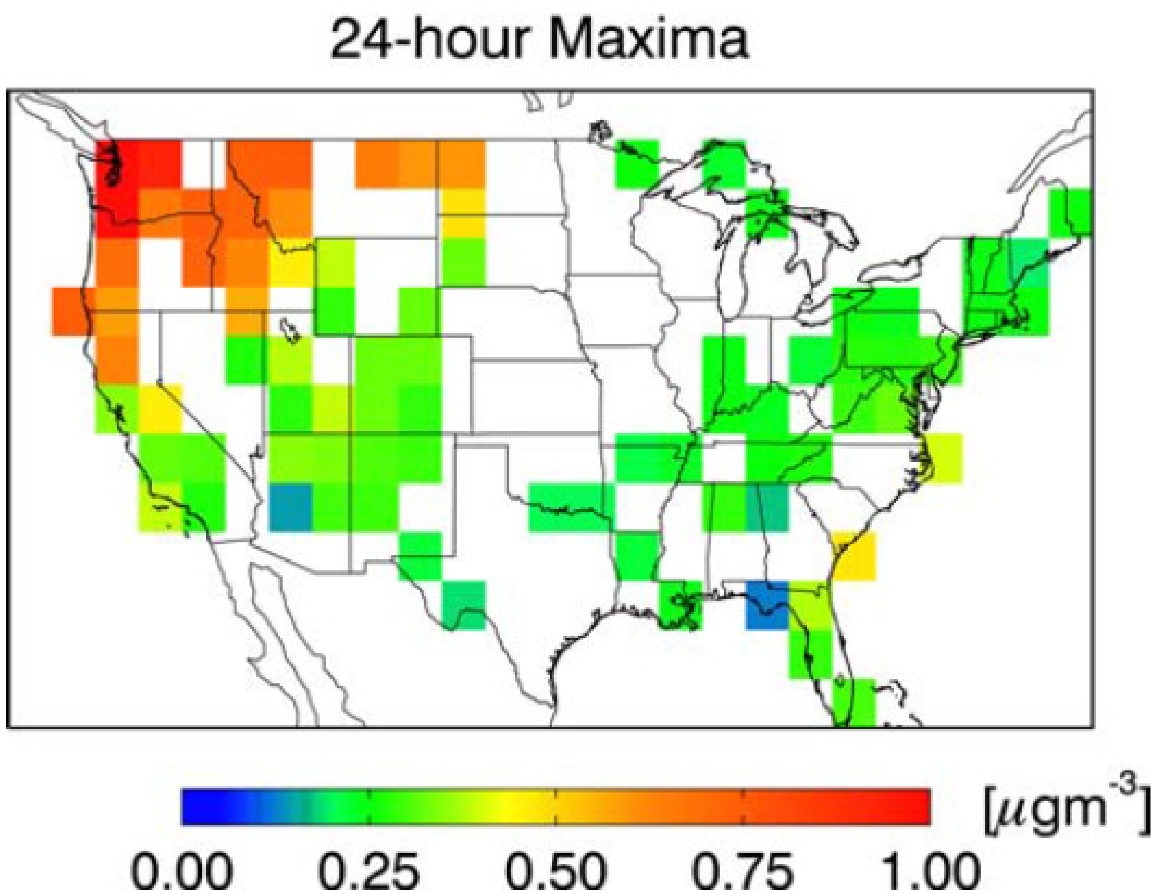
The emissions of SO_2 lead to sulfur deposition primarily in the local to regional scale, with the remainder of SO_2 converted to sulfate aerosol available for long-range transport. This availability occurs when the major SO_2 removal processes from loss to cloud droplets and rainout in the free troposphere is absent and the air is lifted above the boundary layer, preventing the other important removal process by interaction with sea salt aerosols or ocean surface. These conditions occur most frequently during the spring (Maxwell-Meier et al. 2004) and is also documented in global chemical transport models. Because nearly all sulfur deposition occurs with the first 1,000 kilometers from the point of origin, sulfur deposition of Asian emissions over Washington State will not be determined.

3.2 Studies and Findings

Long-range transport of Asian anthropogenic sulfate emissions across the Pacific Ocean was first documented in the 1980s from observations at island sites (Prospero et al. 1985; Huebert et al. 2001).

Aircraft observations of transpacific Asian plumes over the northeast Pacific (Andreae et al. 1988; Price et al. 2003) provided subsequent evidence of sulfate aerosol transport in the lower free troposphere. Similarly, ground- and aircraft-based observations in the Pacific Northwest have identified episodes of trans-Pacific transport of sulfate aerosols (Jaffe et al. 2003; McKendry et al. 2008). Heald et al. (2006), using satellite imagery, GEOS-Chem (GCTM) mode, and surface air monitoring data for the western United States, demonstrated the high sulfate aerosol concentration due to trans-Pacific pollutant transport. They found that the springtime Asian sulfate aerosol enhancements were greatest in Washington State (White Pass) and southern British Columbia, with maximum 24-hour enhancements reaching approximately 1.5 μg/m^3 (Figure 14). This source-to-receptor relationship is applied to determine the contribution of the Proposed Action using Equation 1 for estimating maximum episodic impact.

Figure 14. Asian Anthropogenic Enhancements of Sulfate Concentrations in Surface Air during the Spring of 2001 as Simulated by the GEOS-Chem Model



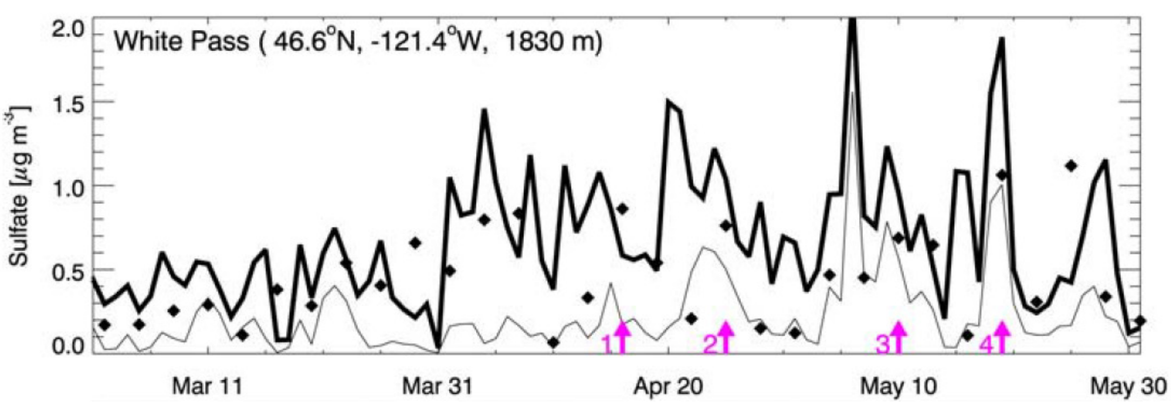
Source: Heald et al. 2006.
Note: The color scale is saturated at 1 μg/m^3.

Park et al. (2004) used the GCTM model for two full-year simulations, which showed that 30% of the annual average background sulfate in both the western and eastern United States was due to trans-Pacific Asian transport. In Park et al. (2006), GCTM modeling with improved chemistry showed that the annual average sulfate concentration in the western United States due to trans-Pacific Asian transport was 0.10 µg/m^3. This source-to-receptor relationship is value applied to determine the contribution of the Proposed Action using Equation 1.

3.3 Application of the GCTM Model to the IPM Scenarios

For each of the five IPM scenarios, emissions of SO_2 for 2025, 2030, and 2040 were used in Equation 1 as the defining emission source strength ($EA_{MBTL,tt}$) for the Proposed Action. The development methodology for the SO_2 emissions is described in the IPM modeling (ICF International 2016). The baseline year emission rate for the GCTM modeling was based on 1999–2000 global anthropogenic emissions. GCTM modeled concentrations (X_{00}) are available based on total Asian SO_2 emissions, which include additional Asian countries where Proposed Action-related coal will not be consumed. Thus, rather than using the total Asian anthropogenic emissions, which totals some 42,800 MT/year, a more conservative emission total was used for just the countries that will potentially consume the coal exported from the proposed coal export terminal: Japan, Korea, China (includes Hong Kong), and Taiwan. The total SO_2 emissions (as found in Ohara et al. 2007) for these countries was 29,800 MT/year. These were adjusted downward to reflect the SO_2 emission source strength used in the GCTM by Park et al. (2006). This conservatively assumes that only Asian emissions from these countries contribute to the portion of Asian sulfate concentration in Washington State. The X_{00} is based on the modeled concentrations as reported for the western United States, as the annual average SO_2 concentration is more uniformly dispersed. To estimate the episodic concentration, based on Equation 1, the 24-hour maximum modeled sulfate concentration of 1.5 µg/m^3 (Heald et al. 2006) was used as modeled at White Pass, Washington (Figure 15).

Figure 15. Time Series of Sulfate Concentration in Surface Air at White Pass, Washington.



Note: The diamonds are observations, the thin blue line is the Asian anthropogenic contribution in the GCTM, and the thick black line the total GCTM values. The pink arrows are the start of transpacific event as observed midway in the Pacific.

Table 15 shows the annual and episodic sulfate concentrations from Proposed Action-related for the Proposed Action minus the No Action by year starting in 2025. Overall the Past Conditions (2014), Lower Bound, and 2015 Energy Policy scenarios are very similar in magnitude for the first 5 years. The Upper Bound and 2015 Energy Policy scenario are nearly identical by 2040. In all cases the concentration is flat over the first 5 years but increases from 50% to more than doubling the concentration by 2040. Park et al. (2006) found the annual average Asian sulfate concentration for

Washington State at 0.10 μg/m³ or 100 ng/m³ in 2000. Assuming that overall growth in coal combustion is balanced with reductions in SO_2 emissions due to application of additional control technology, the maximum MBTL source contribution of just the Asian sulfate concentration in Washington State in 2040 would be less than 0.3%.

Episodic maximum shows substantially higher concentrations over the annual average; still, the maximum increase in sulfate concentration of 3.18 ng/m³ relative to the episodic maximum Asian source sulfate concentration determined at White Pass, Washington, of 1,500 ng/m³ (Heald et al. 2006) is a contribution of 0.2%.

Table 15. Annual Sulfate Concentration in Washington State from Proposed Action-related Coal (ng/m³)

	2025	2030	2040
Past Conditions (2014): Proposed Action minus No Action			
Annual	0.09	0.09	0.16
Episodic	1.33	1.33	2.36
Lower Bound: Proposed Action minus No Action			
Annual	0.08	0.10	0.17
Episodic	1.26	1.50	2.48
Upper Bound: Proposed Action minus No Action			
Annual	0.14	0.14	0.21
Episodic	2.10	2.10	3.16
2015 Energy Policy: Proposed Action minus No Action			
Annual	0.09	0.09	0.21
Episodic	1.33	1.33	3.18

3.4 Uncertainty

As with any estimate of impacts, a level of uncertainty is inherent in the analysis. The largest source of uncertainty is associated with the Asian SO_2 emissions. One approach to estimating the level of uncertainty in the inventories is to compare the estimated SO_2 emissions developed by different researchers using different methods for development. Ohara et al. (2007) reports on inventory projects for SO_2 emissions in East Asia, presenting ranges from a low of 22.6 million MT/year to 42.9 million MT/year, with an average of 31.5 million MT/year, suggesting an uncertainty of approximately ±35%. Historically, Asian emissions have been most uncertain from China, in terms of total SO_2 emissions, due to uncertainties in activity levels, rapid changes in the type and amount of coal combusted, and level of controls. Sulfur content of Chinese coals vary from 0.6 to 2.1%. In recent years, refinements in the understanding of the sulfur content in the coal and improved understanding of coal plants control technology efficiencies and their use have led to a better understanding of the SO_2 emission rates.

Another approach to estimating uncertainty is to compare modeled versus observed sulfate for the Pacific Northwest sulfate monitoring sites. This allows an estimation of error bounds on the global chemical transport modeling to better estimate Asian sulfate pollution influence. This approach was used by Heald et al. (2006), who estimated a ±50% uncertainty in the model results for Asian sulfate enhancements over the northwest United States.

Given these level of uncertainties, the SO_2 impacts in Washington State would be within ±50% of the estimate presented earlier and could be further reduced if GCTM modeling were specifically performed to assess the impacts for the countries expected to import the Proposed Action-related coal and by using the most recent Asian SO_2 inventories.

Chapter 4
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Appendix A

Particulate Matter Measurements in Support of Assessing Coal Emissions from Haul Trains Measurements Report

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PARTICULATE MATTER MEASUREMENTS IN SUPPORT OF ASSESSING COAL DUST FROM COAL HAULING TRAINS

MEASUREMENTS REPORT

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David Bush
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March 31, 2015

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1. INTRODUCTION

This field study program was designed to collect information on coal dust that may emanate from passing trains hauling coal, with the focus on 1 micron and greater sized particles that may be emitted. The study was not designed to measure mass emission rate from diesel fueled locomotives, as that has been extensively studied and reliable emission rates have been developed by the U.S. Environmental Protection Agency (EPA), and the newest and future operating fleets of locomotives are all certified to the emission standards. This section provides an overview of the study performed, the field activities included in the study, and the processing and analysis of the data collected.

1.1 Overview of the Study

The overall sampling program was designed to collect data at a location in Cowlitz County under conditions that were conducive to periods when fugitive coal dust could be measured from the passing coal trains. A one-month planning window in October 2014 provided two weeks for suitable sample collection in the field. The goal was to complete the sample collection prior to the arrival of the rainy season that typically starts in October/November. Equipment was prepared in late September with the deployment to the field and start of sampling on October 1, 2014. The primary sampling was conducted during the first half of the month, prior to the change from dry to prevailing rainy conditions. Specific train sampling was terminated on October 13 when the weather pattern shifted from a dry to wet pattern and daily rainfall began. A state of readiness was maintained until October 22, when the extended forecast showed that rainy conditions were expected to persist, and the sampling program was decommissioned.

The study was designed to measure the fugitive coal dust from passing trains hauling coal with a set of samplers on each side of the tracks to measure the upwind “background” concentrations and deposition, and the downwind concentrations and deposition, the difference being the contribution of the passing trains. A variety of sampling techniques were employed to capture the specific coal dust from the coal hauling activities. Short-term measurements using deposition plates, impaction samplers, and continuous particulate matter (PM) measurements were used to resolve individual train events, while longer averaging intervals (24-hour) of particulate matter were collected using filter-based collection media to help relate the more standard methods of measurement to the shorter term (train event) type sampling. For the duration of the study period, continuous meteorological measurements were made to aid in the analysis of wind flow and document the upwind and downwind environment during each train passing. The meteorological measurements also provided needed data on temperature, humidity, transport, and atmospheric stability that can be used in the modeling of the coal dust from the trains.

1.2 Overview of the Field Activities

The sampling network was deployed in southern Cowlitz County just north of the Lewis River. Trains hauling coal all originated from the south so that any trains reaching the region crossed the bridge over the river, giving a couple of minutes warning prior to the train arrival and final identification of the train type. Approximately 50 trains (coal, freight, and passenger) passed the sampling network each day. Over the study period, an average of two of these trains per day were hauling coal, with the arrival time of the trains being random. This required a constant state of readiness of the sampling network for triggering a sampling event with no more than one or two minutes of advance notice.

A temporary shelter was placed at the sampling site and served as the field headquarters for the duration of the sampling program. Sample preparation, documentation, and entry of data into the project database were performed in this field headquarters. Included in the headquarters was a Digital Video Recording (DVR) system to document the train activities as well as provide an additional measure of security for the network. From this base of operations the following measurements and sampling were conducted:

- Continuous airborne particulate matter using a size-segregating laser-based optical scattering technique with data recorded at a 10-second time resolution. Measurements were made at the anticipated downwind (east) side of the tracks.
- Short-term particulate matter deposition using deposition plates on both sides of the tracks that sampled during triggered events with a coal train passage. Note: throughout the study period, only loaded coal trains passed through the study location. Thus, for the remainder of this report, “coal train” refers to a loaded coal train. In addition, all coal trains were northbound.
- Short-term airborne particulate matter on both sides of the tracks using impaction sampling techniques triggered during selected train passages.
- Long-term (24-hour) airborne particulate matter using filter-based techniques with measurements primarily focused on the anticipated downwind (east) side of the tracks.
- Meteorological measurements of wind speed, wind direction, temperature, humidity, and solar radiation at a high time resolution of 30 seconds to document the conditions during the sampling events.
- Video documentation for train identification, counting of train cars/locomotives, and calculating train speeds.
- Train speed measurements by hand-held radar.
- Bulk sample collection of selected coal samples to aid in the “fingerprinting” of coal and assessment of coal in the soil adjacent to the tracks.
- Train types and characteristics to describe the type, number of engines, number of cars, speed, and other descriptors to document the environment.

A rotating shift of three technicians provided 24-hour coverage of the field sampling effort.

1.3 Overview of the Data Processing and Analysis

All data collected during the measurement program were processed and validated prior to performing analyses. For all of the particulate sampling that required a known flow rate, the samplers were calibrated prior to, and following the sampling program using National Institute of Standards and Technology (NIST) traceable flow measurement standards. This included the real-time optical particle sampler, 24-hour filter, and impaction samplers. These calibrated flows were then used to calculate the total flow through the sampling devices and related final concentration values. Meteorological sensors were calibrated prior to the field program and the calibrations checked following the installation. The most accurate time stamp and maintenance of the time was with the digital data logger used to record the meteorological data. The time on this system was set at the program outset and used as the common time for samples collected. Data downloaded from the continuous particulate monitor were adjusted to match the digital data logger time stamp prior to the merging of the data in the final database. The final database of this continuous data was loaded into the T&B Systems data display system, which is based on the Vista Data Vision software package. All train passage data (train arrival times) were then added to the database, with coal trains also having the time that the last car or locomotive passed. The display system then had all meteorological and DRX data merged with the train passage information, ready for analysis.

Collection of the deposition plate, impaction, and filter sampled media were all labeled with unique sample identifiers and laboratory chain of custody forms used to transfer the samples to the respective laboratories. Chester LabNet conducted the gravimetric analyses of the conventional MiniVol sampler filters. The vast majority of the laboratory analyses were conducted by Environmental Analysis Associates, Inc. (EAA). At EAA, the deposition plate samples were first screened optically to determine if there were visible particles collected. Plates were then rinsed with the material suspended on a slide for more detailed analysis using optical microscopy. The exposure times noted during collection were then used with exposed area in the dish to determine the deposition rate into the plates. Impaction sampled cartridges were opened and the glass cover slip removed that contained the sample and the slide prepared for analysis. Samples collected were analyzed using optical microscopy, and depending on the location of the sample and other criteria, the samples were also analyzed using Scanning Electron Microscopy (SEM), and compared against samples collected of known coal material. For the majority of the samples, the optical techniques provided the appropriate analysis results. The resulting particle counts, sizing, and estimated mass information were then used with the sample collection duration (and related flow rate) to calculate concentrations per unit volume. Longer term filter measurement samples were pre- and post-weighed by the laboratory to determine the mass increase during the sample collection and concentrations calculated based on the total flow through the samples.

Throughout the collection and data processing efforts, appropriate logs, calibration checks, and a variety of calculation cross-checks were employed to provide a quality controlled final data set for analysis. These checks included using multiple methods to calculate train speeds, duplicate counting of key trains for the number of locomotives and cars, and field and laboratory quality control samples for blanks and sample fingerprinting.

2. SAMPLING PROGRAM

The sampling program was focused on collection of airborne and deposition data for coal dust from trains specifically used for hauling coal. This section presents the sampling strategy used in designing and implementing the measurement program and the equipment used for the collection of the data.

2.1 Sampling Strategy

The goal of this study was to collect particulate matter and meteorological data along the BNSF mainline tracks during periods without precipitation and relatively low humidity, with the objective to collect up to 14 days of data during the month of October 2014, prior to the onset of the winter rainy season. Ambient air particulate matter was measured using several techniques. These included dust fall (or deposition plates), impaction samplers, filter-based collection media, and laser-based light scattering methods. The meteorology during the sampling program was documented using an on-site measurement system with sensors for wind, temperature, humidity, and solar radiation. For the entire study, video recording from multiple cameras documented the timing and speed of the trains, cargo type (passenger, freight, coal), as well as the number of engines and cars associated with each train.

A site survey was conducted at the study outset to select an appropriate location for the sampling. Several prospective sites were chosen based on Google Earth images and a field survey performed to refine the candidate sites. Key goals in selection of a sampling location included:

- Locations associated with faster train speeds and minimal braking (some braking adds sand to the braking process, which potentially increases silica levels).
- Locations adjacent to grade crossings and/or public State-owned facilities to simplify permission logistics and placement of samplers.
- Meteorology conducive to upwind/downwind sampling in as predictable a manner as possible.
- Minimal local non-train sources , such as vehicular traffic.
- Power to operate the sampling program equipment.
- Security for equipment during potential “non-attended” time periods.
- Cellular service for appropriate voice and data communications.
- Appropriate exposure for sampling on both the “upwind” and “downwind” sides of the track.
- Permission for access and operations 24-hours per day.

On the basis of the survey performed, a site was selected at the southern edge of Cowlitz County that met the goals listed above. **Figure 2-1** shows the sampling location and surrounding area. A distinct advantage of the selected site was the underpass available to allow movement to either side of the tracks when a train was present. Because of the proximity to the Lewis River, given the low terrain elevation and overall orientation of the tracks, the wind direction was anticipated to cross the tracks in a general west to east flow. Review of past data from meteorological stations in the vicinity also showed that type of flow pattern.

As the schedule for the anticipated time of passage of trains hauling coal was unknown, the sampling network was required to be in a state of attended operational readiness 24 hours per day, allowing initiation of sampling immediately when a coal train was recognized. This required 24-hour staffing of the sampling network and an immediate trigger system for train-specific sampling events based upon visual identification of the appropriate train type, with sampling starting on both sides of the tracks simultaneously.

Figure 2-1. General study area, showing the Lewis River.

The overall goal of the individual sampling events was to capture the coal dust that may be emitted as the trains hauling coal passed. The sampling was designed to monitor dust deposition at various distances away from the tracks, airborne dust concentrations downwind of the train, and a general size distribution of the aerosol on the downwind side of the tracks, both with and without train passages, and with the differing train types (passenger, coal, freight). Samples collected were analyzed for mass, particle count, and composition. For the train-specific samples, the samples were started once the front engines passed, and sampling continued for one to five minutes after the last car or locomotive passed. All of the sampling times were documented in field logs, with the timing of the events verified using the available video from the DVR system.

Summarized below is a description of the individual sampling platforms and samples collected.

2.2 Measurements and Equipment

The measurements made included the following:

- Continuous airborne particulate matter using a laser-based optical scattering technique.

- Particulate matter deposition using deposition plates.
- Short-term airborne particulate matter using impaction techniques.
- Long-term airborne particulate matter using filter-based techniques.
- Meteorology.
- Video documentation.
- Train speed by hand-held radar measurements.
- Bulk soil sample collection.

Each of these methods is described below.

Continuous Airborne Particulate Matter

At the anticipated downwind side of the tracks (east side), a TSI DustTrak DRX was located at the 45 meter “downwind” location, adjacent to the meteorological sensor mast and 24-hour MiniVol samplers. The DRX is a battery operated, data-logging, light-scattering laser photometer used commonly in air quality studies that provides real-time aerosol mass readings, simultaneously measuring both mass and size fraction in the size range cut points of PM_1, $PM_{2.5}$, PM_4, PM_{10} and “Total” size ranges. Data were collected and stored for the duration of the monitoring effort in 10-second averages. Data were downloaded from the system every three days, with a zero check and flow verification performed at each of the download times. **Figure 2-2** shows the tripod mounted case that housed the DRX, adjacent to the MiniVols and meteorological station.

Figure 2-2. Instruments placed at the anticipated downwind side of the tracks. Measurements included the real-time DRX, MiniVols, and weather station.

Particulate Matter Deposition

Particle deposition was measured using a customized sampling mechanism designed specifically for this study. While deposition sampling has been commonly conducted during air quality studies, the operational parameters for this study were uncommon in that they required that the samplers be manually and simultaneously activated for a relatively short sample duration (typically about 7 minutes), exposing the deposition plates only when coal trains (and an occasional freight train, as a control) were passing by the sampling network. Sterile laboratory-grade 100-millimeter (mm) deposition plates were used for the sampling. The deposition plates were placed inside 150-mm-diameter round canisters, 50 mm below the lip of the canister. The height of the sample plate was 1 meter above ground level. The canister lids were in place during non-sampling periods, protecting the plates from any unwanted deposition until the desired sampling period. Opening of the sample canister to expose the plate was performed by remote control using a radio transmitter operated by the on-site technician when a desired sample period was to start. When triggered, the lid was opened by a servo that would completely remove it and leave it attached to the side of the canister, exposing the inside deposition plate to any particles that fall into the canister. The complete lid removal ensured that there was nothing above the sampler opening to influence the collection sample, such as a lid partially open.

Upon completion of the sampling period, the lids were manually placed back over the canister by the technician until the plates were retrieved. The short distance to all sample canisters allowed this covering within a few-minute time period. Upon retrieval, each of the sample plates was given a unique pre-printed identifier and sticker placed on the plate lid, and the lid placed over the sample. Rubber bands were then used to affix the plate top and bottom, and the entire unit was placed in a small zip type bag. In this manner, if a plate lid did come off during transport, the contents would be retained in the bag. **Figure 2-3** shows the sampler with the lid over the plate. **Figure 2-4** shows the exposed plate inside the sample canister. **Figure 2-5** shows the placement in the field at the location nearest to the tracks.

Figure 2-3. Deposition plate sampler with the lid covering the sampling media.

Figure 2-4. Deposition plate sampler with the lid in the off position exposing the sample plate.

Figure 2-5. Placement of two deposition plate samplers on the east side of the tracks. In this configuration, both samplers were located 5 meters from the track.

Short-Term Airborne Particulate Matter

During train passages, ambient air samples were collected using the Air-O-Cell CSI (Collector for SEM Identification) sample cartridges. The Air-O-Cell CSI sample cartridges have been used in a number of sampling programs including forensic investigation of air quality, indoor air quality studies to trace the origin of allergens and pollutants, and outdoor studies to look at ambient concentrations and counts of a variety of organic and inorganic materials. This collection media allowed an ambient air sample to be collected over a short time duration (e.g., the period of a train passage) that is not possible with conventional ambient air sampling media. The sample was collected using a "slit" type inlet with an adhesive media below the slit to capture and hold the sampled particles. The Air-O-Cell CSI has a D50 cut point of 1 micron, efficiently collecting particles greater than 1 micron on the media. The technology for collection of enough sample over the required short time duration to analyze for particles less than 1 micron, such as that performed using a pre-filter cyclone separator, does not yet exist for ambient level concentrations. **Figure 2-6** shows the sample cartridge. **Figure 2-7** provides a diagram of the air flow path through the cartridge with the impaction of the sample on the collection media.

Air flow through the Air-O-Cell CSI was provided using a 12-volt vacuum pump at a flow of 15 liters per minute (lpm). A radio receiver was mounted in the pump/battery case that provided the received signal to trigger both the Air-O-Cell CSI and the above described deposition plates simultaneously with a train passage. While the deposition canisters remained open after the sample signal was turned off, the pump system would respond immediately to stop the sampling at the conclusion of the sampling period. **Figure 2-8** shows the pump/battery system in the case that was placed at the base of the tripod. **Figure 2-9** shows the system with the 2-meter vacuum tube leading to the sample cartridge mounted at 1.5 meters above ground level on the tripod.

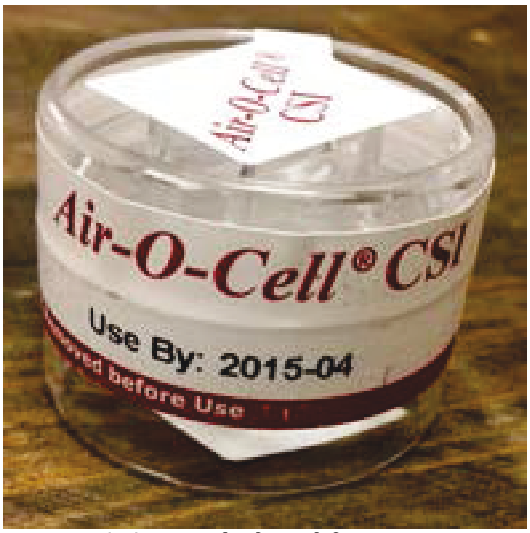


Figure 2-6. Air-O-Cell CSI sample cartridge.

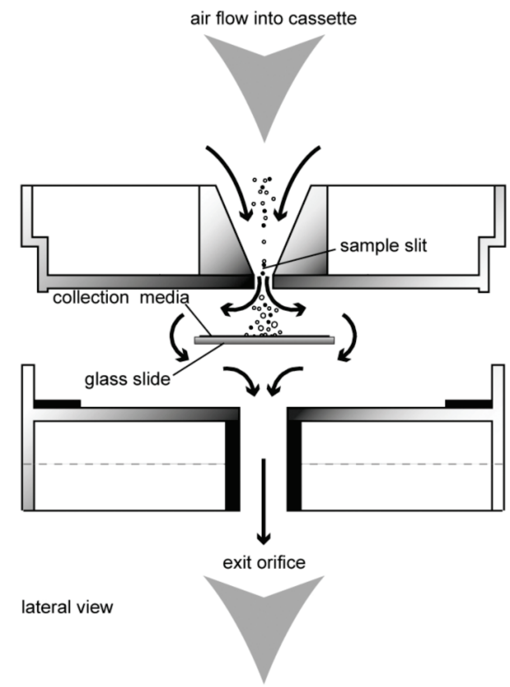


Figure 2-7. Air flow path through the Air-O-Cell CSI cartridge.

Figure 2-8. Battery and pump system with radio receiver for triggering the Air-O-Cell CSI and deposition plate samplers.

Figure 2-9. Air-O-Cell sampling system mounted on a tripod with the pump and battery in the case at the bottom of the tripod.

Long-Term Airborne Particulate Matter

Twenty-four hour average particulate matter concentrations were measured on both sides of the tracks using MiniVol medium volume samplers. These samplers have been used in many large air quality studies, collecting data that correlate well with EPA-approved reference measurement samplers. The samplers are battery powered and integrate the samples over a 24-hour period. The filter collection typically occurred from 1600 to 1600 each day with filters and batteries serviced during the change out period. On the west side (anticipated to be upwind), one $PM_{2.5}$ sampler was operated using polycarbonate filters to collect data for mass and SEM analysis to help understand the fraction of coal in a 24-hour sample relative to other particulate matter. On the east side (anticipated to be downwind), three sets of samples were collected. $PM_{2.5}$ and PM_{10} were collected on Teflon filters and an additional sampler collected $PM_{2.5}$ on polycarbonate filters, similar to the upwind location. The Teflon filters were analyzed for mass, with the option to also analyze for elemental content using XRF (X-ray fluorescence). The polycarbonate filters were analyzed using SEM for the coal fraction. Figure 1 shows the samplers on the east (anticipated downwind) side of the tracks.

Meteorology

The meteorological station consisted of a 3-meter mast for the wind sensor, and temperature, relative humidity (RH), and solar radiation measured at 2 meters. The meteorological equipment all meet EPA specifications required for air quality studies. All data were recorded on a Campbell Scientific CR1000 data logger with averaging intervals of 30 seconds and one hour. Data were downloaded from the station daily. Power for the station was provided from a solar charged battery system. The sensors used are summarized below:

- Wind speed and wind direction – RM Young 05305 AQ Wind Monitor.
- Temperature/relative humidity – RM Young Model 41382 temperature/RH sensor.
- Solar radiation – Licor LI-200.

The mounting and sensors was shown in Figure 2-2.

Video Documentation

Video images of train passages were documented using a Swann DVR9-4200 digital video recorder. The system provided motion–activated, 15 frames per second video with 960H DVD quality resolution. Infrared illumination at night provided a visual range up to 25 meters. Cameras were located in areas to allow documentation of the train types and the ability to replay the videos to count the train cars and calculate the train speeds. This video record became the primary method to perform the speed measurements and car counts for each of the coal train passages. Track distances within the field of view of key cameras were quantified and combined with the known camera frame rate to calculate the speed of the passing trains. These calculated speeds and the number of cars from the video were used for each of the train passages, except when the view was obstructed by fog. Under the foggy conditions, the in-field observations from the field technicians were used. All videos collected were converted from H.264 to AVI format for viewing in Microsoft Windows and other viewer environments.

On October 6 at 0900, camera 2 was moved closer to the tracks to obtain a closer view of the passing trains to improve the IR illumination of the cars at night. The locations of the video cameras were again changed mid-day on October 10 to further improve the train identification during the nighttime hours by having an additional camera located closer to the tracks to optimize the network. This third camera was mounted on the RV once it too was moved closer to the tracks. During this move, cameras 1 and 2 maintained their same positions with only slight changes in rotation to optimize the pictures. The setup of the system with camera locations is shown in **Figure 2-10**. Camera 3 on the RV looked toward the northwest. Camera 1 looked to the south, while camera 2 looked to the west-southwest.

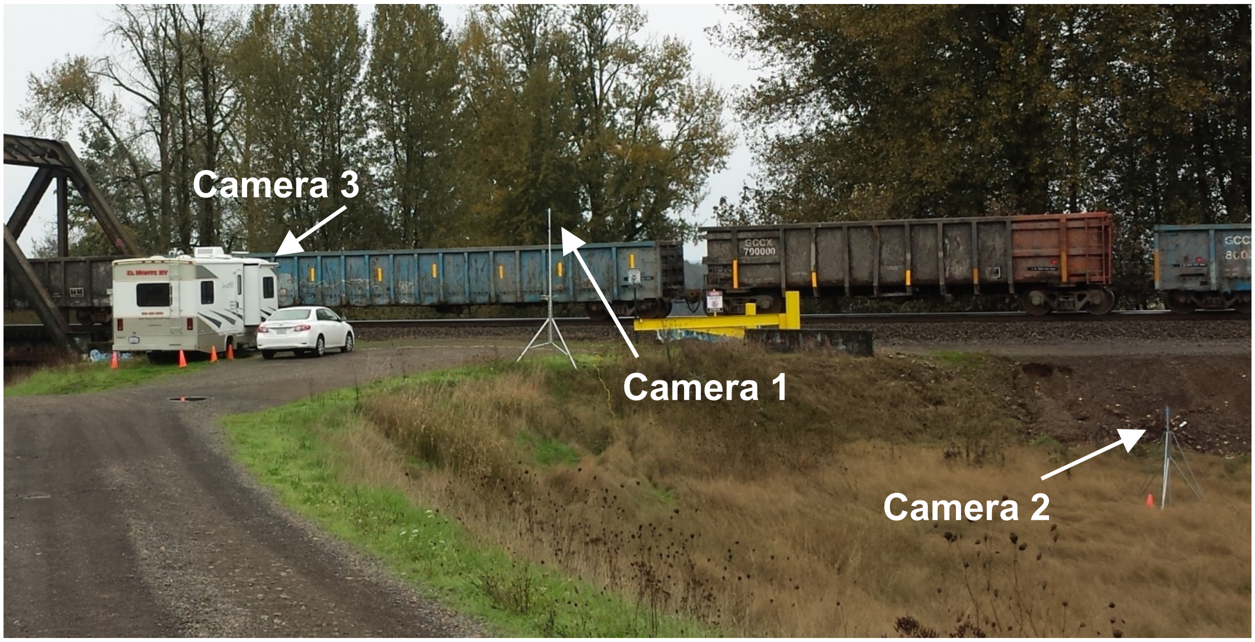


Figure 2-10. Locations of the cameras for documenting the train passages.

<u>Train Speed by Hand-Held Radar Measurements</u>

A Bushnell Speedster III radar speed gun was used to measure the speed of passing trains. The unit measures the relative speed of a target as it approaches (or departs) the unit. If the target is in a direct line then the measurements are accurate. Moving away from the direct line, (i.e., measuring off-axis) decreases the accuracy by biasing the measurements low. For any of the measurements made with the unit, a cosine correction for the off-axis readings was applied to maintain the accuracy of the speeds. Measurements made with the Speedster III were considered backup to the visual measurements made using the DVR post-processing method and were used when the DVR method was not possible due to video obscuration by either fog or a distance too far from the camera.

<u>Bulk Soil Sample Collection</u>

Two types of bulk samples were collected for analysis. The first was from visible coal at a public grade crossing between the study location and the terminus for the coal trains, with the sample placed in a plastic bag and shipped to the laboratory for analysis. This sample provided a “fingerprint” of the material that was anticipated in the both the deposition plate and Air-O-Cell CSI samples, and allowed a more positive identification of coal-like material in the microscopic analysis. The second type of bulk samples were soil samples collected at the study locations, immediately outside of the right-of-way of the rail line (about 5 meters from the rails). These samples were collected to see if there was any deposition of coal-like particles into the soil adjacent to the tracks where the public has access. These samples are discussed in more detail in Section 3.1.

Sampling Network

The sampling network was designed to place the primary measurements in the prevailing downwind direction of the tracks, with measurements upwind to document the concentrations entering the study domain. On the basis of the original meteorological analyses, **Figure 2-11** shows the initial sampling locations. The MiniVols collected the 24-hour samples, plates and Air-O-Cell CSI units collected short-term samples, and the meteorological station was collocated with the MiniVols at the "downwind" location. Following the first several sample days, selected samples from the deposition plates were shipped to the laboratory for a preliminary screening analysis to determine what was being measured in the network and if the sampling strategy should be modified. The initial screening showed little, if any material being deposited in the plates. As a result, it was recommended that the network be moved closer to the tracks in an attempt to bring the deposition levels up to where they could be more readily detected. On October 10 the network was relocated to collect closer in samples. **Figure 2-12** shows the locations of the samplers following the move. As part of the move, an additional deposition sampler was added to the west side of the network to help capture particle fall. **Table 1-1** describes the locations of all samplers before and after the change in the network. The distances from the tracks represent the distance to the nearest rail.

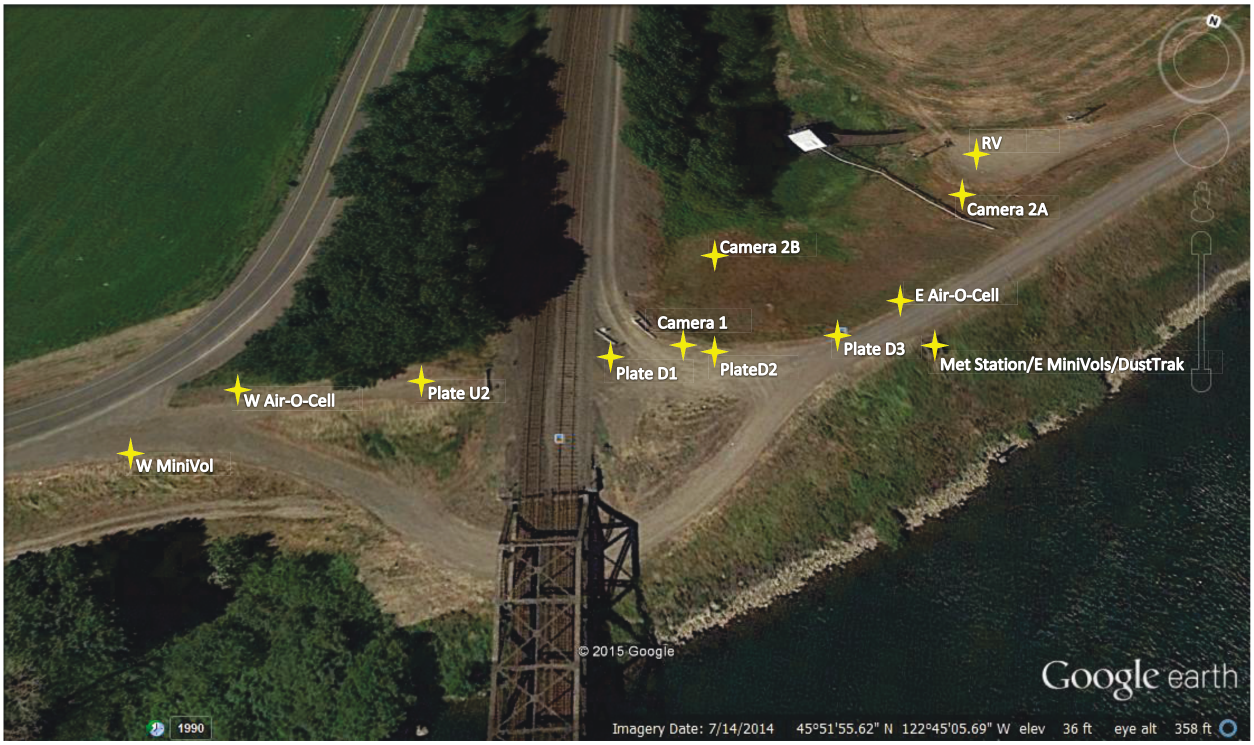


Figure 2.11. Location of the sampling network from the initial sampling on October 1 through mid-day on October 10.

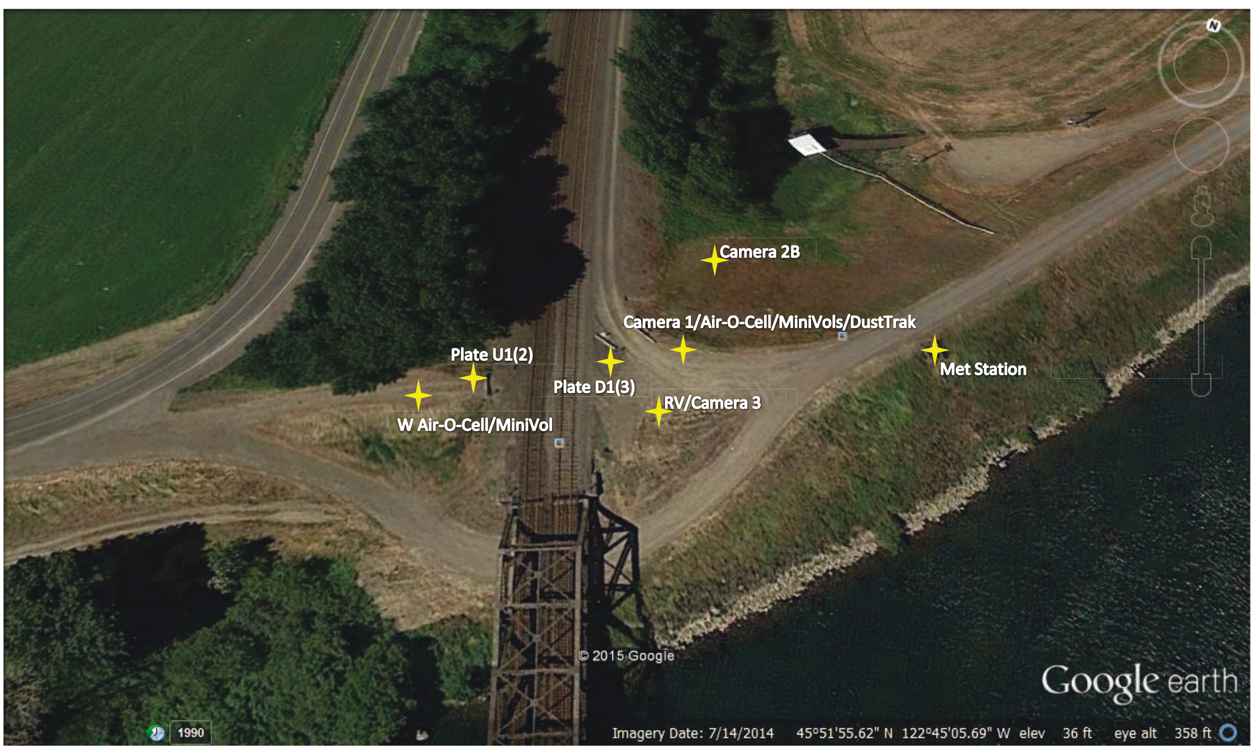


Figure 2-12. Location of the sampling network from mid-day on October 10 through the end of the sampling program.

Table 2-1. Summary of equipment.

Measurement	Measurement Location		Make/Model	Sampling parameters
	Prior to mid-day (10/10)	Starting mid-day (10/10)		
Continuous Airborne Particulate Matter	45 meters (m) east	15 m east	TSI DustTrak DRX	10-second averages
Particulate Matter Deposition	Plate 1 – 5 m east Plate 2 – 15 m east Plate 3 – 30 m east Plate 4 – 5 m west	Plate 1 – 5 m east Plate 2 – 5 m east Plate 3 – 5 m east Plate 4 – 5 m west Plate 5 – 5 m west (samples separated by 2 m)	T&B Deposition Plate Samplers	Sample is taken after the engine of a train passed the sample location and continued for a time after the last car or engine passed
$PM_{2.5}$ SEM $PM_{2.5}$ SEM $PM_{2.5}$, PM_{10} Mass	45 m west 43 m east 43 m east	15 m west 15 m east 15 m east	Airmetrics MiniVol	Integrated 24-hour samples from ~1600 to 1600 local time.
Short-term Particulate Matter	40 m west 40 m east	15 m west 15 m east	Zefon Air-O-Cell CSI with T&B Pump System	Sample is taken after the engine of a coal train passes the sample location. Analysis by optical or scanning electron microscopy.
Wind Speed	45 m east, 3 m high		RM Young 05305 AQ Wind Monitor	1-second scan, 30-second and hourly averages
Temperature	45 m east, 2 m high		RM Young Model 41382	1-second scan, 30-second and hourly averages
Humidity	45 m east, 2 m high		RM Young Model 41382	1-second scan, 30-second and hourly averages
Solar Radiation	45 m east, 2 m high		Licor LI-200 Pyranometer	1-second scan, 30-second and hourly averages

3. LABORATORY ANALYSIS

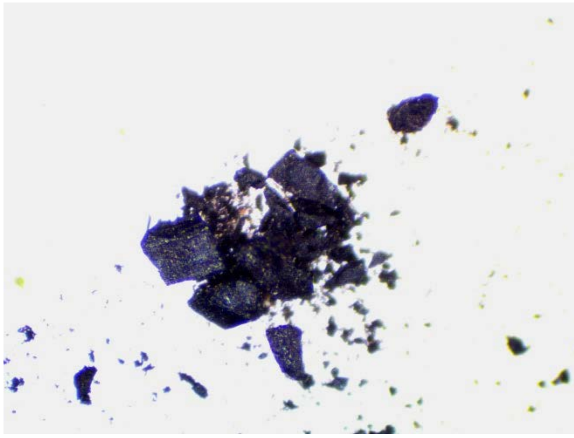
EAA developed specific analytical methods designed to evaluate the potential coal particle concentrations in the three different types of measurements and collection devices: fallout of particles (deposition plates for ~20 micrometers [µm] and larger); airborne concentrations in the optical microscopy size range (Air-O-Cell slit impaction cassettes 3–100 µm); and particles in the “respirable” size range (MiniVol samplers <3 µm). These methods were developed during the initial Optical and Scanning Electron Microscopy analysis of random coal samples, and examination of selected samples collected from the on-site monitoring.

3.1 Initial Testing of Coal Samples

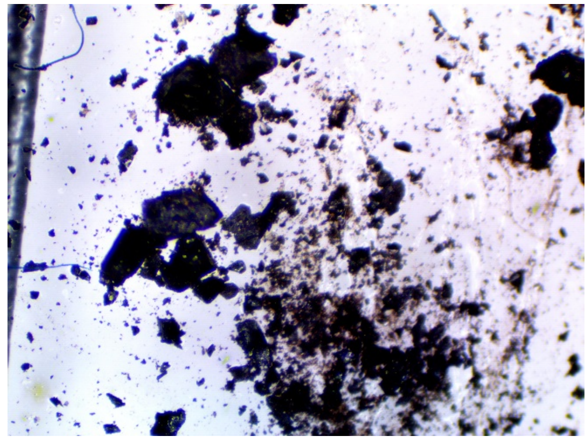
Two randomly collected coal samples were examined by both Optical and Scanning Electron Microscopy to determine the identifying properties of the coal. Based on this examination, the coal samples were found to have very similar “microscopic” and chemical (elemental) properties.

Optical Properties

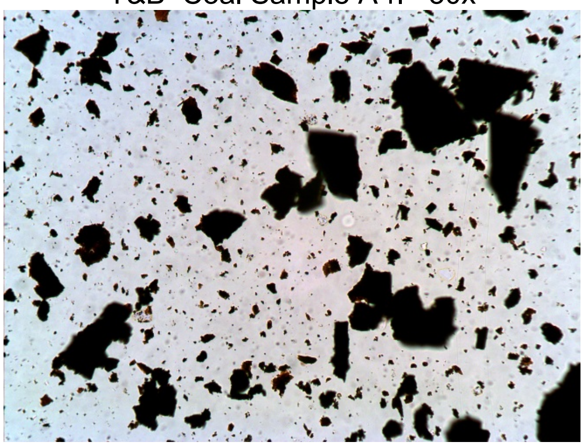
The coal samples appear granular and black/brown with an orange tint present in very thin areas of the particle. This condition was observed in both transmitted light and reflected light. Particles less than approximately 20 µm also have a brown/orange coloring and are a mixture of both angular and rounded particles. The optical properties of the coal, especially the brown-orange-tint coloration in very thin particles, can be used as an indicator to differentiate the coal from other biogenic or organic particles in the sample. Based on examination of the samples collected at the test area, similar potential “look-alike” particles were found, including fire residue, diesel soot, tire rubber, asphalt, and a significant amount of iron oxide. Iron oxide flakes were found to be a significant particle type in all of the air samples collected during the passage of trains, as well as in the bulk soil samples collected in proximity to the railroad tracks. As a result, it was very important to distinguish these particles from “coal-like” particles. Example micrographs of the coal samples and other types of “look-alike” particles are shown in **Figure 3-1**. The abbreviation ”rl” refers to reflected light illumination and “bf” refers to bright field transmitted light illumination.



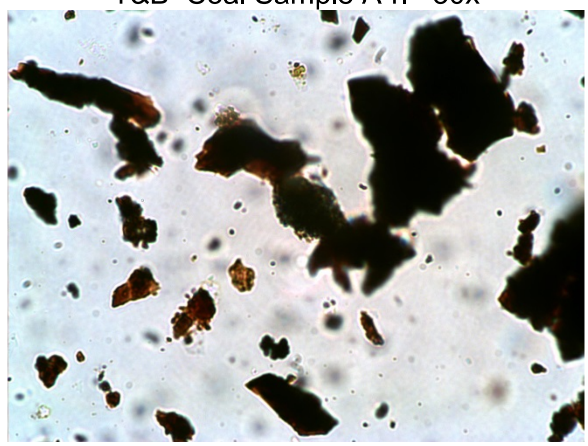
T&B Coal Sample A-rl ~30x



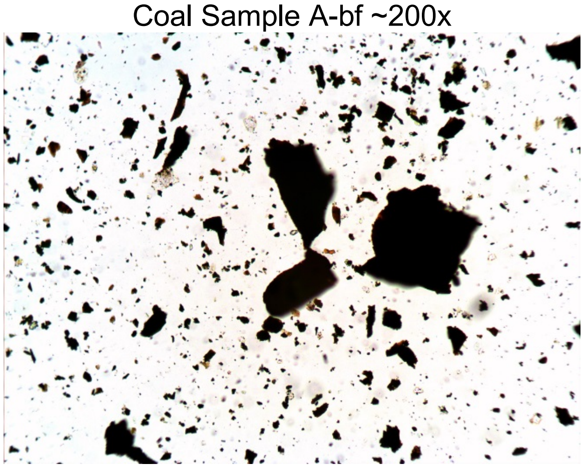
T&B Coal Sample A-rl ~30x



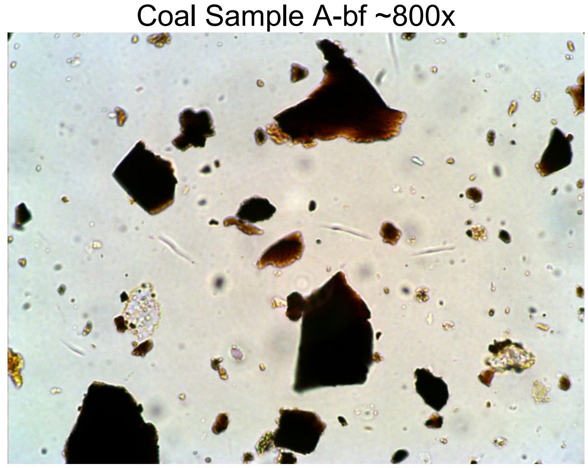
Coal Sample A-bf ~200x



Coal Sample A-bf ~800x



Coal Sample B-bf ~200x



Coal Sample B-bf ~800x

Figure 3-1. Example micrographs of coal samples under differing light and magnification.

Three bulk soil samples were also collected from the vicinity of the railroad tracks to look for the presence of coal particles. All three soil samples were obtained on the east side of the tracks, approximately 5 meters from the tracks. Locations were chosen where track ballast was light and the soil surface exposed. Soil was scraped from the top layer of these exposed areas using a clean utensil and placed in a petri dish (the same type of dish used for the deposition sampling). Review of the sample locations during a rain event revealed that the exposed area where sample #1 was obtained consisted of a spot that runoff from the area first collected in and then flowed out of. Thus, both concentration and depletion of deposited material are a possibility at this location. The location for sample #2 was at the end of the short road leading up to the tracks, and had the possibility of being impacted by foot traffic. Of the three samples, sample #3's location appeared to be the location with the least possibility of disturbances that could potentially impact deposited concentrations. Coal was found in all three samples as well as significant amounts of iron oxide particles and the expected soil minerals including quartz and other feldspar and clay minerals. The highest relative concentrations of coal were observed in sample #1. Example micrographs of the bulk soil samples are shown in **Figures 3-2**, **3-3,** and **3-4** for each of three bulk samples.

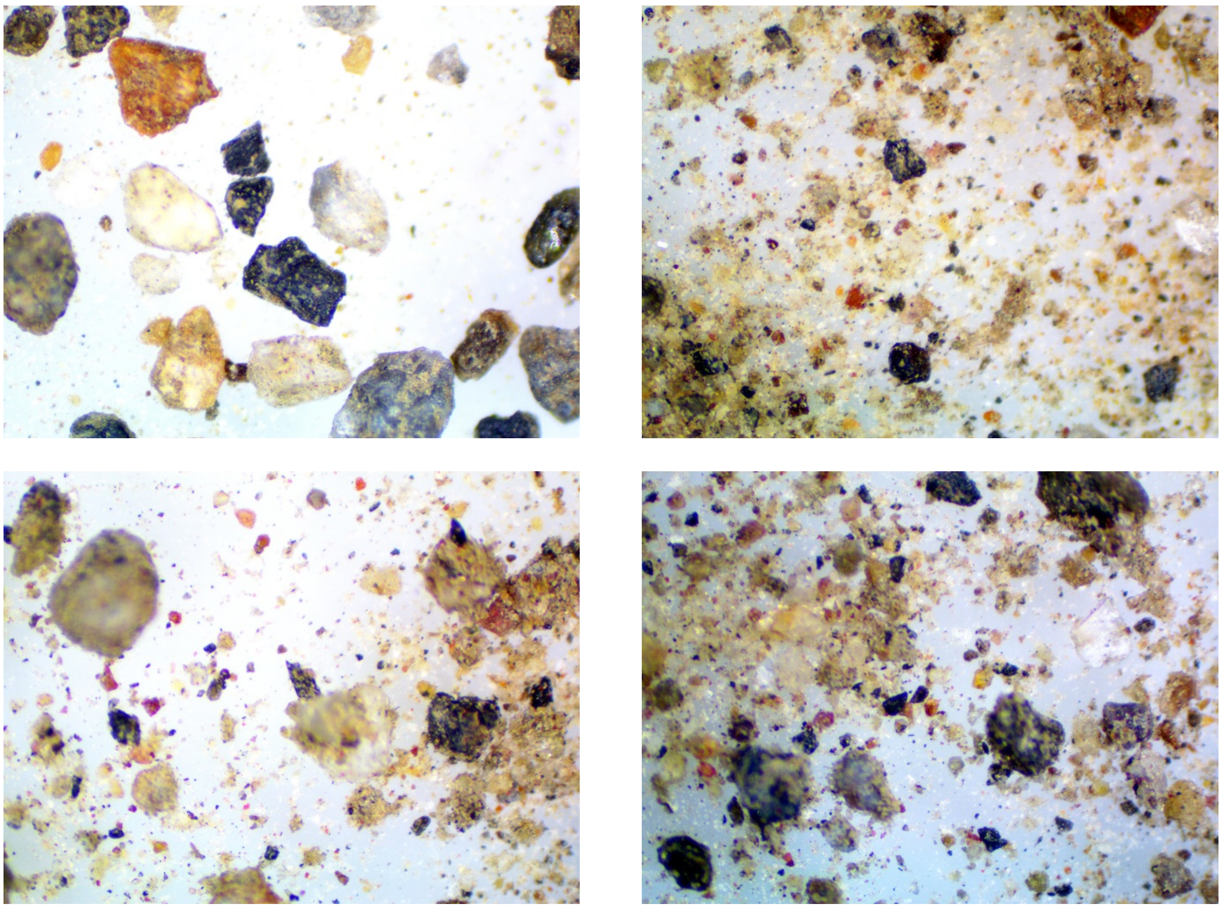


Figure 3-2. Bulk soil sample #1 – rl - 30x, with high amounts of coal and iron-oxide flakes. Horizontal field of view at 30x is 3.7 mm (3,700 μm).

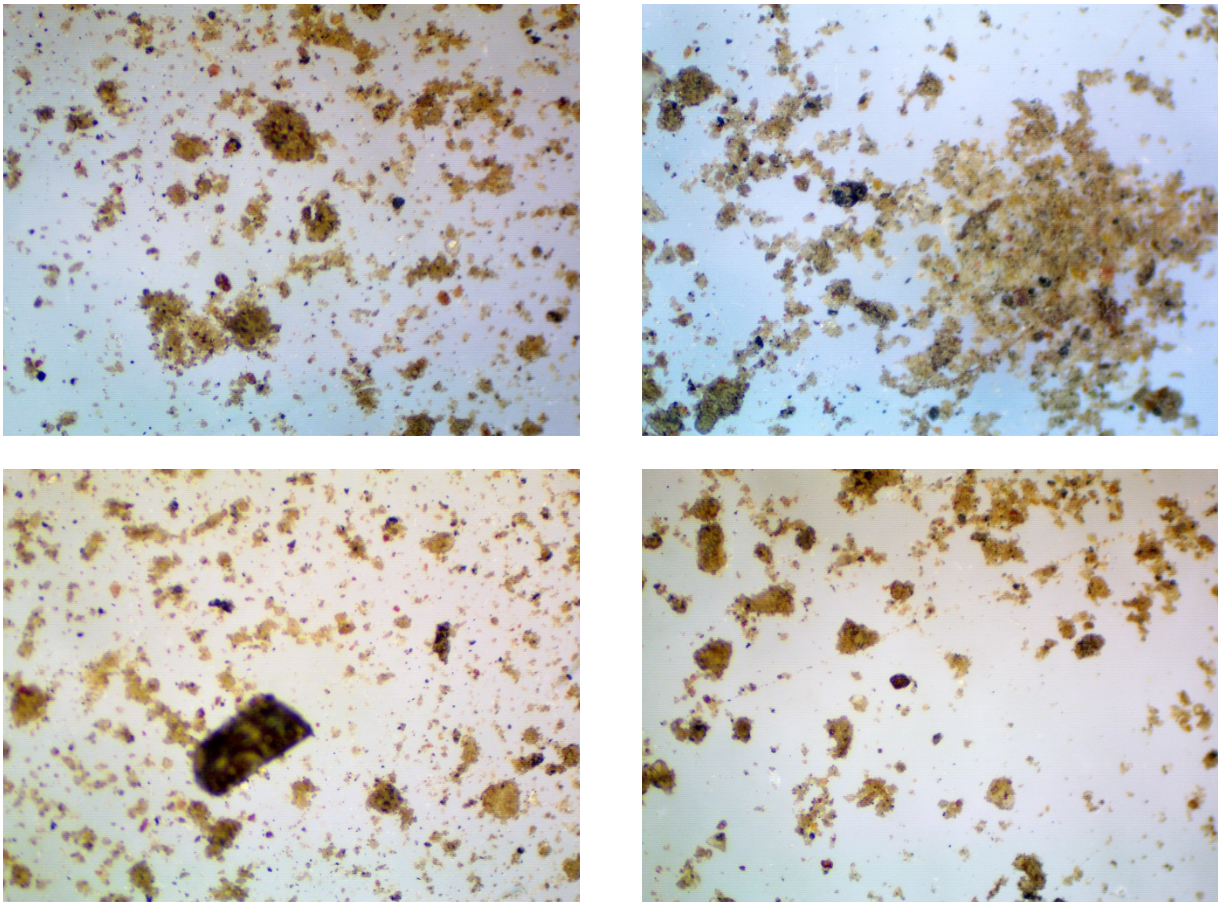


Figure 3-3. Bulk soil sample 2 – rl - 30x, with low to moderate amounts of coal and fine iron-oxide flakes.

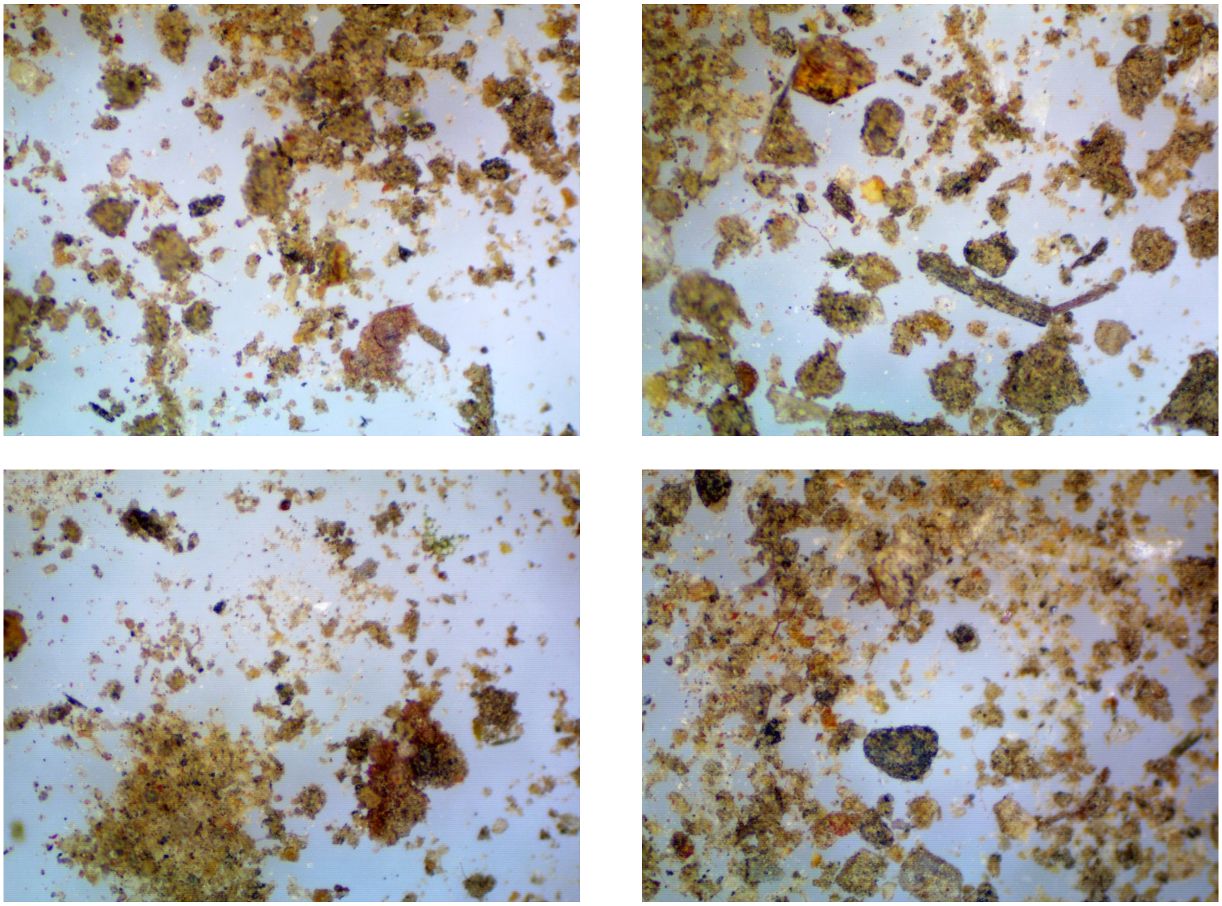
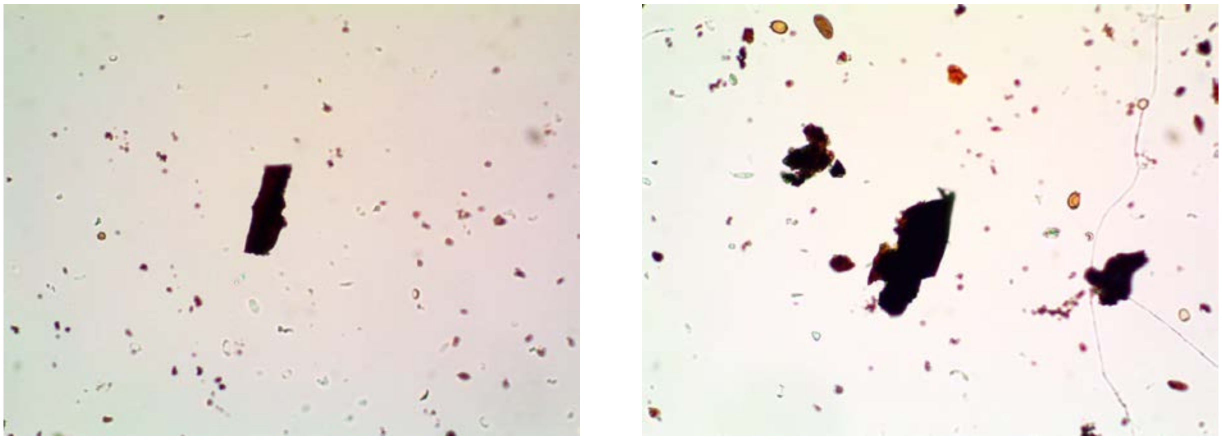


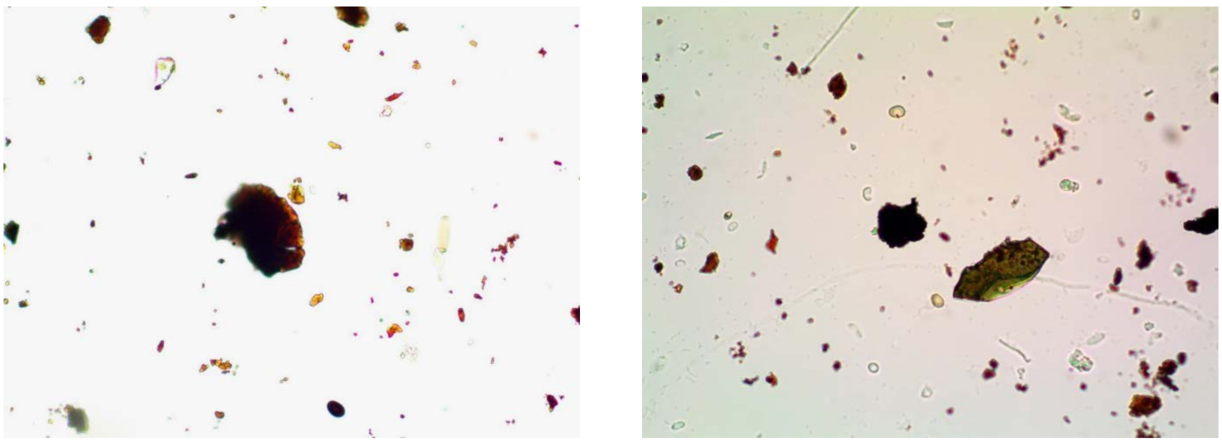
Figure 3-4. Bulk soil sample 3 – rl - 30x, with moderate amounts of coal and iron-oxide flakes.

<u>Particle Classifications Used During Analysis</u>

Examples of the coal-like particles (e.g. soot) encountered during the analysis and their respective classification codes are provided below in **Figure 3-5**. The coal-like particles are differentiated from the "Iron-oxide" classifications based on the uniform coloration edge texture, and internal texture observed in the coal particles and not observed in the iron-oxide particles. The iron-oxide particles have rough edge and internal texture from mechanical and corrosion "pitting."



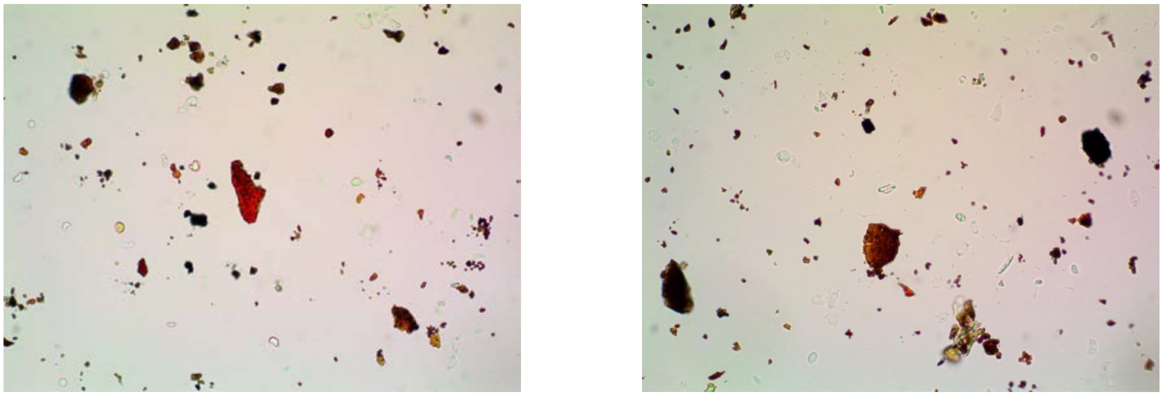
Angular “Coal-like” (AC) U4-016



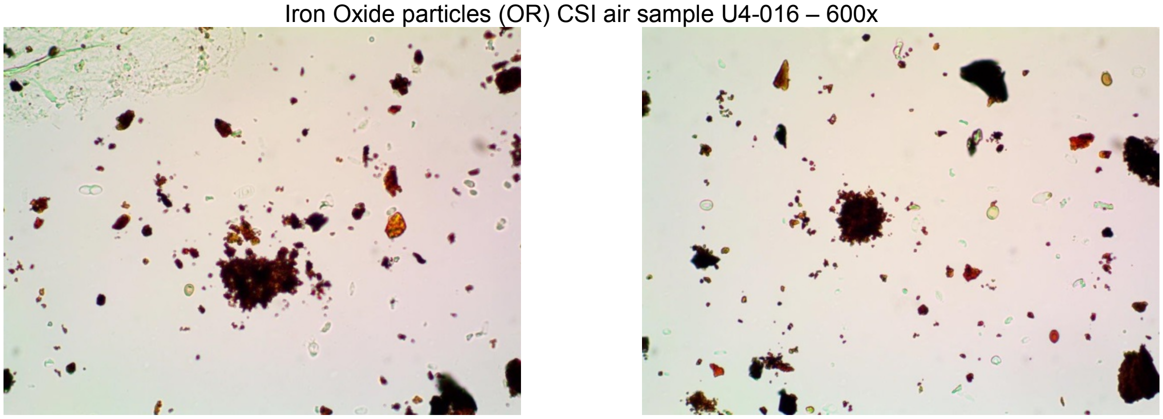
Rounded “Coal-like” (RC) U4-016

Figure 3-5. Angular (AC) and rounded (RC) samples in the same CSI sample at 600x. Horizontal field of view at 600x is 185 μm.

Examples of the common “non-coal” particles encountered during the analysis, and are the basis for the non-coal particle classifications, are shown in **Figure 3-6**.

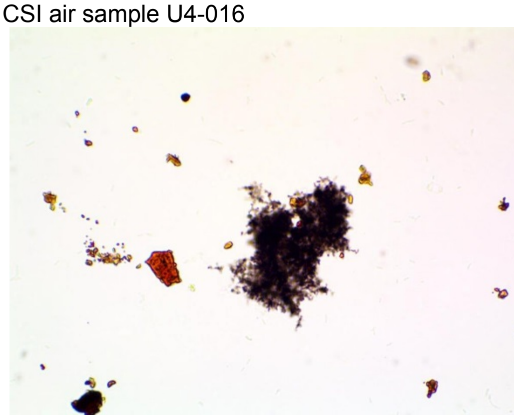


Iron Oxide particles (OR) CSI air sample U4-016 – 600x



Iron Oxide cluster (OC) particles CSI air sample U4-016

Soot-like (SL) – CSI air sample 600x



~ 900x

Quartz (Q) – CSI air sample

Figure 3-6. Common non-coal particles observed in the samples.

The optical properties of actual coal samples include an orange tinged color when the thin sections or edges of the particles are examined. There is a uniform gradation of coloration from dark brown to orange with the relative thickness of particle. The interior and edge texture of the particles are relatively uniform and without any granular texture that would be indicative of corrosion or pitting. As described below, this morphology is used as an identifying feature separating the coal-like particles from other sources (e.g., diesel soot). This required the use of automated SEM/X-ray techniques to help decide on the morphological parameters required to separate coal-like from non-coal particle types.

Elemental Chemistry Properties (Dispersive X-ray Analysis)

Both of the coal samples (labeled as A & B) exhibit similar morphological and chemical properties. The compositions of both samples are a mixture of highly carbonaceous particles (over 90% carbon and oxygen), carbonaceous silicates, carbonaceous alumino-silicates (clays), and iron-containing carbonaceous silicates. Approximately 30% of the coal particles analyzed in sample B were also found to contain a simultaneous presence of iron and sulfur exceeding weight percentages of 1%. These low concentrations can only reliably be detected in particles larger than approximately 2 μm in thickness. Minor amounts of quartz, and iron oxide particles were also identified. The orange "tint" to the particles is likely due to the presence of iron in both of the coal samples.

Based on the initial X-ray analysis of both coal samples, a particle "classification" library was developed to analyze the collected air samples. The following classifications found in the coal samples were developed into a rule-based particle recognition and classification system for the automated SEM/X-ray analysis of the filter samples. A chi square fit analysis (based on the theoretical elemental weight percent) was used to "classify" particles within the sample. The major coal classifications decided upon for this project are given below:

Carbon-H	Highly carbonaceous particles (carbon/oxygen > 90%)
CMgAlFe silicate	Carbonaceous aluminum silicates (Fe and Mg present)
AlSi silicate	Aluminum silicate particles (low carbon)
MgAlSi carbon	Carbonaceous particles (MgAlSi present)
AlSiFe silicate	Aluminum silicate particles (Fe)
Quartz	Quartz – silicon dioxide
FeC oxide	Iron oxide particles with carbon present

Coal particles found with Sulfur (S) present – additional categories based on analysis of coal sample B:

AlSiS carbon	Carbonaceous coal (Al, Si and sulfur [S] present
CaFeS carbon	Carbonaceous coal (Ca, Fe, and sulfur [S] present

Because numerous "biogenic" particles in the outdoor environment may have similar carbon chemistry (carbon and oxygen ratios) when compared to the "highly carbonaceous" particles (Carbon-H) found in the source coal particles, a high percentage of these particles cannot be differentiated by the carbon/oxygen chemistry ratio alone. As a result, particles collected on air filter samples covering the "respirable" size range (<3 μm) cannot be reliably differentiated using the "Carbon-H" classification portion of the X-ray analysis. Thus, a large percentage of the highly carbonaceous particles (Carbon-H) collected over a 24-hour time period may be naturally occurring, and not from a coal source. The "Carbonaceous Silicate" classifications can be used to differentiate coal-like from non-coal particles. Upon examination of the actual Air-O-Cell CSI air samples, the large category of potentially interfering particles has been shown to be iron oxide particles. These particles are likely related to the abrasion of the train rails and can be differentiated from the coal-like particles.

3.2 Deposition Plates

Analysis of the deposition plates showed very little "visible" particle deposition. As a result, direct analysis of the plates could not be performed. Therefore, the dust collected within the deposition plate was concentrated by washing with deionized water into a 25-mm filter funnel loaded with a 0.4 µm pore size mixed cellulose ester filter. By transferring to a filter with a smaller deposition area, the particles are concentrated by approximately 35-fold. The diameter of the deposition plate was 100 mm with an area of approximately 7854 mm^2. The deposition diameter of the transfer filter was ~17 mm with an effective area of 227 mm^2.

The filters were then dried and infiltrated with Triacetin to make them transparent for examination by optical microscopy. Potential coal particles on the filter were quantified in two (2) ways;

1) The entire filter was first screened at approximately 10x to locate any large potential coal-like particles, or areas of the filter where the particle density was highest. The field-by-field analysis was started at this location in order to have the analysis represent a worst-case scenario. The actual detection of any "large coal-like particles" using low power microscopy was a rare occurrence. Particle concentrations were quantified as the number of coal-like particle per deposition plate.

2) The size distribution of particles were calculated according to the following classifications.

   Coal-like Carbonaceous particles:

Code	Description
AC	Angular Carbonaceous – Black/brown/orange-tinged – (coal-like)
RC	Rounded Carbonaceous – Black/brown/orange-tinged – (coal-like)

   Note: The interior of the particles must have a smooth/non-corrosion morphology

   Other Potential "look-alike" particles (not associated with coal):

Code	Description
OR	Orange tinged Iron-oxide (corrosion morphology present)
OC	Orange tinged Iron-oxide aciniform cluster (corrosion morphology present)
I	Indeterminate Opaque – (likely biogenic or other brown/black particles)
SL	Soot-like black aciniform (not associated with coal)
Q	Quartz
M	Other unidentified minerals

Both Bright Field and Polarized Light Microscopy were employed during the analysis to classify and measure particles. The particles were classified using optical properties including their shape, texture, and coloration as compared to the actual submitted coal samples. The particles with coal-like morphology were then counted and sized and the results reported as a numerical concentration (particles/deposition plate). The size distribution was also reported for coal-like particles and the estimated mean particles sizes and theoretical mass concentrations of coal-like particles were reported as estimated micro-grams per settling plate (µg/plate).

3.3 Air-O-Cell CSI Air Samples

Initial examination of the Air-O-Cell CSI samples showed moderate surface particle deposition and good discrimination of coal-like particles from other biogenic particle classifications. Initial comparisons between the actual measured upwind and downwind locations showed a differential in the concentration and distribution of the particle classifications. Coal-like particles were observed to be more prevalent in the downwind samples. Both Bright Field and Polarized Light Microscopy were employed during the analysis. The same classifications for Optical Microscopy were used as with the deposition plate samples described above.

The particles with "coal-like" morphology were analyzed by Optical Microscopy using two types of reporting formats:

1). Numerical Concentrations: The numerical concentrations of particles were reported as particles/cubic meter of air (particles/m^3) in each particle classification given above, and based on the sampling times and volumes reported during sampling.

2). Size Distribution & Estimated Mass: The samples were separately analyzed for the size distribution of particles in the carbonaceous classifications (only) that are consistent with coal particles (see reports for Sample U2-025). A known percentage of the sample was analyzed and the size distribution statistics and estimated mass concentrations were calculated. The resulting mean particles sizes and theoretical mass concentrations of coal-like particles are reported as micro-grams per cubic meter of air (µg/m^3).

3.4 MiniVol Filter Samples

MiniVol filter samples were collected in an attempt to examine and chemically analyze the respirable (<3 µm) size fraction of dust emitted from the passing coal trains. The 24-hour duration MiniVol filter samples showed very low surface deposition in both the upwind and downwind locations. Any coal concentrations will also likely be masked by background biogenic particles that continue to be collected during the "non-train passage" sampling period. Because the biological particles contain carbon and oxygen ratios similar to a percentage of carbon/coal particles found in samples of the actual coal, the ability to differentiate coal-like particles from non-coal related particles was diminished. Analysis of the two collected coal samples showed high percentages of particles with primarily carbon and oxygen. These samples also showed highly carbonaceous alumino-silicate and iron silicate particles that can be readily differentiated from non-coal particles using the automated SEM analysis. However, these particles were found in a lower concentration. When these observations were combined with the dilution of "non-train passage air," the value of the MiniVol samples was significantly diminished. Collection of a sufficiently concentrated air sample in the "respirable" size range will require both a sample with more concentrated particle deposition (higher volume/flow rates), and a collection interval that only samples during the passage of coal trains. Based on these initial observations, it was determined that further analyses of the collected MiniVol filters using SEM would provide no additional information, and no additional samples were analyzed.

It must also be recognized, that the inability to detect significant coal particles in the respirable size fraction over a 24-hour period (as measured during the initial sampling) also indicates that coal-like particles in the respirable range appears to be low.

4. QUALITY ASSURANCE

The quality assurance efforts implemented throughout the program were designed to create a data set of known quality suitable for the study goals.

4.1 Acceptance Tests

All instrumentation used for collection of data in the field underwent evaluation and acceptance testing before the start of the field program. The study included the use of automated deposition samplers that were designed and constructed specifically for this sampling effort. The TSI DustTrak DRX Aerosol Monitor used was obtained from a rental agency (EcoRental Solutions) and upon receipt was checked using the manufacturers procedures for the zero and flow checks. The instrument was then allowed to run overnight to confirm operation.

4.2 Field Quality Assurance/Quality Control (QA/QC)

Calibrations

All equipment were calibrated during installation using known standards and procedures consistent with EPA guidelines and/or manufacture recommendations:

- MiniVol Samplers – The sampler's internal flow meter (a rotameter) was calibrated against an NIST-certified Bios flow meter. Flows were confirmed to be operating within 5% of the sampler's design flow rate of 5 lpm, which is necessary for maintaining the cutpoints of the impactors.
- Air-O-Cell CIS Samplers – The operational flow rate of 15 lpm was confirmed at the beginning and end of the study using an NIST-certified Bios flow meter.
- DustTrak DRX – The operational flow rate of the DRX was verified at the beginning and end of the study using an NIST-certified Bios flow meter. The zero response of the instrument was verified using the manufacturer-supplied HEPA filter used to produce particulate-free air.
- Wind Speed – The RM Young wind speed sensor was calibrated using a certified selectable speed anemometer drive connected to the sensor shaft to simulate wind speeds the operating range of the sensor.
- Wind Direction – The RM Young wind speed sensor was calibrated by aiming the sensor at a landmark of known orientation and through rotation of the sensor to known directions and comparison to the data logger output values.
- Temperature – The RM Young temperature and relative humidity sensor was compared at multipoint points to known standards of temperature and humidity.
- Solar Radiation – The Licor pyranometer was compared to a recently certified unit at multiple times during the day.

Field QC

Study-specific sample forms were designed to collect required sampling information. In addition, the forms provided a checklist for conducting routine quality control during the study. Key elements of the quality control effort include the following:

- Battery voltages for all equipment were checked on a daily basis, and batteries changed as required.
- The zero response of the DustTrak DRX was checked every three days using the HEPA filter supplied by the manufacturer. The zero response did not deviate more than 0.001 $\mu g/m^3$ from zero over the course of the study.
- MiniVol flow rates were recorded at the beginning and end of each sample period.
- Field blanks were collected for each of the sample media used during the study, This included filed blanks for the MiniVol samplers, deposition plates, and Air-O-Cell CSI samplers. All blanks were handled in the same manner as normal samples, and in actuality were samples that for one reason or another did not have the sample pump turned on (in the case of the CSI samples) or were not exposed to ambient air (in the case of the deposition plates). Thus, using the deposition plates as an example, the blanks included the process of removing the lid of the petri dish, inserting the dish into the sampler, closing the top of the sampler, and repeating the reversed process to remove the petri dish. The samples were then analyzed by the laboratories as normal samples using the same procedures used to analyze the collected samples. No coal-like particles were found on the five blank deposition samples. Coal-like concentration for the five CSI blank samples average an equivalent concentration of 0.12 $\mu g/m^3$.

Sample Chain-of-Custody

Sample chain-of-custody was controlled from the field to the laboratory using chain-of-custody forms to document and verify handling of the sampling media.

4.3 Laboratory Analyses and Data Processing

Continuous meteorological and DRX instrumentation data were loaded into the T&B Systems data display system, which is based on the Vista Data Vision software package. All train passage data (train arrival times) were then added to the database, with coal trains also having the time that the last car or locomotive passed. This allowed for quick review of data for reasonableness and to identify any data quality issues. This review did reveal an issue with the solar radiation data where, due to an installation siting oversight, it became clear that the wind sensor shaded the radiation sensor at times, and under specific wind direction conditions. The 30-second data were edited, removing the invalid data, and the hourly averages were recalculated for solar radiation.

Data from EAA were submitted to T&B as five- to six-page reports for each sample analyzed (an example report can be found in Appendix B). Key data from these reports were then compiled into spreadsheets in order to better review the data and to allow for analysis of the data. The compiled data were verified independently by a second reviewer. Appendix A contains these summaries. An important task in this effort, given the large number of samples sent to the EAA, was to verify that reports were received for each of the samples submitted. Review of the compiled data indicated that near-zero readings for the Air-O-Cell CSI sampler located across the tracks on the west occurred during the middle of the study. This was the sampler that could not be manually confirmed to be sampling during the passage of the train, due to the number of tasks occurring during train passage sampling and the far proximity of this sampler from the other sampling efforts. Midway through the study, a disconnected wire associated with the control of this sampler was discovered, apparently due to minor vandalism and/or an inadvertent unplugging of the sampler at night. The near-zero readings correspond to three days prior to this discovery, supporting the conclusion that sampling issues had occurred. These samples were designated as field blanks and excluded from the upwind/downwind analysis used to support the conclusions in this report.

Review of the laboratory data also revealed an issue with the calculation of mass concentrations for the deposition plate and CSI sampler data. EAA, when calculating the mass concentrations, simplified the calculations by taking a mean of the particle diameters and using this and the total number of particles identified to calculate particle volume and mass. Review showed that this approach had the possibility of significantly underreporting the mass, since mass increases as the cube of the particle radius, and even a few large particles can contribute enormously to the mass content of a sample. The analytical reports contained details on all particles identified during the analyses, including particle diameter. T&B Systems used the data in the reports to calculate the mass of each particle individually, and sum these up to obtain a more representative estimate of mass concentration for each sample.

5. RESULTS

Detailed summaries of the analytical results are presented in Appendix A. An example laboratory analysis report is presented in Appendix B..

The data supplied EAA contains considerable information regarding the deposition plate samples and Air-O-Cell CSI samples, including size distribution and particle characterization. The results presented here focus on the primary goal of the study, to characterize coal dust concentration in air and deposition from the coal hauling trains. Note that when comparing the data in Appendix A with that reported in the analytical reports, the mass concentrations in Appendix A will be higher than those in the reports for the reason discussed in Section 4.3, above.

A number of issues impacted sample collection for this study, including the following:

- While the study enjoyed 10 days of little to no precipitation, rainy weather dominated the area beginning October 14, and the study was terminated on October 20.
- In designing the study, a limited number of viable sampling locations were identified in Cowlitz County. The chosen location was picked for several reasons as described in Section 2, including that it appeared to offer the best possibility of cross-track winds, which review of available local meteorological data showed to consist of westerly winds (flowing west to east) for this time of the season. The samplers and deposition plates were laid out in a grid based on this assumption, with the majority of the measurements located on the east side of the tracks. However, winds with an easterly component were much more common during the study than anticipated based on available data, with only four of the 25 trains monitored occurring during winds with the expected westerly component. This impacted the goals in identifying gradients in deposition rates, and limited the usefulness of the DustTrak and MiniVol PM_{10} and $PM_{2.5}$ data.
- The relative humidity at this site was higher than anticipated, with nighttime fog common during the study period. It is unknown whether this might affect release of coal from trains that passed by the monitoring location.

5.1 Train Traffic

All train traffic was recorded and documented during the 11 days of active sampling. Train traffic data are summarized in **Table 5-1**. The number of freight trains indicated includes those that were hauling coal.

Table 5-1. Train traffic during study.

Date	Type	Northbound				Southbound		
		No. of Trains	Average Speed (mph)	Average No. of Cars/Train	No. of Stopped Trains	No. of Trains	Average Speed (mph)	Average No. of Cars/Train
1-Oct	Freight	9	41	111		7	44	78
(partial day)	Passenger	2	70	11		1	70	10
2-Oct	Freight	22	41	91	2	20	37	89
	Passenger	4	61	11		6	60	10
3-Oct	Freight	26	34	94	3	20	23	90
	Passenger	4	70	11		6	70	11
4-Oct	Freight	27	37	93	1	17	31	88
	Passenger	4	61	11		5	60	12
5-Oct	Freight	21	20	108	5	13	35	89
	Passenger	5	66	13		4	68	11
6-Oct	Freight	33	33	100	4	14	34	103
	Passenger	6	60	13		6	60	11
7-Oct	Freight	29	30	94	6	19	42	79
	Passenger	5	62	12		5	66	11
8-Oct	Freight	28	38	102	3	20	42	91
	Passenger	5	67	12		5	62	12
9-Oct	Freight	28	42	89	2	21	36	98
	Passenger	5	67	12		5	68	11
10-Oct	Freight	16	34	88	2	8	36	52
	Passenger	1	74	13		0	0	0
12-Oct	Freight	23	42	98	3	10	32	86
	Passenger	5	70	11		4	62	11

Due to work north of the site, northbound trains (and only northbound trains) would sometimes stop at the location of the sampling to allow southbound trains to pass. The duration of the stop would vary from 10 to 50 minutes. This affects the average northbound freight speed because the trains that stopped were generally traveling at a lower speed than other rail traffic when they passed the sampling location. There were more northbound trains in a given day than southbound, and generally northbound trains had more cars and apparently more locomotives. About the same number of passenger trains came from the north as from the south, and their speeds were in the 65–70 mph range, with 11–13 cars.

Figure 5-1 shows the distribution of train traffic over a one-week period during the study. The plot shows that the distribution of train traffic is relatively uniform through the day. While some gaps in traffic are noted, they do not appear to be limited to a particular time of the day. Passenger train traffic is predictably limited primarily to the period from 9 a.m. to 9 p.m. Coal trains occur at a consistent rate of about two per day, though there is no apparent pattern concerning when during the day they passed.

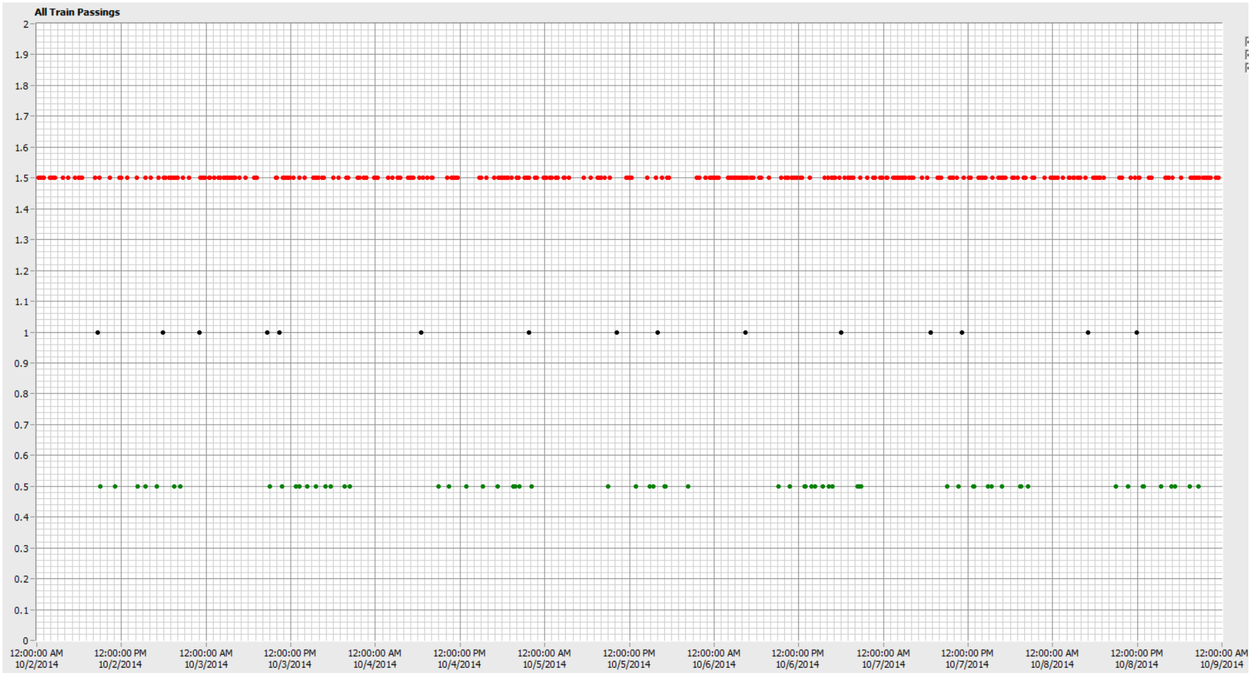


Figure 5-1. Train traffic during one-week period. Red dots = freight train; black dot = coal train; green dots = passenger train.

During the 11 days of active monitoring, 23 coal trains were observed, and samples were obtained during passage of 22 of the trains. All coal trains were northbound, and no empty coal trains were observed. **Table 5-2** presents a descriptive summary of the coal trains observed and the sampling conducted. Note that the last two trains in the summary are actually non-coal freight trains sampled as controls.

Of the 22 coal train sample sets collected, 11 where submitted to the laboratory for full analyses. These are highlighted in green in Table 5-2. The remaining 11 sample sets were not analyzed for several reasons, the most common of which was that the train stopped on the section of track being studied. Between the variable and relatively low speeds of these trains (see Table 5-2) and the confounding issues created by either sampling or not sampling while the train was stopped, it was determined that analytical data from these sample sets would not provide useful data for this study. The other reasons for not analyzing sample sets were due to measurement issues or vehicle traffic in the area adjacent to the samplers that would have confounded results.

5.2 Optical Characteristics of Samples

<u>Deposition Plates</u>

Based on the deposition plate analysis, quantitative information can be obtained; however, the results are likely to be less conclusive than the Air-O-Cell CSI samples because of the lower number of identifiable particles collected, and reliance on passive collection.

Table 5-2. Summary of coal train activity, and sampling and analyses activity (green highlighted sets had laboratory analysis).

						Engines		Cars				
Sample Set	Date	Arrival Time	Depart Time	Passage Time	Speed	Front	Back	Coal	Other	Total	Estimated Train Length (miles)	Comments
1	10/1/2014	18:30:17	18:32:16	0:01:59	40	3	1	126		130	1.3	
2	10/2/2014	8:34:08	8:35:55	0:01:47	44	3	1	122		126	1.3	Sampled only last 70 cars, closest plate malfunctioned
3	10/2/2014	17:53:33	17:55:07	0:01:34	53	2	2	119		123	1.4	Stopped sampling 1 minute after train passage because of road traffic.
4	10/2/2014	23:02:25	23:13:46	0:11:21	19 to 0 to 31	3	1	165		169		Train stopped
5	10/3/2014	8:38:59	8:40:38	0:01:39	43	3	1	114		118	1.2	Sampled for 89 cars. Pickup on road during sampling
6	10/3/2014	10:22:34	10:24:48	0:02:14	38	3	1	125		129	1.4	Sampled for 107 cars
8	10/4/2014	1:59:51	2:01:31	0:01:40	46	2	1	89		92	1.3	Nightime. Tech not absolutely sure cars contained coal
	10/4/2014	6:24:08	6:25:43	0:01:35	52	3	1	121		125	1.4	Not sampled because of very heavy dew
9	10/4/2014	11:43:33	11:44:27	0:00:54	38	2	0	25	24	51	0.6	Half freight, half coal
10	10/4/2014	21:46:53	22:26:31	0:39:38	15 to 0 to 26	4	0	126		130		Train stopped for 35 minutes, passed by 2 trains
11	10/5/2014	10:12:10	10:42:33	0:30:23	22 to 0 to 22	3	1	122		126		Train stopped for 25 minutes, passed by 1 train
12	10/5/2014	16:04:36	16:06:49	0:02:13	37	3	1	124		128	1.4	
13	10/6/2014	4:25:01	4:26:54	0:01:53	44	3	1	122		126	1.4	
15	10/6/2014	17:57:20	17:59:05	0:01:45	41	3	1	126		130	1.2	
16	10/7/2014	6:42:10	6:43:01	0:00:51	47	3	0	72		75	0.7	2 cars on levy road during sampling
17	10/7/2014	11:07:47	11:30:56	0:23:09	9 to 0 to 16	3	1	123		127	NA	Train stopped for 25 minutes
18	10/8/2014	5:00:14	5:01:54	0:01:40	43	3	1	125		129	1.2	
19	10/8/2014	11:55:26	12:05:14	0:09:48	13 to 0 to 16	3	1	124		128	NA	Train stopped for 5 minutes
20	10/10/2014	3:13:17	3:21:32	0:08:15	16 to 0 to 16	3	1	126		130		Train stopped for 1 minute
21	10/10/2014	5:22:42	5:24:21	0:01:39	43	3	2	124		129	1.2	
22	10/10/2014	7:30:22	7:32:07	0:01:45	40	2	2	125		129	1.2	
24	10/12/2014	12:58:01	12:59:34	0:01:33	48	3	1	122		126	1.2	New sample configuration
25	10/13/2014	9:47:54	9:49:48	0:01:54	43	3	1	125		129	1.4	New sample configuration
7	10/3/2014	16:29:18	16:31:05	0:01:47	46	2	1		112	115	1.4	Freight train
14	10/6/2014	16:13:18	16:15:03	0:01:45	38	2	1		111	114	1.1	Freight train

Examination of the initially selected deposition plate samples (both upwind and downwind) show very low but visible surface deposition of particles. The settled coal-like particles range in size from 10–50 microns. The concentration of the collected dust through filtration on to a small sized filter does provide usable particle concentrations in the locations closest to the train tracks.

Air-O-Cell CSI Air Samplers

Very low particle deposition (both upwind and downwind) was observed on the CSI impaction samples analyzed by Optical Microscopy. Although particles were visible down to approximately 1 µm, only particles greater than approximately 3 µm in diameter can be classified. Particle sizes ranged from 1 µm to approximately 100 µm. A higher ratio of particles less than 3 µm to those greater than 3 µm was observed by SEM.

24-Hour Filter Samples

Examination of the initially selected filter samples (both upwind and downwind) showed very low surface deposition of particles when examined by SEM, with the particle sizes ranging from 0.5 µm to 10 µm. The majority of the deposited particles (numerical concentration) were less than 1 µm in diameter. X-ray analysis results showed predominantly iron oxide containing particles (>80% of all particles analyzed). Lower concentrations of carbonaceous particles (biogenic mold spores, plant fragments, and insect dropping fragments) were detected. Concentrations of particles with a morphology consistent with coal particles were rarely detected.

5.3 Coal Concentrations

Table 5-3 summarizes the concentrations of coal-like material identified on the deposition plates and CSI air samples analyzed for this study. Note that in this table, "upwind" and "downwind" refer to actual meteorological conditions during sampling, based on the wind direction relative to the direction of the tracks at the sampling location (160º/340º). For example, remembering that there were three deposition plates east of the tracks and one plate west of the tracks, for Sample Set 3 when winds are coming more from the west, the three plates ended up being on the downwind side of the tracks, but end up being upwind for Sample Set 22, with winds from the east.

While the range of concentrations measured across the number of samples collected makes definitive conclusions difficult, a review of the data does point to a number of likely conclusions, as listed below:

Deposition Plates

- In reviewing the data from the plates, it is worth emphasizing that particles were rarely identifiable visually on the plates, as discussed in some detail in Section 3. In addition, it is important to note that no coal-like particles were identified in any of the field blank samples, as discussed in Section 4. Note also that all the deposition plates were all analyzed for a single coal train event.
- Looking first at data from the revised sampling configuration, concentrating on Sample Set 25, the potential for large variability in concentrations collected by different plates is readily evident. Looking at samples collected on the downwind side (as defined by the

measured wind direction) and only the material identified as coal-like, two plates located at the same distance from the track collected notably different concentrations of 2,591 μg/m^2 and 59 μg/m^2. Eighty percent of the 2,591 μg/m^2 sample is due to one 84.1 μm diameter particle (about the diameter of a human hair) that was collected on this plate. In general, deposition plates showing higher deposition concentrations are due to a large particle deposited on the sample. For example, the 2,234 μg/m^2 concentration shown for Sample Set 18 is due entirely to a single 96.7 μm diameter particle.

- Concentrating on the largest, primary data set with winds across the tracks, the data show that coal particles fall on both the upwind and downwind sides of the tracks. This is likely due to the wake created by the train itself, which was observed by the technicians conducting the sampling but not quantified during this study. The data do, however, show higher deposition on the downwind side of the train. This is most representatively observed by looking at the averages of the samplers located 15 meters from the tracks, which were obtained both upwind and downwind for all sample sets regardless of the wind direction. The average for the downwind coal-like samples is 890 μg/m^2 versus 334 μg/m^2 for the upwind samples.
- Based on the data obtained from sampling two non-coal freight trains (Sample Sets 7 and 14), concentrations of coal-like material for non-coal freight trains are lower than those for coal trains, averaging just 28 μg/m^2 for the non-coal trains, compared to either the upwind or downwind averages (334 and 890 μg/m^2, respectively) stated above.
- The data collected show apparent variability from train to train. This is demonstrated by the data from Sample Set 18, which show notably higher deposition amounts than those for the other sample sets. Conversely, results for Sample Set 1 are consistently low—at essentially the same deposition as those reported for the non-coal freight trains described above.
- The variability shown in the sampling results prevents estimation of a change in deposition as a function of distance from the track.

<u>Air-O-Cell CSI Air Samplers</u>

- Review of the data revealed that there was a period during which the CSI sampler west of the tracks was not operating correctly, which limits the number of sample sets that have both an upwind and downwind CSI sample. Un-run samples, however, were used instead as field blanks. Results from these field blanks showed consistently low coal-like concentrations (0.0, 0.0, 0.0, 0.0, and 0.6 μg/m^3, for an average of 0.1 μg/m^3 for the five samples).
- Despite the above issue, there were six upwind/downwind sample pairs for six individual coal train pass-bys, five of which show a significant upwind/downwind difference in concentrations. Concentrating on the primary data set obtained during across-track winds, the averaged downwind concentration is 9.4 μg/m^3 for the coal-like particles compared to 1.5 μg/m^3 for the upwind samples of coal-like particles. Sample Set 1 is the lone outlier in this data set, with upwind concentrations higher than downwind concentrations. However, it is worth noting that the crosswind component of the wind was particularly low for this sample set, with the wind speed recorded during this 2-minute period as only 0.3 meter per second, and the wind direction just 20º off of the track direction of 160º. It is possible that the train's wake played a bigger role than the winds in this case. If Sample Set 1 is removed from the calculations, the average concentrations are 11.3 and 0.6 μg/m^3 for the downwind and upwind samplers, respectively. The upwind concentrations are consistent with the concentrations measured during the non-coal freight train passages.

Table 5-3. Summary of coal-like concentrations off of coal trains.

Winds across tracks

							CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
Sample			Speed	WS	WD	RH	Upwind	Downwind	Upwind			Downwind		
Set	Date	Time	(mph)	(m/s)	(deg)	(%)	40 m	40 m	30 m	15 m	5 m	5 m	15 m	30 m
1	10/1/2014	1830	40	0.3	140	75	5.1	0.2	18.3	31.1	39.7		28.4	
3	10/2/2014	1755	53	1	310	56	0.3	8.6		204.3		2.9	17.5	92.6
6	10/3/2014	1022	38	2	20	70	1.9	5.2	45.2	121.5	1347.3		101.5	
12	10/5/2014	1602	37	2	310	49		0.5				426.5	950.7	145.6
13	10/6/2014	424	44	1	70	89	0.6		148.2	134.3	741.0		120.3	
18	10/8/2014	500	43	0.9	30	87	2.5		0.0	2233.5	1399.9		6934.4	
21	10/10/2014	521	43	0.9	60	97	0.1	19.6	11.7	17.0	40.8		1484.8	
22	10/10/2014	730	40	1.3	80	97	0.1	22.5	76.7	55.7	31.6		379.1	

New sampling configuration
Winds across tracks

							CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
Sample			Speed	WS	WD	RH	Upwind	Downwind	Upwind			Downwind		
Set	Date	Time	(mph)	(m/s)	(deg)	(%)	15 m	15 m	5 m	5 m	5 m	5 m	5 m	5 m
25	10/13/2014	947	41	2.5	85	87	0.41	26.5	22.7	9.6	90.6	2590.9	59.4	

Winds parallel to tracks

							CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
Sample			Speed	WS	WD	RH	East	West	East of Tracks			West of Tracks		
Set	Date	Time	(mph)	(m/s)	(deg)	(%)	40 m	40 m	30 m	15 m	5 m	5 m	15 m	30 m
15	10/6/2014	1800	45	1.5	340	54	15.1		38.3	56.8	155.9		33.3	

New sampling configuration
Winds parallel to tracks

							CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
Sample			Speed	WS	WD	RH	East	West	East of Tracks			West of Tracks		
Set	Date	Time	(mph)	(m/s)	(deg)	(%)	15 m	15 m	5 m	5 m	5 m	5 m	5 m	5 m
24	10/12/2014	1258	50	1.2	160	83	6.76		46.9	64.1	44.9	5.5	0.0	

Freight Train
Winds across tracks

							CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
Sample			Speed	WS	WD	RH	Upwind	Downwind	Upwind			Downwind		
Set	Date	Time	(mph)	(m/s)	(deg)	(%)	40 m	40 m	30 m	15 m	5 m	5 m	15 m	30 m
7	10/3/2014	1627	46	0.8	230	29		0.4	15.5	42.1	11.1		17.8	

Freight Train
Winds parallel to tracks

							CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
Sample			Speed	WS	WD	RH	East	West	East of Tracks			West of Tracks		
Set	Date	Time	(mph)	(m/s)	(deg)	(%)	40 m	40 m	30 m	15 m	5 m	5 m	15 m	30 m
14	10/6/2014	1613	38	2	340	49	1.1		60.7	16.5	36.3		25.3	

- Similar to the deposition plates, there is evidence of train-to-train variability in emitted coal-like concentrations. Looking at Sample Set 21, the measured downwind concentration is significantly higher than for other trains. This is supported by the downwind deposition plate for this sample set, which has one of the highest concentrations of the study. Sample Set 22 also shows both a high downwind CSI concentration and moderately high deposition plate concentrations.
- Higher concentrations were monitored by the CSI sampler when it was moved closer to the tracks (from a distance of 40 meters to a distance of 15 meters), as evidenced by the Sample Set 25 data.
- One of the goals of the study was to investigate the effect of train speed on the source strength of coal dust from the train. The small number of samples and the relatively consistent speed of the passing coal trains (averaging about 43 mph) make conclusions regarding the effect of train speed difficult. However, it can be observed that for the fast train observed (Sample Set 3 – 53 mph) the downwind concentration is amongst the highest of the study, whereas for the slowest train (Sample Set 12 – 37 mph), the downwind concentration is amongst the lowest. However, the highest concentration measured with the original configuration (22.5 $\mu g/m^3$ – Sample Set 22) occurred for a train traveling at 40 mph, indicating that speed may not be the only factor affecting coal dust source strength..
- Similarly, the data were reviewed to see if relative humidity was correlated with measured coal dust. With the highest concentrations noted during a period when relative humidity was 97% (Sample Sets 21 and 22), this does not appear to be an obvious factor based on the data collected. If average humidity during coal transport does affect coal dust source strength, measurements at a single location would not be representative of the entire haul route in any case.

5.4 MiniVol Gravimetric Samples and DustTrak DRX Data

The data collected from the DRX were anticipated to be used to help understand the differing size distribution of coal dust and particulate matter from the different train types. However, the usefulness of the data is questionable under the observed study conditions due to the high humidity during much of the study period and the resulting drift in the instrument baseline. Laser-based photometers have known issues under high humidity, and this is apparent with the collected data. Many of the nighttime and early morning hours also had extensive fog, as documented with the video taken at the site and measured relative humidity. **Figure 5-2** shows the diurnal pattern of $PM_{2.5}$ during the period of October 3 through October 6 when the largest diurnal swings in relative humidity occurred. The values are averaged RH and $PM_{2.5}$ within each of the hourly periods that reflect the close correlation of high RH values with the higher $PM_{2.5}$ values. Additionally, as the RH increases past about 90%, the noise in the values increases significantly. As a result, not much can be done to remove the influence of humidity on the data when the RH reaches 80 to 90%. This makes correlating the DRX to the collected filter samples to establish a “K” correction factor for calibration inappropriate because during the study period there were always times within each 24 hour period that had high humidity. The best use of the DRX data is therefore to look at any potential relative values during periods when the humidity was lower and wind directions were appropriate to carry coal dust from the train to the location of the DRX. Use of the DRX in future studies should be restricted to applications and time periods with lower humidity, or different instrumentation should be used to measure the size-segregated data under the varying humidity conditions in the study region.

Despite the limitations of the DRX data collected in this study, a comparison of the DRX data with the filter-based MiniVol data was conducted by calculating 24-hour average concentrations obtained from the DRX corresponding to the MiniVol sample times and comparing them with the MiniVol 24-hour averages. These results are presented in **Table 5-4**.

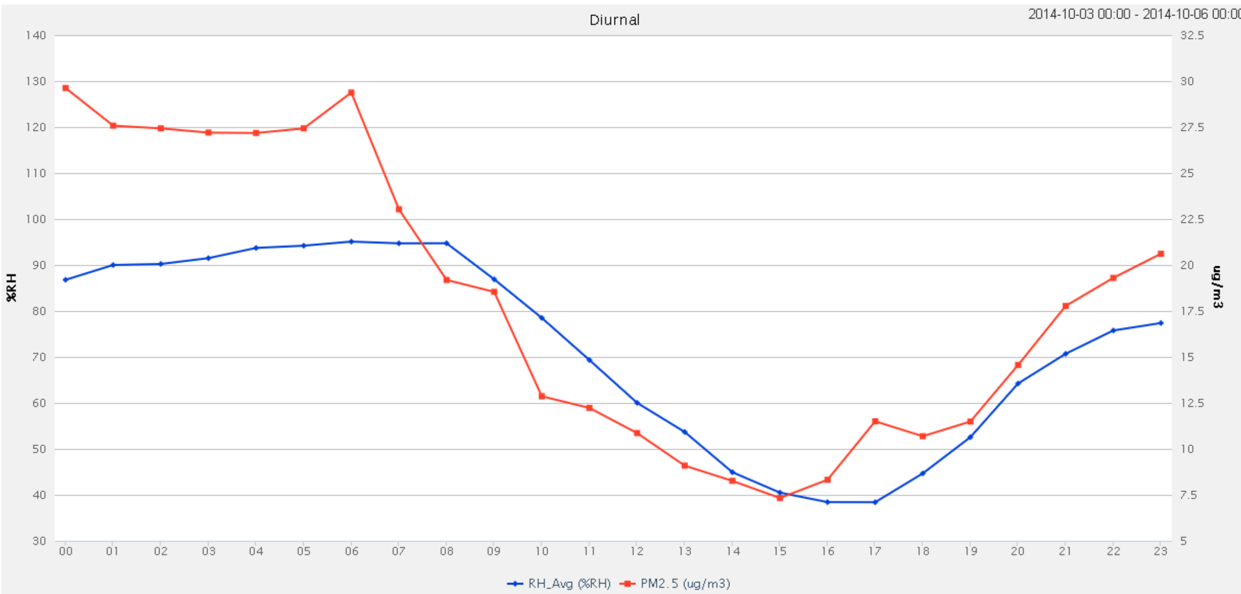


Figure 5-2. Diurnal variation of relative humidity and $PM_{2.5}$ during a three-day period showing the correlation of concentration to humidity.

Table 5-4. MiniVol/DustTrak DRX data and comparison.

		Filter (ug/m^3)		DRX (ug/m3)				Filter/DRX Ratio	
Date	RH	PM 2.5	PM 10	PM1	PM 2.5	PM 4	PM 10	PM 2.5	PM 10
10/1/2014	79.5	9.2	17.4	19.7	21.3	24.1	26.9	0.432	0.647
10/2/2014	69.2	8.6	15.2	17.7	18.7	20.7	21.2	0.460	0.717
10/3/2014	74.5	8.9	16.6	18.2	19.4	22.5	23.9	0.459	0.695
10/4/2014	72.2	11.5	20.2	16.7	17.4	18.4	19.7	0.661	1.025
10/5/2014	70	9.6	19.9	15.2	15.7	16.4	18.1	0.611	1.099
10/6/2014	74.1	7.6	17.2	13.1	14	15.7	17.9	0.543	0.961
10/7/2014	75.8	7	17.5	11.9	12.4	13.2	15.2	0.565	1.151
10/8/2014	82.4	10	14	20.7	21.7	23.2	24.4	0.461	0.574
10/9/2014	83.9	8.1	20.6	24.4	25.4	26.9	28.3	0.319	0.728
10/12/2014	84.6	19.1	16.7	18.4	19.6	20.6	21	0.974	0.795
Study Average	76.6	8.9	17.5	17.6	18.6	20.2	21.7	0.501	0.839

It should be noted that MiniVol samples were changed around 4 p.m. each day. The final sample on October 12 was actually conducted over a 32-hour period in order to include sampling through the end of the study, which was defined by an approaching rain storm.

In reviewing the data, the $PM_{2.5}$ sample dated October 12 (highlighted in yellow on Table 5-4) stands out for a number of reasons. The concentration is notably higher than that for any of the other days. In addition, it is higher than the reported PM_{10} concentration for that day, while the PM_{10} concentration appears to be very similar to those for the other days. Finally, the Filter/DRX ratio is notably different—almost twice the average. For this reason, the $PM_{2.5}$ results for October 12 are considered highly questionable, and have been removed from the calculation of the study averages.

Comparisons with the average relative humidity for the sample period revealed no definitive relationships, though there is a weak correlation between relative humidity and the Filter/DRX ratio ($r = -0.50$ and -0.68 for $PM_{2.5}$ and PM_{10}, respectively), with lower factors associated with higher relative humidity. This is consistent with observations that higher humidity causes an over-reporting of the concentration, and thus requires a lower "K" factor to correct it.

Based on the above comparison, possible "K" correction factors for the DRX data would be 0.50 for the $PM_{2.5}$ data and 0.84 for the PM_{10} data, with some possibility of adjusting these factors for humidity. However, while these factors may be fairly representative for 24-hour averages, their use for shorter time periods (e.g., 1-hour) has not been confirmed with this study.

5.5 MiniVol $PM_{2.5}$ Scanning Electron Microscopy Analyses

As discussed in Section 3.4, the usefulness of the SEM analysis of the 24-hour $PM_{2.5}$ filters collected for this study was found to be limited. This is due to the relatively small amounts of coal being emitted (two train events). Nevertheless, five samples were analyzed to explore further the potential use of this analysis as a tool to extract more information about the ambient concentrations of coal. These samples were as follows:

- Coal sample A – A portion of Coal Sample A was pulverized and fractionated by settling through a water column until the average particle diameter was less than approximately 10 µm. This sample was then analyzed by automated SEM with size discrimination to only analyze particles from 0.5 µm to 5.0 µm in diameter. This preparation procedure was performed in order to simulate coal-like particles that may be found in the "respirable" size range on the ambient air $PM_{2.5}$ samples.
- Samples U4-008 and D4-008 – A 24-hour sample pair was collected during a period when no coal trains passed.
- Samples U4-009 and D4-009 – A 24-hour sample pair was collected during a period when two coal trains passed, immediately following the sample pair above (U4-008 and D4-008). Specifically, these were the trains identified in Table 5-3, above, as Sample Sets 21 and 22, both of which showed strong upwind/downwind gradients for coal-like particles. Both trains passed under similar meteorological (upwind/downwind) conditions. Furthermore, the percentage of across-track upwind/downwind periods for this sample pair were virtually identical to the "no coal train" sample pair, above (80% toward the downwind sampler versus 20% toward the upwind sampler – a 4:1 ratio).

Analysis reports for these and other samples discussed in this section are included in Appendix C.

Figure 5-3 summarizes the results of the analysis of the coal sample. As can be seen, the composition of the coal can be divided into essentially four categories: AlSi carbon (carbonaceous aluminum silicates), Carbon H (highly carbonaceous, >80% carbon), CMgAlFe silicate (carbonaceous silicates, low concentrations of magnesium, aluminum, and iron), and quartz. However, for both CMgAlFe silicate and quartz, the concentrations are extrapolated from a single larger particle, and therefore should not be considered conclusive. Notably missing from this sample is iron oxide (FeC oxide), supporting the assumption that any iron oxide is likely coming from the steel rails.

Figure 5-4 presents a similar summary for the downwind “coal train” ambient air sample. Several differences between this sample and the coal sample are apparent. Most obvious is the increase in the percentage of Carbon H, and the notable difference in the Carbon H to AlSi carbon ratio. Almost half of the mass analyzed by SEM in the “respirable” size range was classified as Carbon H. Optical Microscopy examination of the Air-O-Cell CSI samples (as discussed in previous sections) showed that a significant percentage of carbonaceous particles are likely biologically derived (mold spores, pollen, carbonaceous fragments). The <3 µm size range of particles cannot be accurately classified by Optical Microscopy because of their small sizes. Thus, an important discriminatory was to estimate the portion of Carbon H particles that are potentially coal-like in nature versus those that are organic.

Another very noticeable difference between the two figures is the presence of iron oxide (Fe oxide) in the ambient sample, which again was not detected in the coal sample. This, again, is consistent with the assumption that the primary source of iron oxide concentrations in the air samples are from the train rails.

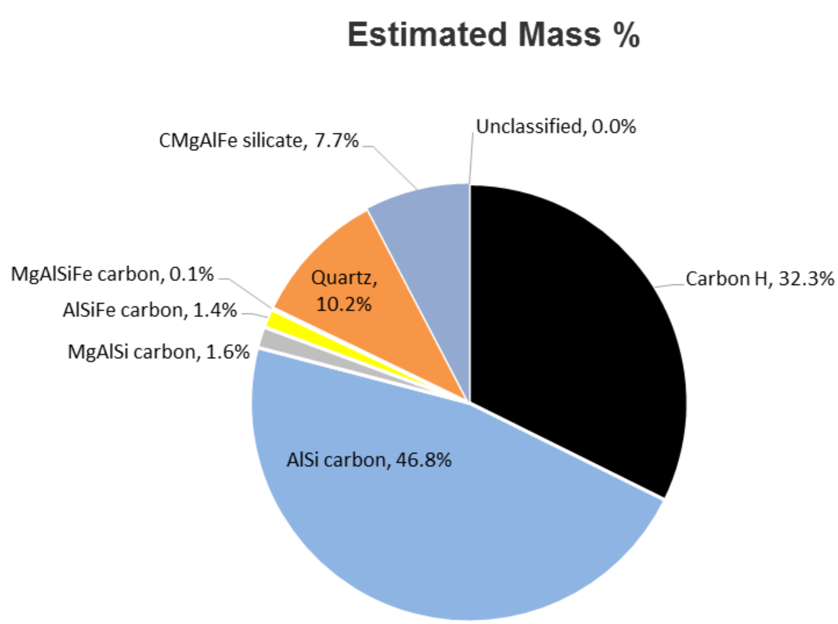


Figure 5-3. Relative mass concentration for coal sample #1 in the respirable range.

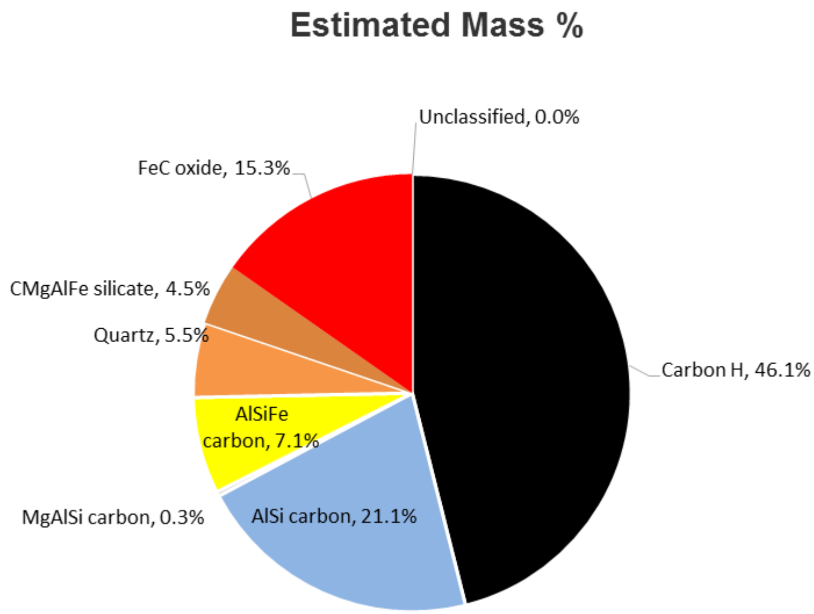


Figure 5-4. Relative mass concentration for downwind "coal train" sample.

Table 5-5 summarizes the concentration data for the five samples. The sample pair collected when no coal trains passed are very similar. The only classifications that show any significant difference between upwind and downwind concentrations are the iron classifications (FeC oxide and AlSiFe carbon), which are not unexpectedly higher downwind than upwind due to the abrasive mass loss from wheels with the steel rail. Furthermore, concentrations for this pair for the two most prevalent coal-related compounds (Carbon H, and AlSi carbon) are almost identical to the upwind sample "coal trains" sample (D4-009), supporting the conclusion that all three of these concentrations could be representative of "background" concentrations. The possible contribution due to the coal-related classifications can therefore be calculated simply as the difference between the downwind and upwind concentrations for the two coal-related classifications (Carbon H, and AlSi carbon). This produces an estimated upper bound for coal-like contribution of 1.33 $\mu g/m^3$ for two trains.

This conclusion, however, should be evaluated taking into account the limitations associated with this methodology. Based on the experience of EAA, the variability in microscopic particle counting will range from a relative standard deviation (RSD) of 0.15 to 0.30. This normal variability is essentially a 50 to 100% difference between two compared "numerical" values (i.e., the difference between detecting 5 particle counts and 10 particle counts). When this variability between numerical counts is further extrapolated to the calculation of mass concentrations, this variability will be even higher. As a result, the upwind and downwind mass concentrations given in Table 5-5 are not statistically different and are within the statistical variability of the method. In other words, the data may indicate a "trend" for the coal-like mass concentrations in a downwind sample (i.e., U4-009) to be higher than in upwind samples (D4-009). However, these two samples are not statistically different. Recognizing these limitations, and for purposes of a upper-bound analysis, it is assumed in Table 5.5 that the "trend" between upwind and downwind samples is indicative of a coal-like contribution.

Table 5-5. SEM analysis of 24-hour $PM_{2.5}$ samples (all values in $\mu g/m^3$)

Sample ID	Description	Carbon H	AlSi carbon	MgAlSi carbon	AlSiFe carbon	MgAlSiFe carbon	Quartz	CMgAlFe silicate	FeC oxide	FeMgAlSi carbon	Unclassified	Total
Coal A	Coal sample	1.130	1.630	0.050	0.050	0.000	0.360	0.270	0.000	0.000	0.000	3.490
D4-008-SEM	Upwind, no coal trains	1.205	0.451	0	0.017	0.067	0	0.045	0.010	0	0	1.795
U4-008-SEM	Downwind, no coal trains	1.014	0.541	0	0.274	0.040	0.013	0	0.109	0	0	1.991
D4-009-SEM	Upwind, 2 coal trains	0.991	0.456	0	0.336	0	0.003	0.330	0.173	0.097	0.058	2.444
U4-009-SEM	Downwind, 2 coal trains	1.907	0.874	0.014	0.296	0	0.229	0.187	0.632	0	0	4.139
	Net difference (downwind - upwind) for sample pair 009	0.916	0.418									1.334

Because the use of the Carbon H category appears to be non-specific for coal particles in the ambient environment, an effort was made to look for other chemical indicators for coal particles, particularly for vanadium and manganese, two elements that typically can be found at trace levels in coal. This investigation was performed by conducting additional SEM analyses of both coal samples A and B (labeled as coal samples #1 and #2, respectively, in the lab reports) at longer X-ray acquire times and using a particle definition library refined for identifying trace particles. While manganese and vanadium were only detected at levels greater than 1% in a single isolated particle in each sample, the analyses did reveal a potential simultaneous relationship between elevated sulfur (S >1%) and iron (Fe >4%) in many coal particles, with the ratio of sulfur to iron consistently in the 1:4 to 1:5 range. This simultaneous presence of elevated sulfur and iron was only noticeable when the analysis was performed on particles larger than approximately 2 µm, and when longer X-ray acquire times were utilized. This is directly due to the increased electron beam penetration into the background collection media when the particles are very small. As a result, the X-ray spectra reflects the carbon and oxygen chemistry of the sample media as well as the sample. This effect reduces the detection efficiency of trace elements such as sulfur. Thus, the possibility of identifying sulfur during a reanalysis of $PM_{2.5}$ sample U4-009, even using the longer X-ray acquire times and the modified definition library, was marginal at best. No sulfur containing particles (let alone the detection of both sulfur and iron) were identified in sample U4-009.

Furthermore, of the two coal samples, only coal sample B revealed the consistent presence of sulfur and iron at the ratios described above for particles greater than 2 µm. A total of 46 out of 188 particles analyzed contained S>1%, 26 of which also contained iron in the 1:4 to 1:5 ratio. In contrast, for coal sample A, while 27 of the 188 particles had S>1%, only one particle had iron at the 1:5 (sulfur to iron) ratio. The ratio of sulfur to iron is important if sulfur is to be used a potential tracer. In ambient samples, there are other particle sources that will contain sulfur or iron, and this ratio would appear to be a possible way to differentiate coal from these other sources. Thus, there is a potential in future studies to use this methodology to estimate coal contributions, provided total particulate concentrations rather than $PM_{2.5}$ are collected. The reason for the differences between the two coal samples needs to be resolved (possibly due to different coal sources) before this potential “tracer” can be used to differentiate biogenic carbon sources from coal particles.

5.6 Iron Oxide Analyses

In addition to investigating coal-like concentrations observed during the sampling effort, iron oxide concentrations were reviewed due to the likely presence of iron from the interaction between the rails and train wheels and their potential contribution to $PM_{2.5}$ and PM_{10} concentrations. **Table 5-6** summarizes the iron concentration from the deposition plate and CSI Air-O-Cell sampling. For the purposes of this table, iron oxide and iron oxide cluster concentrations have been summed into a single concentration.

- There is considerable variability in the deposition plate results, again demonstrated by the downwind results for Sample Set 25, where two similarly positioned samples collected significantly different concentrations. Furthermore, some of the highest concentrations are reported by the deposition sampler located farthest from the tracks (Sample Sets 15 and 22), with no consistent concentration gradients as a function of distance from the tracks. A likely source of this variability is due to unusually high variability in iron oxide concentrations for the sample blanks. Iron oxide concentrations for the five blank samples were as follows, with one particularly high concentration:

121.5, 0.0, 49.8, 7,596.3, and 14.2 μg/m^2. This is in stark contrast to the blank concentrations reported for coal-like particles for same plates, which averaged only 0.1 μg/m^2 for the five blank samples. Again, it should be noted that blanks were obtained using all sampling procedures short of actually exposing the sample during a train passage (see discussion in Section 4.2). It is possible that the sampling equipment's continual exposure to iron oxide, which would occur from all trains, makes it difficult to load and unload the sampler without occasionally knocking an accumulated particle off of the sampler and into the deposition plate.

- The Air-O-Cell CSI samples also show more variability and less upwind/downwind correlation in the iron oxide results than in the coal-like results. However, unlike the deposition plates, the blank samples for the CSI samples showed no elevated concentrations, averaging only 0.1 μg/m^3 for five blank samples.
- Despite the complicating issues of the deposition plate blanks, the variability noted in the iron oxide results compared against the coal-like results may be due to the source mechanism. Assuming that iron oxide concentrations are being emitted at the rail level, then dispersion of the particles is dependent on the more random winds generated by the wake of the train. In contrast, coal dust emanates predominantly from the very top of the coal cars, where local crosswinds may have a more significant influence.
- There is no apparent difference in the iron oxide concentrations between the coal trains and the non-coal (freight) trains. This is most apparent when looking at the deposition plate concentrations, with concentrations for the freight trains falling along the same range as those for the coal trains, with the same degree of variability. The CSI concentrations for the non-coal trains are on the low end, but still easily fall within the variability noted for the for coal trains.
- The relationship between the $PM_{2.5}$ and PM_{10} ratio of iron oxide could be of interest for this study. While the study took samples for these two fractions, comparison of the PM_{10} results for the CSI samples with the $PM_{2.5}$ SEM results is problematic for a number of reasons:
  - The analytical methods are inherently different. The optical method used for the CSI samples manually identifies the particles, whereas the SEM analysis automatically infers iron oxide based on the mineral analytical spectrum.
  - The sample periods are very different, with the CSI samples collected for a few minutes and only while a train is present, whereas the SEM samples are integrated over a 24-hour period, which included only about 90 minutes of the 24-hour period when trains were present.
  - Similarly, the CSI samples are obtained over a short period when winds are essentially from a given direction, whereas the 24-hour SEM samples include a mix of both upwind and downwind conditions.

  With this in mind, the SEM $PM_{2.5}$ samples U4-009 (the predominantly downwind sample) and D4-009 (the predominantly upwind sample) showed 24-hour iron oxide concentrations of 0.173 and 0.632 μg/m^3 respectively, as described in Section 5.5. Note that this is consistent with the 4:1 downwind versus upwind ratio noted for these samples. During the same period, two trains were monitored (Sample Sets 21 and 22, discussed above), with reported iron oxide concentrations of 1.8 and 13.8 μg/m^3. These concentrations represent particles predominantly in the 2.5 to 10 μm range.

Table 5-6. Iron Concentrations

								CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
	Sample			Speed	WS	WD	RH	Upwind	Downwind	Upwind			Downwind		
Winds across tracks	Set	Date	Time	(mph)	(m/s)	(deg)	(%)	40 m	40 m	30 m	15 m	5 m	5 m	15 m	30 m
	1	10/1/2014	1830	40	0.3	140	75	23.7	1.7	80.9	16.6	231.4		113.8	
	3	10/2/2014	1755	53	1	310	56	0.6	17.0		22.5		16.9	90.2	28.9
	6	10/3/2014	1022	38	2	20	70	6.3	1.7	179.1	371.1	44.6		36.3	
	12	10/5/2014	1602	37	2	310	49		98.8		806.5		4312.9	146.8	72.0
	13	10/6/2014	424	44	1	70	89	1.8		572.6	168.3	58.5		96.6	
	18	10/8/2014	500	43	0.9	30	87	6.2		70.8	28.8	18414.5		960.9	
	21	10/10/2014	521	43	0.9	60	97	0.0	13.8	2.2	3496.9	4200.0		10.2	
	22	10/10/2014	730	40	1.3	80	97	0.0	1.8	3979.4	952.6	170.5		66.2	

								CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
	Sample			Speed	WS	WD	RH	Upwind	Downwind	Upwind			Downwind		
New sampling configuration	Set	Date	Time	(mph)	(m/s)	(deg)	(%)	15 m	15 m	5 m	5 m	5 m	5 m	5 m	5 m
Winds across tracks	25	10/13/2014	947	41	2.5	85	87	0.8	22.0	11.7	423.7	42.5	5514.2	252.9	

								CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
	Sample			Speed	WS	WD	RH	East	West	East of Tracks			West of Tracks		
Winds parallel to tracks	Set	Date	Time	(mph)	(m/s)	(deg)	(%)	40 m	40 m	30 m	15 m	5 m	5 m	15 m	30 m
	15	10/6/2014	1800	45	1.5	340	54	35			1167.6		63.4	78.7	2859.4

								CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
	Sample			Speed	WS	WD	RH	East	West	East of Tracks			West of Tracks		
New sampling configuration	Set	Date	Time	(mph)	(m/s)	(deg)	(%)	15 m	15 m	5 m	5 m	5 m	5 m	5 m	5 m
Winds parallel to tracks	24	10/12/2014	1258	50	1.2	160	83	54.9		547.7	155.0	158.2	142.2	71.7	

								CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
	Sample			Speed	WS	WD	RH	Upwind	Downwind	Upwind			Downwind		
Freight Train	Set	Date	Time	(mph)	(m/s)	(deg)	(%)	40 m	40 m	30 m	15 m	5 m	5 m	15 m	30 m
Winds across tracks	7	10/3/2014	1627	46	0.8	230	29		0.3		108.9		3206.2	896.9	24.9

								CSI Sampler (ug/m3)		Deposition Plates (ug/m2)					
	Sample			Speed	WS	WD	RH	East	West	East of Tracks			West of Tracks		
Freight Train	Set	Date	Time	(mph)	(m/s)	(deg)	(%)	40 m	40 m	30 m	15 m	5 m	5 m	15 m	30 m
Winds parallel to tracks	14	10/6/2014	1613	38	2	340	49	5.2			4.3		177.5	282.5	51.4

6. KEY FINDINGS

The overall sampling program was conducted during the fall of 2014. Throughout the preparatory process, a key objective was to have a monitoring system in place before the weather patterns changed from the dry summer to wet weather patterns in order to measure fugitive coal dust when they would not be mitigated by precipitation and/or high humidity. While the first half of October had favorable (dry) conditions for the study, the weather patterns shifted mid-month with a change to a rainy pattern for the latter half of the month.

The principal challenge of the study design was to attempt to measure coal dust from passing coal trains from fixed ground-based samplers located along the tracks. This operational parameter necessitated using a sampling and analysis methodology that relied on identifying individual particles collected during the train passage.

Key findings of the study can be summarized as follows:

- No coal dust was visible to the technicians in the study area, including any form of deposition on the sampling support equipment. The largest particle collected by any of the deposition plates had a diameter of 97 µm (about the diameter of a human hair), and only nine coal-like particles with diameters greater than 50 µm were identified during analysis. The largest coal-like particle identified by the CSI air sampler was 58 µm.
- Coal-like particle deposition concentrations, based on the upwind/downwind deposition plates located 15 meters from the track, averaged 400 $\mu g/m^2$ upwind and 890 $\mu g/m^2$ downwind on average per coal train. Based on the collected data, the bulk of these concentrations appear to be fugitive coal dust from the coal cars, as coal-like concentrations for deposition plates collected during non-coal train passage were notably lower (averaging 28 $\mu g/m^2$). While detectable concentrations were obtained, the measured deposition values are consistent with the lack of visual evidence of coal residual in the area.
- Air concentrations of coal-like particles greater than 3 µm, measured from samplers located 40 meters downwind from the track, averaged 11.3 $\mu g/m^3$ per coal train, compared to 0.6 $\mu g/m^3$ from similarly placed upwind samplers.
- The collected data indicate that there is train-to-train variability in the amount of coal emitted, with some coal trains showing concentrations similar to those measured for non-coal trains.

In addition to the above, the following observations were made:

- As discussed in Section 5, the usefulness of the DRX data was compromised to a significant degree by the high humidity conditions associated with season in which the study occurred and possibly inherent to the site itself. Use of the DRX in future studies should be restricted to applications that are at lower humidity, or different (and more costly) instrumentation should be used to measure the size-segregated data across varying humidity conditions.
- The use of the deposition plates successfully achieved the study goal of identifying coal dust specifically during the passage of a coal train; however, little material was collected from the approximately two loaded coal trains per day that passed by the monitoring site. While the data collected indicate that some coal particle deposition occurred, quantifying the results at the concentrations observed is somewhat problematic because a few relatively large particles collected during some sampling events can significantly affect

the interpreted results. Even if samples were combined, the total particle count is still small due to low deposition rates, which limits the quantitative conclusions that can be drawn from the data.

- The Air-O-Cell CSI method of sampling provided the best means of identifying coal-like particles given the limited amount of fugitive coal dust from the rail coal hauling operations. Given the high particle resolution for the short duration of sampling, use of this method could be further refined to help establish the gradient of airborne coal as the distance increases from the tracks, providing more definitive information than the deposition plates.

Appendix A

Summary of Analytical Results

Air-O-Cell CSI Sampler Results in µg/m³

Position: Down=Downwind, Up=Upwind, Parallel=Wind along tracks

Dist = Distance from tracks

Sample Set	Sample ID	Type	Position	Dist (m)	Units	WS (m/s)	RH (%)	Train Speed (mph)	Angular Coal-like	Rounded Coal-like	Unident-ified Opaque	Iron Oxide	Iron Oxide Cluster	Soot-like-Aciniform	Quartz	Other Minerals	Total Coal	Total Iron Oxide	Total	Comment
1	D4-001	CSI	Up	40	ug/m3	0.3	75	40	0.3	4.8		22.8	0.9		0.3	430.0	5.1	23.7	459.1	
1	U4-001	CSI	Down	40	ug/m3	0.3	75	40	0.1	0.1		1.2	0.5		0.6	461.0	0.2	1.7	463.5	
3	D4-003	CSI	Down	40	ug/m3	1.0	56	53	5.9	2.7	7.4	15.4	1.6		855.6	10.6	8.6	17.0	899.2	Vehicle on dirt road during sampling
3	U4-003	CSI	Up	40	ug/m3	1.0	56	53	0.2	0.2	0.2	0.6			0.1	1.3	0.4	0.6	2.6	
6	D4-006	CSI	Up	40	ug/m3	2.0	70	53	0.7	1.2		2.8	3.5			1.3	1.9	6.3	9.5	
6	U4-006	CSI	Down	40	ug/m3	2.0	70	38	0.6	4.6	0.2	1.2	0.5	7.5		1.4	5.2	1.7	16.0	
7	D4-007	CSI	Down	40	ug/m3	0.8	29	46	0.3	0.1		0.3			0.2	50.0	0.4	0.3	50.9	
12	U4-012	CSI	Up	40	ug/m3	2.0	49	37								2.3	0	0.0	2.3	Sampler apparently did not run
12	D4-012	CSI	Down	40	ug/m3	2.0	49	37		0.5	0.5	88.9	9.9		0.1	77.1	0.5	98.8	177.0	
13	D4-013	CSI	Up	40	ug/m3	1.0	89	44	0.5	0.1		1.8			6.2	10.8	0.6	1.8	19.4	
14	D4-014	CSI	Parallel	40	ug/m3	2.0	49	38	0.7	0.4	0.4	2.2	3.0	1.2	0.2	1.3	1.1	5.2	9.4	
14	U4-014	CSI	Parallel	40	ug/m3	2.0	49	38	0.6	0.0		0.3			4.8	1.2	0.63	0.3	6.9	Sampler apparently did not run
15	D4-015	CSI	Parallel	40	ug/m3	1.5	54	41	14	1.1		30.8	4.2		0.6	0.4	15.1	35.0	51.1	
15	U4-015	CSI	Parallel	40	ug/m3	1.5	54	41	0.01							4.3	0.01	0.0	4.3	Sampler apparently did not run
18	D4-018	CSI	Up	40	ug/m3	0.9	87	43	0.5	2.0		5.5	0.7	0.4		6.9	2.5	6.2	16.0	
18	U4-018	CSI	Down	40	ug/m3	0.9	87	43								11.3	0	0.0	11.3	Sampler apparently did not run
21	D4-021	CSI	Up	40	ug/m3	0.9	97	43	0.1	0.0						0.6	0.1	0.0	0.7	
21	U4-021	CSI	Down	40	ug/m3	0.9	97	43	1.5	18.1		11.7	2.1	0.2		1.2	19.6	13.8	34.8	Large coal particle captured (44 um)
22	D4-022	CSI	Up	40	ug/m3	1.3	97	40	0.0	0.1				0.1		6.9	0.1	0.0	7.1	
22	U4-022	CSI	Down	40	ug/m3	1.3	97	40	0.2	22.5		1.8			0.6	4.0	22.7	1.8	29.1	Large coal particle captured (58 um)
24	D2-024	CSI	Parallel	15	ug/m3	1.2	83	48	5.67	1.1	1.4	45.5	9.4		0.8	0.4	6.76	54.9	64.3	
24	U2-024	CSI	Blank	15	ug/m3	1.2	83	48	0.001			0.3			1.8	10.6	0.001	0.3	12.7	Sampler did not run
25	D2-025	CSI	Up	15	ug/m3	2.5	87	43	0.26	0.2		0.2	0.6	1.0	0.9	6.1	0.41	0.8	9.2	
25	U2-025	CSI	Down	15	ug/m3	2.5	87	43	26.1	0.4	0.5	10.1	11.9	0.5	0.3	1.8	26.54	22.0	51.7	

Air-O-Cell CSI Sampler Results in particles/m^3

Position: Down=Downwind, Up=Upwind, Parallel=Wind along tracks   Dist = Distance from tracks

Sample Set	Sample ID	Type	Position	Dist (m)	Units	WS (m/s)	RH (%)	Train Speed (mph)	Angular Coal-like	Rounded Coal-like	Unident-ified Opaque	Iron Oxide	Iron Oxide Cluster	Soot-like-Acinifor m	Quartz	Other Minerals	Total Coal	Total Iron Oxide	Total	Comment
1	D4-001	CSI	Up	40	P/m3	0.3	75	40	833.3	1250.0		2083.3	208.3		208.3	5416.7	2083	2291.6	10000	
1	U4-001	CSI	Down	40	P/m3	0.3	75	40	868.1	347.2	173.6	3993.1	173.6		347.2	3125.0	1215	4166.7	9028	
3	D4-003	CSI	Down	40	P/m3	1.0	56	53	2725	817	2180	5450	272		1907	4905	3542	5722.0	18256	
3	U4-003	CSI	Up	40	P/m3	1.0	56	53	163	488	349	349	23	23	558	2721	651	372.0	4674	
6	D4-006	CSI	Up	40	P/m3	2.0	70	38	3324	1995	665	6317	1995			2992	5319	8311.2	17287	
6	U4-006	CSI	Down	40	P/m3	2.0	70	38	3491	6483	2493	4488	997	1496		4987	9973	5485.3	24435	
7	D4-007	CSI	Down	40	P/m3	0.8	29	46	553	221	332	442			111	3648	774	442.0	5307	
12	U4-012	CSI	Up	40	P/m3	2.0	49	37			20					153	0	0.0	173	Sampler apparently did not run
12	D4-012	CSI	Down	40	P/m3	2.0	49	37		1562	7028	23428	2343		781	6247	1562	25771.0	41389	
13	D4-013	CSI	Up	40	P/m3	1.0	89	44	776	621		1242			931	8692	1397	1241.7	12262	
14	D4-014	CSI	Parallel	40	P/m3	2.0	49	38	1674	558	1563	4353	223	335	223	1116	2232	4576.0	10045	
14	U4-014	CSI	Parallel	40	P/m3	2.0	49	38	19	29		10			48	86	48	10.0	192	Sampler apparently did not run
15	D4-015	CSI	Parallel	40	P/m3	1.5	54	41	9601	1130	1130	31627	1130		2259	2259	10731	32757.0	49136	
15	U4-015	CSI	Parallel	40	P/m3	1.5	54	41	12			36			12	349	12	36.0	409	Sampler apparently did not run
18	D4-018	CSI	Up	40	P/m3	0.9	87	43	1042	651	521	1563	130	130		2344	1693	1693.0	6381	
18	U4-018	CSI	Down	40	P/m3	0.9	87	43								56	0	0.0	56	Sampler apparently did not run
21	D4-021	CSI	Up	40	P/m3	0.9	97	43	648	748	598	50		249		150	1396	50	2443	
21	U4-021	CSI	Down	40	P/m3	0.9	97	43	3491	1496	748	6732	499	249		748	4987	7231	13963	
22	D4-022	CSI	Up	40	P/m3	1.3	97	40	332	1108	443	55		388		499	1441	55	2826	
22	U4-022	CSI	Down	40	P/m3	1.3	97	40	1496	1828		3491		166	166	831	3324	3491	7979	
24	D2-024	CSI	Parallel	15	P/m3	1.2	83	48	5682	1420	473	24621	1894		1420	1420	7102	26515	36930	
24	U2-024	CSI	Blank	15	P/m3	1.2	83	48	10			30			30	172	10	30	242	Sampler did not run
25	D2-025	CSI	Up	15	P/m3	2.5	87	43	748	873	499	748	249	374	748	1870	1621	997	6109	
25	U2-025	CSI	Down	15	P/m3	2.5	87	43	5984	1995	499	19947	1496	499	499	1995	7979	21443	32914	

Deposition Plate Results in μg/m²

Position: Down=Downwind, Up=Upwind, Parallel=Wind along tracks   Dist = Distance from tracks

Sample Set	Sample ID	Type	Position	Dist (m)	Units	WS (m/s)	RH (%)	Train Speed (mph)	Angular Coal-like	Rounded Coal-like	Unidentified Opaque	Iron Oxide	Iron Oxide Cluster	Soot-like-Aciniform	Quartz	Other Minerals	Total Coal	Total Iron Oxide	Total	Comment
1	D3-001	Plate	Up	30	ug/m2	0.3	75	40	13.6	4.7	0.1	80.9				1710.6	18.3	80.9	1809.9	
1	D2-001	Plate	Up	15	ug/m2	0.3	75	40	12.3	18.8	0.8	16.6			369.4	943.8	31.1	16.6	1361.7	
1	U2-001	Plate	Down	15	ug/m2	0.3	75	40	25.2	3.2	2.4	113.8				5484.0	28.4	113.8	5628.6	
1	D1-001	Plate	Up	5	ug/m2	0.3	75	40	36.7	3.0	13.8	231.4			578.8	4186.3	39.7	231.4	5050.0	
3	D3-003	Plate	Down	30	ug/m2	1.0	56	53	25.2	67.4	1.8	28.9			38.0	535.6	92.6	28.9	696.8692	
3	D2-003	Plate	Down	15	ug/m2	1.0	56	53	14.5	3.0	4.3	90.2			534.0	15092.1	17.5	90.2	15738.11	
3	U2-003	Plate	Up	15	ug/m2	1.0	56	53	2.8	201.5	0.2	22.5			178.2	1856.2	204.3	22.5	2261.354	
3	D1-003	Plate	Down	5	ug/m2	1.0	56	53	0.9	2.0		16.9			9924.6	1046.2	2.9	16.9	10990.6	
6	D3-006	Plate	Up	30	ug/m2	2.0	70	38	19.8	25.4	0.2	179.1			5632.8	3894.2	45.2	179.1	9751.5	
6	D2-006	Plate	Up	15	ug/m2	2.0	70	38	22.9	98.6	8.0	371.1			543.4	1174.4	121.5	371.1	2218.4	
6	U2-006	Plate	Down	15	ug/m2	2.0	70	38	4.7	96.8	1.2	36.3			1295.6	864.6	101.5	36.3	2299.2	
6	D1-006	Plate	Up	5	ug/m2	2.0	70	38	101.0	1246.3	3800.3	44.6			125.0	570.8	1347.3	44.6	5888.0	Captured 65 um coal particle
7	D3-007	Plate	Down	30	ug/m2	0.8	29	46	10.9	4.6	5.5	24.9			10.6	423.1	15.5	24.9	479.6	
7	D2-007	Plate	Down	15	ug/m2	0.8	29	46	2.4	39.7	1.6	896.9			8.4	752.5	42.1	896.9	1701.5	
7	U2-007	Plate	Up	15	ug/m2	0.8	29	46	1.6	16.2	3.4	108.9			33.8	620.6	17.8	108.9	784.5	
7	D1-007	Plate	Down	5	ug/m2	0.8	29	46	8.5	2.6	0.1	3206.2			171.4	5171.9	11.1	3206.2	8560.7	
12	D3-012	Plate	Down	30	ug/m2	2.0	49	37	71.8	73.8	3.3	72.0			163.6	1560.2	145.6	72.0	1944.7	
12	D2-012	Plate	Down	15	ug/m2	2.0	49	37	933	17.7	1.3	146.8			730.0	1034.2	950.7	146.8	2863.0	Captured 56 um coal particle
12	D1-012	Plate	Down	5	ug/m2	2.0	49	37	426.5		94.2	43.4	4269.5		430.0	3079.4	426.5	4312.9	8343.0	
13	D3-013	Plate	Up	30	ug/m2	1.0	89	44	41.5	106.7	5.3	572.6			354.2	1259.4	148.2	572.6	2339.7	
13	D2-013	Plate	Up	15	ug/m2	1.0	89	44	13.8	120.5	11.3	168.3			59.4	22327.3	134.3	168.3	22700.6	
13	U2-013	Plate	Down	15	ug/m2	1.0	89	44	44.7	75.6	1.1	96.6				1655.8	120.3	96.6	1873.8	
13	D1-013	Plate	Up	5	ug/m2	1.0	89	44	652.2	88.8	1.5	58.5		24.4	887.2	2330.2	741.0	58.5	4042.8	Captured 58 um coal particle
14	D3-014	Plate	Parallel	30	ug/m2	2.0	49	38	1.7	59.0	0.4	51.4			106.4	715.4	60.7	51.4	934.3	
14	D2-014	Plate	Parallel	15	ug/m2	2.0	49	38	8.4	8.1	4.3	282.5			80.6	706.3	16.5	282.5	1090.2	
14	U2-014	Plate	Parallel	15	ug/m2	2.0	49	38	21.3	4.0	7.1	4.3			1561.2	2471.2	25.3	4.3	4069.1	
14	D1-014	Plate	Parallel	5	ug/m2	2.0	49	38	35.8	0.5	0.8	177.5			1270.4	508.7	36.3	177.5	1993.7	
15	D3-015	Plate	Parallel	30	ug/m2	1.5	54	41	31.5	6.8	0.1	2859.4			90.8	196.9	38.3	2859.4	3185.5	
15	D2-015	Plate	Parallel	15	ug/m2	1.5	54	41	49.1	7.7	122.5	74.8			14.4	864.6	56.8	74.8	1133.1	
15	U2-015	Plate	Parallel	15	ug/m2	1.5	54	41	30.6	2.7	49.1	932.9	234.7		3174.8	5204.0	33.3	1167.6	9628.8	
15	D1-015	Plate	Parallel	5	ug/m2	1.5	54	41		155.9	15.9	63.4			2814.2	433.7	155.9	63.4	3483.1	

Deposition Plate Results in μg/m^2 (continued)

Position: Down=Downwind, Up=Upwind, Parallel=Wind along tracks | Dist = Distance from tracks

Sample Set	Sample ID	Type	Position	Dist (m)	Units	WS (m/s)	RH (%)	Train Speed (mph)	Angular Coal-like	Rounded Coal-like	Unidentified Opaque	Iron Oxide	Iron Oxide Cluster	Soot-like-Aciniform	Quartz	Other Minerals	Total Coal	Total Iron Oxide	Total	Comment
18	D3-018	Plate	Up	30	ug/m2	0.9	87	43			18.2	70.8				545.6	0	70.8	634.6	
18	D2-018	Plate	Up	15	ug/m2	0.9	87	43		2233.5	322.3	18.2	10.6			221.7	2233.5	28.8	2806.3	One single large coal particle (89 um)
18	U2-018	Plate	Down	15	ug/m2	0.9	87	43	15.5	6918.9	15.7	960.9			4481.4	108.3	6934.4	960.9	12500.7	Captured 97 um coal particle
18	D1-018	Plate	Up	5	ug/m2	0.9	87	43	1305.2	94.7	6.2	18414.5			4202.6	4664.8	1399.9	18414.5	28688.0	
21	D3-021	Plate	Up	30	ug/m2	0.9	97	43	11.7		7.8	2.2			812.8	7392.1	11.7	2.2	8226.6	
21	D2-021	Plate	Up	15	ug/m2	0.9	97	43	8.7	8.3	9.4	3496.9		0.3		5833.5	17.0	3496.9	9357.1	
21	U2-021	Plate	Down	15	ug/m2	0.9	97	43	1409.3	75.5	1.2	10.2			1042.6	2716.9	1484.8	10.2	5255.7	Captured 72 um coal particle
21	D1-021	Plate	Up	5	ug/m2	0.9	97	43	40.3	0.5	0.3	4200.0				3441.2	40.8	4200.0	7682.3	
22	D3-022	Plate	Up	30	ug/m2	1.3	97	40	15.0	61.7	0.8	3679.4		0.8	1116.8	2297.5	76.7	3679.4	7172.0	
22	D2-022	Plate	Up	15	ug/m2	1.3	97	40	41.1	14.6	296.6	936.0	16.6		1665.6	7458.5	55.7	952.6	10429.0	
22	U2-022	Plate	Down	15	ug/m2	1.3	97	40	0.2	378.9	1.8	66.2			4.6	19533.7	379.1	66.2	19985.4	
22	D1-022	Plate	Up	5	ug/m2	1.3	97	40	22.1	9.5	2.6	170.5			728.0	3695.2	31.6	170.5	4627.9	
24	D1-024	Plate	Parallel	5	ug/m2	1.2	83	48	34.1	12.8		547.7			14.8	1871.5	46.9	547.7	2480.9	
24	D1-024b	Plate	Parallel	5	ug/m2	1.2	83	48	63.1	1.0	0.5	153.2	1.8		105.6	497.1	64.1	155.0	822.3	Captured 58 um coal particle
24	D1-024c	Plate	Parallel	5	ug/m2	1.2	83	48		44.9	5.5	158.2				577.1	44.9	158.2	785.7	
24	U1-024	Plate	Parallel	5	ug/m2	1.2	83	48	4.6	0.9		142.2			96.0	1713.8	5.5	142.2	1957.5	
24	U1-024b	Plate	Parallel	5	ug/m2	1.2	83	48			5.5	71.7			47.6	6478.1	0	71.7	6602.9	
25	D1-025	Plate	Up	5	ug/m2	2.5	87	43	20.4	2.3	145.5	11.7			762.4	1481.9	22.7	11.7	2424.2	
25	D1-025b	Plate	Up	5	ug/m2	2.5	87	43	3.3	6.3	2.0	423.7			168.6	4166.7	9.6	423.7	4770.6	
25	D1-025c	Plate	Up	5	ug/m2	2.5	87	43	60.8	29.8	2.8	42.5			2.0	3572.7	90.6	42.5	3710.6	
25	U1-025	Plate	Down	5	ug/m2	2.5	87	43	2165.1	425.8	0.4	5514.2			405.6	253.3	2590.9	5514.2	8764.4	Captured 84 um coal particle
25	U1-025b	Plate	Down	5	ug/m2	2.5	87	43	3	56.4	0.1	252.9			4.4	458.8	59.4	252.9	775.6	
26	D1-026 A	Plate	Blank	5	ug/m2						3.1	121.5				731.5	0	121.5	856.1	
26	D1-026 B	Plate	Blank	5	ug/m2						3.0					120.4	0	0.0	123.4	
26	D1-026 C	Plate	Blank	5	ug/m2						2.5	49.8				154.0	0	49.8	206.3	
26	U1-026	Plate	Blank	5	ug/m2						1723.8	7596.3			10059.4	9247.7	0	7596.3	28627.2	
26	U1-026 b	Plate	Blank	5	ug/m2						66.3	14.2			1563.4	1228.5	0	14.2	2872.4	
	Water Blank		Water Blank		ug/m2					0.3	3.7	2.5				478.5	0.3	2.5	485.0	

Deposition Plate Results in particles/m^2

Position: Down=Downwind, Up=Upwind, Parallel=Wind along tracks

Dist = Distance from tracks

Sample Set	Sample ID	Type	Position	Dist (m)	Units	WS (m/s)	RH (%)	Train Speed (mph)	Angular Coal-like	Rounded Coal-like	Unidentified Opaque	Iron Oxide	Iron Oxide Cluster	Soot-like-Aciniform	Quartz	Other Minerals	Total Coal	Total Iron Oxide	Total	Comment
1	D3-001	Plate	Up	30	P/m2	0.3	75	40	32625.8	20391.1	4078.2	12234.7				134581.6	53017	12235	203912	
1	D2-001	Plate	Up	15	P/m2	0.3	75	40	45572.6	51269.2	22786.3	11393.2			5696.6	148111.0	96842	11393	284829	
1	U2-001	Plate	Down	15	P/m2	0.3	75	40	52950.1	29416.7	29416.7	17650.0				164733.7	82367	17650	294167	
1	D1-001	Plate	Up	5	P/m2	0.3	75	40	44073.5	18888.6	12592.4	31481.1			18888.6	188886.4	62962	31481	314811	
3	D3-003	Plate	Down	30	P/m2	1.0	56	53	25122	25122	14355	28711			7178	39477	50244	28711	139965	
3	D2-003	Plate	Down	15	P/m2	1.0	56	53	26782	16069	16069	32139			16069	160694	42851	32139	267822	
3	U2-003	Plate	Up	15	P/m2	1.0	56	53	22786	51269	11393	22786			22786	153808	74055	22786	284828	
3	D1-003	Plate	Down	5	P/m2	1.0	56	53	14355	7178		10767			10767	50244	21533	10767	93311	
6	D3-006	Plate	Up	30	P/m2	2.0	70	38	9832	24581	9832	29497			29497	142570	34414	29497	245811	
6	D2-006	Plate	Up	15	P/m2	2.0	70	38	40438	50547	10109	15164			5055	131422	90985	15164	252735	
6	U2-006	Plate	Down	15	P/m2	2.0	70	38	39151	52201	19576	32626			19576	163129	91352	32626	326258	
6	D1-006	Plate	Up	5	P/m2	2.0	70	38	79752	53168	26584	46522			6646	119628	132920	46522	332300	
7	D3-007	Plate	Down	30	P/m2	0.8	29	46	14355	17944	14355	10767			14355	107665	32299	10767	179441	
7	D2-007	Plate	Down	15	P/m2	0.8	29	46	7178	10767	3589	10767			3589	82543	17945	10767	118433	
7	U2-007	Plate	Up	15	P/m2	0.8	29	46	14355	3589	14355	25122			3589	111254	17944	25122	172264	
7	D1-007	Plate	Down	5	P/m2	0.8	29	46	13803	18404	4601	27606			23005	142633	32207	27606	230052	
12	D3-012	Plate	Down	30	P/m2	2.0	49	37	4687	14062	23437	18750			9375	149999	18749	18750	220310	
12	D2-012	Plate	Down	15	P/m2	2.0	49	37	68723	76358	45815	45815			7636	137445	145081	45815	381792	
12	D1-012	Plate	Down	5	P/m2	2.0	49	37	33967		81521	27174	13587		20380	163042	33967	40761	339671	
13	D3-013	Plate	Up	30	P/m2	1.0	89	44	61087	45815	15272	38179			38179	183260	106901.7	38179	381791.8	
13	D2-013	Plate	Up	15	P/m2	1.0	89	44	50547	15164	25274	35383			5055	121313	65711	35383	252735	
13	U2-013	Plate	Down	15	P/m2	1.0	89	44	35888	59814	17944	29907				155517	95702	29907	299070	
13	D1-013	Plate	Up	5	P/m2	1.0	89	44	43648	24249	19399	33949		9700	9700	101846	67897	33949	242489	
14	D3-014	Plate	Parallel	30	P/m2	2.0	49	38	11215	16823	11215	28038			39253	173835	28038	28038	280379	
14	D2-014	Plate	Parallel	15	P/m2	2.0	49	38	41183	11767	11767	23533			29417	176500	52950	23533	294167	
14	U2-014	Plate	Parallel	15	P/m2	2.0	49	38	41410	18404	18404	18404			13803	124229	59814	18404	234654	
14	D1-014	Plate	Parallel	5	P/m2	2.0	49	38	34508	6902	13803	34508			34508	220852	41410	34508	345081	
15	D3-015	Plate	Parallel	30	P/m2	1.5	54	41	4934	4934	4934	49342			9868	172696	9868	49342	246708	
15	D2-015	Plate	Parallel	15	P/m2	1.5	54	41	9375	14062	46875	18750			9375	107812	23437	18750	206249	
15	U2-015	Plate	Parallel	15	P/m2	1.5	54	41	14062	14062	42187	28125	9375		18750	107812	28125	37500	234373	
15	D1-015	Plate	Parallel	5	P/m2	1.5	54	41		18750	23437	18750			14062	121874	18750	18750	196873	

Deposition Plate Results in particles/m^2 (continued)

Position: Down=Downwind, Up=Upwind, Parallel=Wind along tracks

Dist = Distance from tracks

Sample Set	Sample ID	Type	Position	Dist (m)	Units	WS (m/s)	RH (%)	Train Speed (mph)	Angular Coal-like	Rounded Coal-like	Unidentified Opaque	Iron Oxide	Iron Oxide Cluster	Soot-like-Aciniform	Quartz	Other Minerals	Total Coal	Total Iron Oxide	Total	Comment
18	D3-018	Plate	Up	30	P/m2	0.9	87	43			51448	40015				194358	0	40015	285821	
18	D2-018	Plate	Up	15	P/m2	0.9	87	43		4687	56250	14062	4687			126562	4687	18749	206248	
18	U2-018	Plate	Down	15	P/m2	0.9	87	43	71777	123046	20508	82031			41015	174315	194823	82031	512692	
18	D1-018	Plate	Up	5	P/m2	0.9	87	43	81565	130503	48939	130503			97878	326258	212068	130503	815646	
21	D3-021	Plate	Up	30	P/m2	0.9	97	43	45492		10109	20219			5055	171860	45492	20219	252735	
21	D2-021	Plate	Up	15	P/m2	0.9	97	43	41183	17650	17650	29417		5883		182384	58833	29417	294167	
21	U2-021	Plate	Down	15	P/m2	0.9	97	43	66256	22085	11043	22085			16564	138032	88341	22085	276065	
21	D1-021	Plate	Up	5	P/m2	0.9	97	43	33128	11043	22085	44170				165639	44170	44170	276065	
22	D3-022	Plate	Up	30	P/m2	1.3	97	40	35185	49259	7037	56296		7037	28148	168887	84443	56296	351847	
22	D2-022	Plate	Up	15	P/m2	1.3	97	40	52012	36409	15604	20805	5201		5201	124829	88421	26006	260061	
22	U2-022	Plate	Down	15	P/m2	1.3	97	40	9444	51944	9444	14167			4722	146387	61388	14167	236108	
22	D1-022	Plate	Up	5	P/m2	1.3	97	40	17650	23533	11767	5883			23533	211801	41183	5883	294167	
24	D1-024	Plate	Parallel	5	P/m2	1.2	83	48	39876	35445		44307			8861	88613	75321	44307	217102	
24	D1-024b	Plate	Parallel	5	P/m2	1.2	83	48	67921	16823	16823	112151	5608		5608	50468	84744	117759	275402	
24	D1-024c	Plate	Parallel	5	P/m2	1.2	83	48		14062	9375	18750				56250	14062	18750	98437	
24	U1-024	Plate	Parallel	5	P/m2	1.2	83	48	28711	10767		3589			7178	71777	39478	3589	122022	
24	U1-024b	Plate	Parallel	5	P/m2	1.2	83	48			4687	14062			9375	107812	0	14062	135936	
	Water Blank		Water Blank		P/m2					3589	10767	3589				32300	3589	3589	50245	
25	D1-025	Plate	Up	5	P/m2	2.5	87	43	78302	45676	78302	19576			26101	78302	123978	19576	326259	
25	D1-025b	Plate	Up	5	P/m2	2.5	87	43	36809	50612	36809	32208			13803	59814	87421	32208	230055	
25	D1-025c	Plate	Up	5	P/m2	2.5	87	43	75918	89721	55213	20705			6902	96623	165639	20705	345082	
25	U1-025	Plate	Down	5	P/m2	2.5	87	43	58995	44246	9832	29497			14749	88492	103241	29497	245811	
25	U1-025b	Plate	Down	5	P/m2	2.5	87	43	35888	17944	4486	94207			13458	58319	53832	94207	224302	
26	D1-026 A	Plate	Blank	5	P/m2						18750	28125				93749	0	28125	140624	
26	D1-026 B	Plate	Blank	5	P/m2						28125					79687	0	0	107812	
26	D1-026 C	Plate	Blank	5	P/m2						18750	28125				117187	0	28125	164062	
26	U1-026	Plate	Blank	5	P/m2						74013	24671			98684	419405	0	24671	616773	
26	U1-026 b	Plate	Blank	5	P/m2						28125	4687			4687	126562	0	4687	164061	

Appendix B

Sample EAA Analytical Report – Optical Microscopy

Optical Microscopy Air Sample - Summary Report

Air-O-Cell CSI Cassette - Size Range - Particles >3.0um

Client Name :	T& B Systems	Analysis Date :	2/2/15
Contact :	Mr. Bob Baxter	EAA Project # :	14-0402
Client Project# :	4300	EAA Sample # :	U4-006
Client Sample # :	U4-006		
Sample Description :	Not specified	Fields Counted / passes :	2
Analysis Method :	Bright Field/Polarized Light Microscopy	Field area cted (mm^2) :	0.640
Analysis Magnifcation :	600	Field area (mm^2) :	15.0
Scale (µm/div.) :	3	% of sample counted :	4%
Total particles counted :	49	Particles / mm^2 :	77
Sample volume (m^3) :	0.047	Particles / sample :	1148
		Estimated Particles / m^3 :	24435

Particle Classification	Part. Cted	Mean (um)	Num. %	* Mass %	* S.G.	Particles / Sample	Particles / m^3	Mass ug/m^3
Angular Coal-like	7	5.7	14.3%	7.3%	1.3	164	3491	0.43
Rounded Coal-like	13	6.9	26.5%	25.0%	1.3	305	6483	1.47
Unidentified opaque	5	4.9	10.2%	3.1%	1.0	117	2493	0.15
Iron oxide	9	4.6	18.4%	18.3%	4.0	211	4488	0.91
Iron oxide cluster	2	7.9	4.1%	7.5%	3.0	47	997	0.76
Soot-like-Aciniform	3	16.0	6.1%	21.2%	1.0	70	1496	3.22
Quartz								
Other Minerals	10	5.3	20.4%	17.7%	2.5	234	4987	0.99
Total counted :	49					Total particle mass (ug/m^3) :		7.9

** The calculated mass/m^3 is based on estimates of the average particle size & specific gravity (S.G.) and should be used as a rough comparative estimates.*

Definitions

Angular Coal-like : Angular brown/orange particles with uniform interior texture and edges consistent with a coal standard.

Rounded Coal-like : Rounded brown/orange particles with uniform interior texture consistent with a coal standard

Iron oxide : Brown to orange tinged individual particles with irregular and pitted morphology consistent with corrosion.

Iron Oxide -" cluster" : Clusters of brown to orange tinged particles with irregular and pitted morphology consistent with corrosion. Clusters include an assemblage of imacted particles of similar composition. The size is estimated as the diameter of the entire cluster.

Soot-like aciniform : Black fine particles with "aciniform" morphology consistent with vehicular diesel emissions.

Quartz : Particles with optical polarized light characteristics of the mineral quartz.

Other minerals : All other crystalline and non-crystalline translucent particles.

Analysis Method : Bright Field/Polarized Light Microscopy

Analyst : Daniel M. Baxter   Date : 2/2/15

NUMERICAL SIZE DISTRIBUTION ANALYSIS

(Optical Microscopy - Total Sample Statistics)

Client Name: T& B Systems
Contact : Mr. Bob Baxter
Client Project# : 4300
Client Sample # : U4-006
Sample Description : Not specified
Analysis Method : Bright Field/Polarized Light Microscopy
Analysis Magnifcation : 600
Scale (µm/div.) : 3.00
Total particles counted : 49 Particles/mm^2 : 77

Analysis Date : 2/2/15
EAA Project # : 14-0402
EAA Sample # : U4-006

SIZE DISTRIBUTION STATISTICS				MORPHOLOGY STATISTICS (all particles)			
Description	**Mean**	Std.Dev.	95%CL	**Description**	**Mean**	Std.Dev.	95%CL
Arith. Mean Aerodynamic Dia.(µm)	6.4	±4.8	±1.3	Aspect Ratio	1.3	±0.44	±0.12
Arith. Mean Projected Dia.(µm)	6.2	±4.5	±1.3	Particle Sphericity	0.9	±0.09	±0.02
Median aerodynamic dia.(µm)	4.8			Particle counts / mm^2	38		
Numerical Mode (size category)	1.6			Field area counted (mm^2)	1.2800		
Skewness	3.0			Estimated particle area (mm^2)	0.00030		
Kurtosis	12.1			Area covered by particles (%)	0.0%		

Numerical Size Distribution (µm >= aerodynamic stated size)

Particle Size (µm)	**>=0.2**	**>=0.4**	**>=0.8**	**>=1.6**	**>=3.1**	**>=6**	**>=13**	**>=25**	**>=50**	**>=100**	**>=200**
Midpoint size (µm)	0.3	0.6	1.2	2	5	9	19	38	75	150	>=200
Cumulative Count	49	49	49	49	31	16	3	1			
Individual Count				18	15	13	2	1			
Individual Numerical %				36.7%	30.6%	26.5%	4.1%	2.0%			
Cumulative Numerical %				36.7%	67.3%	94%	98%	100%			

*** **Estimated Aerodynamic Mass (Volume) Distribution**

Particle Size (µm)	**>=0.2**	**>=0.4**	**>=0.8**	**>=1.6**	**>=3.1**	**>=6**	**>=13**	**>=25**	**>=50**	**>=100**	**>=200**
Individual Volume %				5.7%	15.1%	34.5%	17.1%	27.6%			
Cumulative Volume %				5.7%	20.9%	55%	72%	100%			

* All numerical size distribution statistics are based on the estimated arithmetic mean diameter.
** The largest size category is reported in bimodal distributions.
*** The estimated mass distribution is based on particle volume in each size catagory, and uses an estimate of particle specific gravity.

Statistical Parameter Definitions:

Geometric Aerodynamic Diameter	Geometric mean of feret length, width, and approximate thickness using the sphericity coefficient.
Geometric Projected Diameter	Geometric mean of particle size based on length and width and not accounting for particle thickness.
Median	Number in the middle of a distribution; that is, half the values are greater than the median, and half the values below.
Mode	Most frequently occurring size category/range in a size distribution
Skewness	Degree of symmetry of a population around its mean. Positive skewness indicates a distribution with an asymmetric tail towards more positive values. Negative skewness indicates an asymmetric tail towards more negative values.
Kurtosis	Relative peakedness or flatness of a distribution compared to the normal distribution. Positive kurtosis indicates a relatively peaked distribution. Negative kurtosis indicates a relatively flat distribution.
95% C.L.	95% Confidence Limit (i.e. probability that 95% of time the mean value will fall within the specified size range).
Aspect Ratio	Ratio of the particle longest projected length divided by the particle width
Particle Sphericity	Measure of effective particle size based on the formula (thickness ^2 / (length*width))^0.333
Roundness	Measure of the shape or irregularity of the particle = 0.07948*(perimeter)^2/area. Higher values indicate more angularity
Surface area covered	Theoretical percent area occupied by particles (projected particle area / total area examined)

Analyst : Daniel M. Baxter Date : 2/2/15

COMPOSITION SIZE & MASS DISTRIBUTION ANALYSIS
(Report Detail)

Client Name :	T& B Systems	Analysis Date :	02/02/15
Contact :	Mr. Bob Baxter	EAA Project # :	14-0402
Client Project# :	4300	EAA Sample # :	U4-006
Client Sample # :	14-0402	Scale (µm/div.) :	3.00
Sample Description :	U4-006	Total particles counted :	49
Analysis Method :	Bright Field/Polarized Light Microscopy		
Total particles counted :	49		
Analysis Magnifcation :	600		

Mineral Category	Numerical Count	Individual Count % >= stated aerodynamic size(µm) >=0.2	>=0.4	>=0.8	>=1.6	>=3.1	>=6	>=13	>=25	>=50	>=100	>=200
Angular Coal-like	7				4.1%	6.1%	4.1%					
Rounded Coal-like	13				14.3%	2.0%	6.1%	4.1%				
Unidentified opaque	5				4.1%	4.1%	2.0%					
Iron oxide	9				8.2%	8.2%	2.0%					
Iron oxide cluster	2						4.1%					
Soot-like-Aciniform	3						4.1%		2.0%			
Quartz												
Other Minerals	10				6.1%	10.2%	4.1%					

Mineral Category	Category Code	Count %	* Estimated Mass %	Mean Size (µm)	Aspect Ratio	Roundness Mean	>3.13	<3.13
Angular Coal-like	ac	14.3%	7.3%	5.7	1.21	3.58	4.14	2.18
Rounded Coal-like	rc	26.5%	25.0%	6.9	1.29	2.42	2.02	2.77
Unidentified opaque	i	10.2%	3.1%	4.9	1.40	2.04	2.21	1.80
Iron oxide	or	18.4%	18.3%	4.6	1.28	1.82	2.21	2.15
Iron oxide cluster	oc	4.1%	7.5%	7.9	1.50	2.06	2.06	
Soot-like-Aciniform	sl	6.1%	21.2%	16.0	1.24	1.38	1.38	
Quartz	q							
Other Minerals	m	20.4%	17.7%	5.3	1.25	2.50	2.72	1.98

INDIVIDUAL SIZE DISTRIBUTION COUNT DATA

Client Name: T& B Systems
Client Project# : 4300
EAA Project # : 14-0402

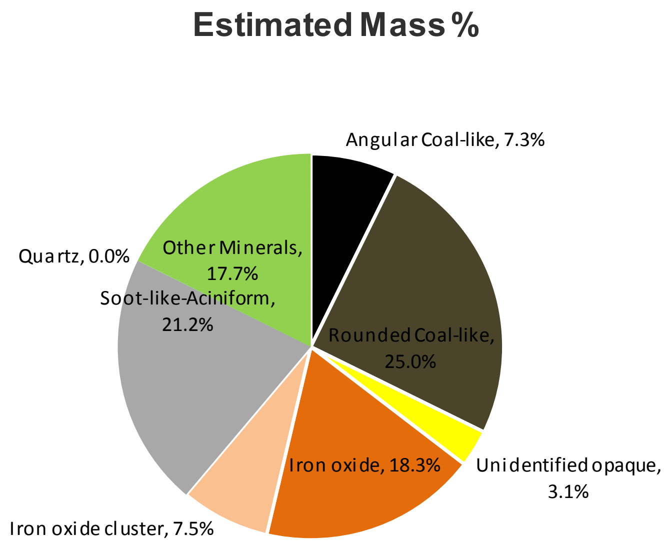
Client Sample # : U4-006
EAA Sample # : U4-006

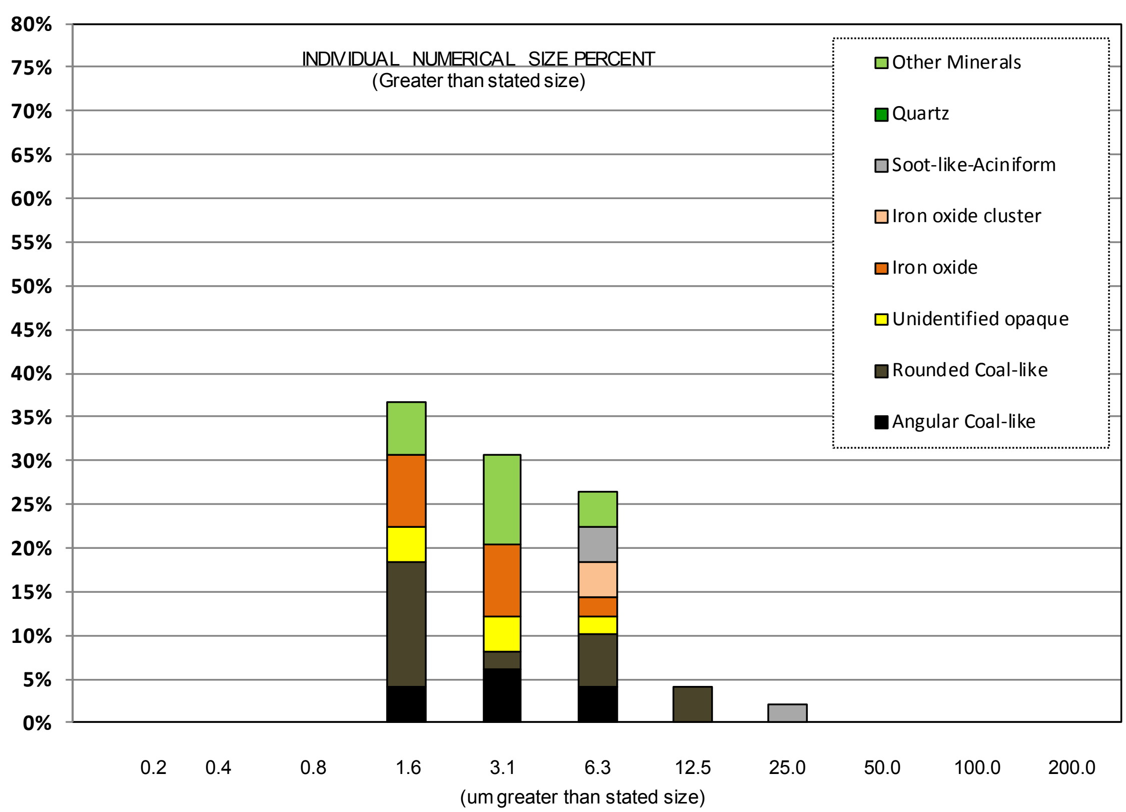
Particle Number	Particle Type	L feret (µm)	I feret (µm)	Proj. L (µm)	Thickness est. (µm)	Projected Dia.(µm)	Mean Dia.(µm)	Aspect Ratio	Round Coeff.	Particle Sphericity
1	m	3.0	3.0	3.0	3.0	3.0	3.0	1.00	1.28	1.0
2	i	3.0	3.0	3.0	3.0	3.0	3.0	1.00	2.52	1.0
3	ac	6.0	6.0	6.0	6.0	6.0	6.0	1.00	6.65	1.0
4	rc	3.0	3.0	3.0	3.0	3.0	3.0	1.00	1.39	1.0
5	rc	9.0	9.0	9.0	9.0	9.0	9.0	1.00	3.73	1.0
6	m	6.0	3.0	6.0	3.0	4.5	4.8	2.00	5.07	0.8
7	m	6.0	6.0	6.0	6.0	6.0	6.0	1.00	1.88	1.0
8	rc	24.0	9.0	24.0	9.0	16.5	17.3	2.67	1.64	0.7
9	or	6.0	6.0	6.0	6.0	6.0	6.0	1.00	1.22	1.0
10	or	3.0	3.0	3.0	3.0	3.0	3.0	1.00	0.99	1.0
11	sl	36.0	21.0	36.0	21.0	28.5	30.1	1.71	1.15	0.8
12	or	6.0	3.0	6.0	3.0	4.5	4.8	2.00	0.97	0.8
13	oc	9.0	6.0	9.0	6.0	7.5	7.9	1.50	2.19	0.9
14	rc	3.0	3.0	3.0	3.0	3.0	3.0	1.00	3.83	1.0
15	rc	3.0	1.5	3.0	1.5	2.3	2.4	2.00	6.18	0.8
16	rc	9.0	9.0	9.0	9.0	9.0	9.0	1.00	1.46	1.0
17	i	9.0	9.0	9.0	9.0	9.0	9.0	1.00	1.28	1.0
18	rc	21.0	12.0	21.0	12.0	16.5	17.4	1.75	2.26	0.8
19	or	3.0	3.0	3.0	3.0	3.0	3.0	1.00	3.36	1.0
20	rc	6.0	6.0	6.0	6.0	6.0	6.0	1.00	1.32	1.0
21	rc	3.0	3.0	3.0	3.0	3.0	3.0	1.00	1.45	1.0
22	ac	6.0	6.0	6.0	6.0	6.0	6.0	1.00	2.88	1.0
23	or	3.0	3.0	3.0	3.0	3.0	3.0	1.00	1.54	1.0
24	or	3.0	3.0	3.0	3.0	3.0	3.0	1.00	2.71	1.0
25	rc	12.0	9.0	12.0	9.0	10.5	10.9	1.33	1.69	0.9
26	i	6.0	3.0	6.0	3.0	4.5	4.8	2.00	3.68	0.8
27	ac	3.0	3.0	3.0	3.0	3.0	3.0	1.00	3.48	1.0
28	ac	3.0	3.0	3.0	3.0	3.0	3.0	1.00	0.87	1.0
29	ac	9.0	9.0	9.0	9.0	9.0	9.0	1.00	5.64	1.0
30	ac	9.0	6.0	9.0	6.0	7.5	7.9	1.50	2.15	0.9
31	sl	9.0	9.0	9.0	9.0	9.0	9.0	1.00	1.63	1.0
32	m	6.0	6.0	6.0	6.0	6.0	6.0	1.00	1.30	1.0
33	m	6.0	3.0	6.0	3.0	4.5	4.8	2.00	2.40	0.8
34	or	9.0	6.0	9.0	6.0	7.5	7.9	1.50	3.30	0.9
35	i	6.0	3.0	6.0	3.0	4.5	4.8	2.00	1.66	0.8
36	or	6.0	6.0	6.0	6.0	6.0	6.0	1.00	1.38	1.0
37	or	6.0	3.0	6.0	3.0	4.5	4.8	2.00	0.95	0.8
38	rc	3.0	3.0	3.0	3.0	3.0	3.0	1.00	0.82	1.0
39	rc	3.0	3.0	3.0	3.0	3.0	3.0	1.00	1.71	1.0
40	m	6.0	6.0	6.0	6.0	6.0	6.0	1.00	5.53	1.0
41	m	9.0	6.0	9.0	6.0	7.5	7.9	1.50	1.81	0.9
42	rc	3.0	3.0	3.0	3.0	3.0	3.0	1.00	4.03	1.0
43	sl	9.0	9.0	9.0	9.0	9.0	9.0	1.00	1.35	1.0
44	m	9.0	9.0	9.0	9.0	9.0	9.0	1.00	1.08	1.0
45	m	3.0	3.0	3.0	3.0	3.0	3.0	1.00	2.70	1.0
46	oc	9.0	6.0	9.0	6.0	7.5	7.9	1.50	1.92	0.9
47	m	3.0	3.0	3.0	3.0	3.0	3.0	1.00	1.96	1.0
48	ac	6.0	3.0	6.0	3.0	4.5	4.8	2.00	3.40	0.8
49	i	3.0	3.0	3.0	3.0	3.0	3.0	1.00	1.08	1.0
50										

Optical Microscopy -Grapical Report - Mass & Size Distribution

Client Name : T& B Systems
Contact : Mr. Bob Baxter
Client Project# : 4300
Client Sample # : U4-006
Sample Description : Not specified
Analysis Method : Bright Field/Polarized Light Microscopy

Analysis Date : 2/2/15
EAA Project # : 14-0402
EAA Sample # : U4-006





Millennium Bulk Terminals—Longview SEPA Environmental Impact Statement

SEPA Greenhouse Gas Emissions Technical Report

Prepared for:

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April 2016

ICF International. 2016. *Millennium Bulk Terminals—Longview, SEPA Environmental Impact Statement, SEPA Greenhouse Gas Emissions Technical Report.* April. (ICF 00264.13.) Seattle, WA. Prepared for Cowlitz County, Kelso, WA, in cooperation with Washington State Department of Ecology, Southwest Region.

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Acronyms and Abbreviations

°F	degrees Fahrenheit
Applicant	Millennium Bulk Terminals—Longview, LLC
BNSF	BNSF Railway Company
Btu	British thermal unit
CARB	California Air Resources Board
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COLE	Carbon Online Estimator
eGRID	Emissions & Generation Resource Integrated Database
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FR	Federal Register
GHG	greenhouse gas
GWP	global warming potential
hp	horsepower
$kgCO_2e$	kilograms of carbon dioxide equivalent
kg CO_2e/MWh	kilograms of carbon dioxide equivalent per megawatt hour
LVSW	Longview Switching Company
MMBtu	million British thermal units
$MMTCO_2e$	million metric tons of carbon dioxide equivalent
$MtCO_2e$	metric tons of carbon dioxide equivalent
NEPA	National Environmental Policy Act
PUD	Public Utility District
RCW	Revised Code of Washington
SEPA	Washington State Environmental Policy Act
UP	United Pacific Railroad
USC	United States Code
WAC	Washington Administrative Code

Chapter 1
Introduction

This technical report assesses the potential greenhouse gas (GHG) emissions impacts of the proposed Millennium Bulk Terminals—Longview project (Proposed Action) and No-Action Alternative. For the purposes of this assessment, GHG emissions include the emissions from construction and operation of the Proposed Action as well as the indirect, market-influenced transportation and end-use fossil fuel combustion emissions from operations. This report describes the regulatory setting, establishes the method for assessing potential GHG emissions impacts, presents the historical and current GHG conditions in the study area, and assesses potential impacts from GHG emissions.

1.1 Project Description

Millennium Bulk Terminals—Longview, LLC (Applicant) proposes to construct and operate a coal export terminal in Cowlitz County, Washington, along the Columbia River (Figure 1). The coal export terminal would receive coal from the Powder River Basin in Montana and Wyoming and the Uinta Basin in Utah and Colorado via rail, then load and transport the coal by ocean-going ships via the Columbia River and Pacific Ocean to overseas markets in Asia. The coal export terminal would be capable of receiving, stockpiling, blending, and loading coal by conveyor onto ships for export. Construction of the coal export terminal would begin in 2018. For the purpose of this analysis, it is assumed the coal export terminal would operate at full capacity in 2028.

The following subsections present a summary of the Proposed Action and No-Action Alternative. For detailed information on these alternatives, see the Washington State Environmental Policy Act (SEPA) Alternatives Technical Report (ICF International 2016).

1.1.1 Proposed Action

The Proposed Action would develop a coal export terminal on 190 acres (project area). The project area is located within an existing 540-acre area currently leased by the Applicant at the former Reynolds Metals Company facility, and land currently owned by Bonneville Power Administration. The project area is adjacent to the Columbia River in unincorporated Cowlitz County, Washington near Longview city limits (Figure 2).

The Applicant currently and separately operates, and would continue to separately operate, a bulk product terminal on land leased by the Applicant. Industrial Way (State Route 432) provides vehicular access to the Applicant's leased land. The Reynolds Lead and the BNSF Spur, both operated by Longview Switching Company,[1] provide rail access to the Applicant's leased area from a point on the BNSF Railway Company (BNSF) main line (Longview Junction, Washington) located to the east in Kelso, Washington. Ships access the Applicant's leased area via the Columbia River and berth at an existing dock (Dock 1) operated by the Applicant in the Columbia River.

[1] The Longview Switching Company (LVSW) is jointly owned by BNSF Railway Company (BNSF) and Union Pacific Railroad.

Figure 1. Project Vicinity

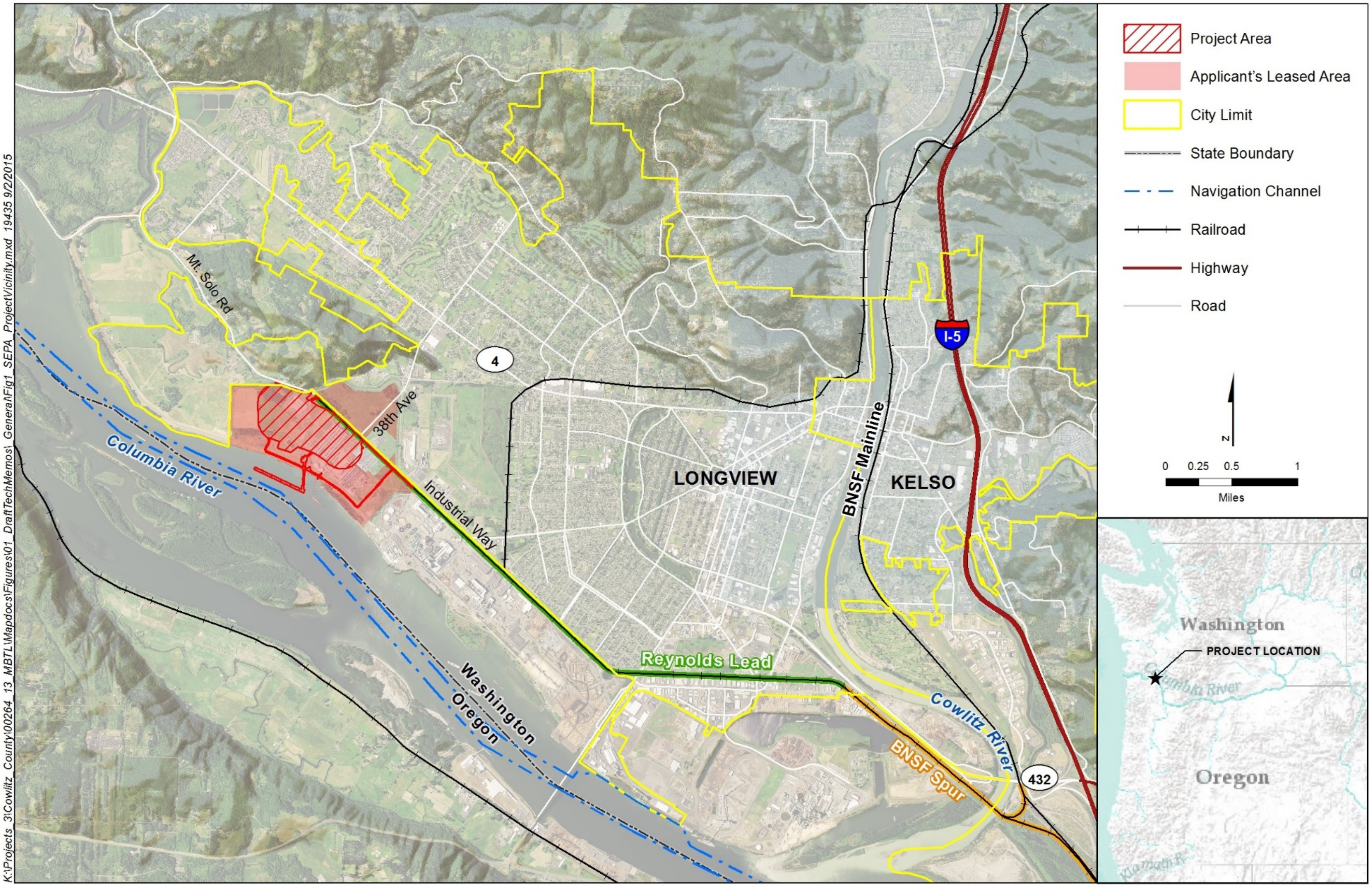
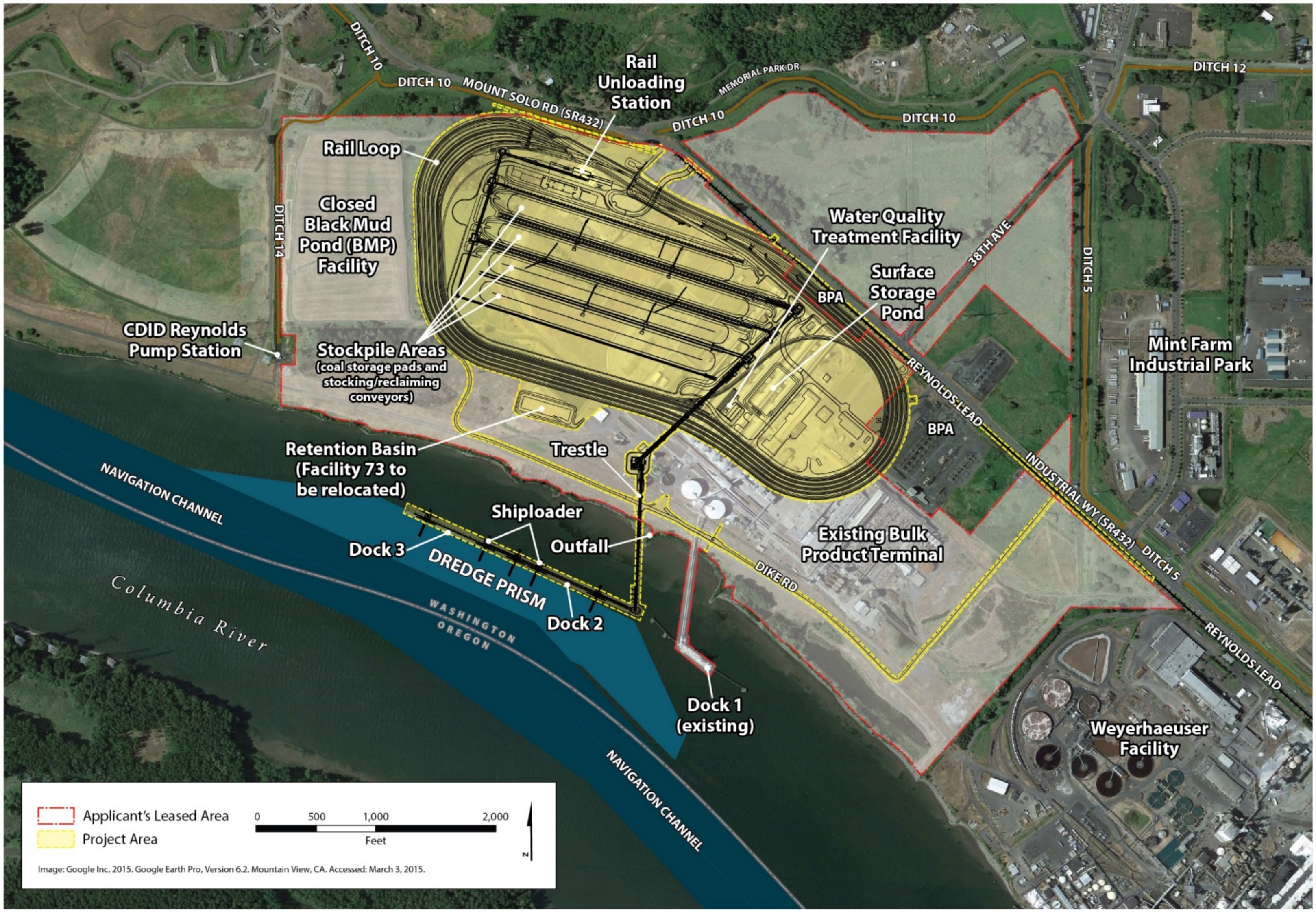


Figure 2. Proposed Action



Under the Proposed Action, BNSF or Union Pacific Railroad trains would transport coal in rail cars from the BNSF main line at Longview Junction, Washington, to the project area via the BNSF Spur and Reynolds Lead. Coal would be unloaded from rail cars, stockpiled and blended, and loaded by conveyor onto ocean-going ships at two new docks (Docks 2 and 3) on the Columbia River for export.

Once construction is complete, the Proposed Action would have an annual throughput capacity of up to 44 million metric tons.[2] The coal export terminal would consist of one operating rail track, eight rail tracks for the storage of rail cars, rail car unloading facilities, stockpile areas for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks 2 and 3), and ship-loading facilities on the two docks. Dredging of the Columbia River would be required to provide access to and from the Columbia River navigation channel and for berthing at the two new docks.

Vehicles would access the project area from Industrial Way (State Route 432). Ships would access the project area via the Columbia River and berth at one of the two new docks. Terminal operations would occur 24 hours per day, 7 days per week. The coal export terminal would be designed for a minimum 30-year period of operation.

1.1.2 No-Action Alternative

Under the No-Action Alternative, the proposed export terminal would not be constructed. Current operations of the bulk product terminal, which include the storage and transport of alumina and up to 150,000 metric tons per year of coal. Importing of alumina would continue and increase in the project area using Dock 1. The Applicant could expand the existing bulk product terminal onto the 190-acre project area, developing storage and shipment facilities to bulk product terminal operations. Coal and alumina would continue to be stored, transferred, and shipped. Additional bulk product transfers activities involving products such as calcine pet coke, coal tar pitch, cement, fly ash, and sand or gravel could also be pursued, and new or revised permits could be required. These operations would involve storage and upland transfer of bulk products, which would use existing or new buildings. Construction of new buildings could involve demolition and replacement of existing buildings and new or modified permits. Any new construction would be limited to uses allowed under existing Cowlitz County development regulations and federal and state permits.

1.2 Regulatory Setting

The jurisdictional authorities and corresponding regulations, statutes, and guidance for determining potential impacts on GHG emissions are summarized in Table 1.

[2] A metric ton is the U.S. equivalent to a tonne per the International System of Units, or 1,000 kilograms or approximately 2,204.6 pounds.

Table 1. Regulations, Statutes, and Guidance for Greenhouse Gases

Regulation, Statute, Guideline	Description
Federal	
National Environmental Policy Act (42 USC 4321 *et seq*.)	Requires the consideration of potential environmental effects. NEPA implementation procedures are set forth in the President's Council on Environmental Quality's Regulations for Implementing NEPA (49 CFR 1105).
Clean Air Act of 1963 (42 USC 7401) as amended	In 2007, the U.S. Supreme Court ruled that GHGs are air pollutants under the Clean Air Act.
The President's Climate Action Plan (2013)	Sets forth plan for cutting carbon pollution, preparing for the impacts of climate change, and leading international efforts to address climate change (Executive Office of the President 2013).
Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units	In 2015, under the Clean Power Plan, EPA set state-specific target emissions reductions to reduce CO_2 emissions in the power sector by 32% below 2005 levels by 2030 (80 FR 64661). The rate-based CO_2 emission goal for Washington state is 983 pounds of CO_2 per net MWh (80 Federal Register 64962) and the mass-based CO_2 emission goal for Washington state for the 2 year block of 2030–2031 is 21,478,344 short tons of CO_2 (80 Fedeal Register 64963) (or a final goal of 10,739,172 short tons of CO_2 (80 Federal Register 64825)). The greenhouse gas analysis uses the proposed Clean Power Plan. The final Clean Power Plan was released in August 2015, after the modeling was completed for the greenhouse gas analysis.
United States Submittal to the United Nations Framework on Climate Change	U.S. and other nations submitted Intended Nationally Determined Contribution to the United Nations in 2015.
Revised Draft Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in NEPA Reviews	The Council on Environmental Quality (CEQ) has published revised draft guidance on how NEPA analysis and documentation should address greenhouse gas emissions and the impacts of climate change.
State	
Washington State Environmental Policy Act (WAC 197-11, RCW 43.21C)	Requires state and local agencies in Washington to identify potential environmental impacts that could result from governmental decisions.
Limiting Greenhouse Gas Emissions (RCW 70.235)	Requires state to reduce overall GHG emissions as compared to a 1990 baseline and report emissions to the governor bi-annually. Specific goals include achieving 1990 GHG emissions levels by 2020; 25% below 1990 levels by 2035; and 50% below 1990 levels by 2050 or 70% below the state's expected emissions that year.

Regulation, Statute, Guideline	Description
Washington Clean Air Act (RCW 70.94)	Establishes rules regarding preservation of air quality and penalties for violations. CO_2 mitigation fees are evaluated as part of the permit required by the Clean Air Act (RCW 70.94.892) to reflect requirements from RCW 80.70. RCW 70.94.151 states that the department will be responsible for adopting rules requiring reporting of emissions defined by 70.235.010 from facility, source, site, or fossil fuel supplier that meet or exceed 10,000 metric tons of CO_2e annually.
Washington Carbon Pollution and Clean Energy Action (Executive Order 14-04, 2014)	In December 2014, Governor Inslee established the Governor's Carbon Emissions Reduction Taskforce to provide recommendations to the 2015 legislative session on the design and implementation of a carbon emissions limits and market mechanisms program for Washington State.
Washington's Leadership on Climate Change (Executive Order 09-05, 2009)	In 2009, Governor Gregoire ordered the state to assess the effectiveness of various GHG reduction strategies by estimating emissions, quantifying necessary reductions, and identifying strategies and actions that could be used to meet the 2020 target. Assessments were done across multiple sectors and sources of emissions, including industrial facilities, the electricity sector, low-carbon fuel standards, vehicle miles traveled, coal plants, and forestry.
Path to a Low-Carbon Economy: An Interim Plan to Address Washington's Greenhouse Gas Emissions (2010)	The second Climate Comprehensive Plan report to the Governor and State Legislature outlines a plan to achieve emissions reductions to 1990 levels by 2020, as required by RCW 70.235.
Local	
Cowlitz County SEPA Regulations (CCC 19.11)	Provide for the implementation of SEPA in Cowlitz County.

Notes:

[a] In 2009, EPA proposed the Endangerment Finding and the Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act. The Endangerment Findings determined that the current and projected concentrations for carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorinated chemicals, and sulfur hexafluoride posed a threat to the health and welfare of current and future generations (U.S. Environmental Protection Agency 2009). This sets the legal foundation for regulating GHG emissions from sources of these six well-known GHGs, such as vehicles, industrial facilities, and power plants.

[b] Light duty vehicles include passenger cars, light-duty trucks, and medium-duty passenger vehicles.

USC = United States Code; CFR = Code of Federal Regulations; EPA = U.S. Environmental Protection Agency; FR = *Federal Register*; GHG = greenhouse gas; CO_2 = carbon dioxide; CO_2e = carbon dioxide equivalent; WAC = Washington Administrative Code; RCW = Revised Code of Washington; SEPA = Washington State Environmental Policy Act; CCC = Cowlitz County Code

1.3 Study Area

GHG emissions contribute to the global greenhouse effect, which is the process by which the Earth retains heat (Section 2.1, *Greenhouse Effect*). GHGs emitted anywhere in the globe affect the global environment.[3] The study area for GHG emissions for Cowlitz County as a Washington State Environmental Policy Act (SEPA) co-lead agency is defined as Cowlitz County. GHG emissions for the Washington State Department of Ecology as a SEPA co-lead agency were studied based on the expected transportation routes and emissions from the combustion of coal. While the study areas for the co-lead agencies are different, the analysis used the same approach to calculate GHG emissions.

[3] Some short-lived climate pollutants, such as black carbon, have only a local impact, and are not considered in this analysis.

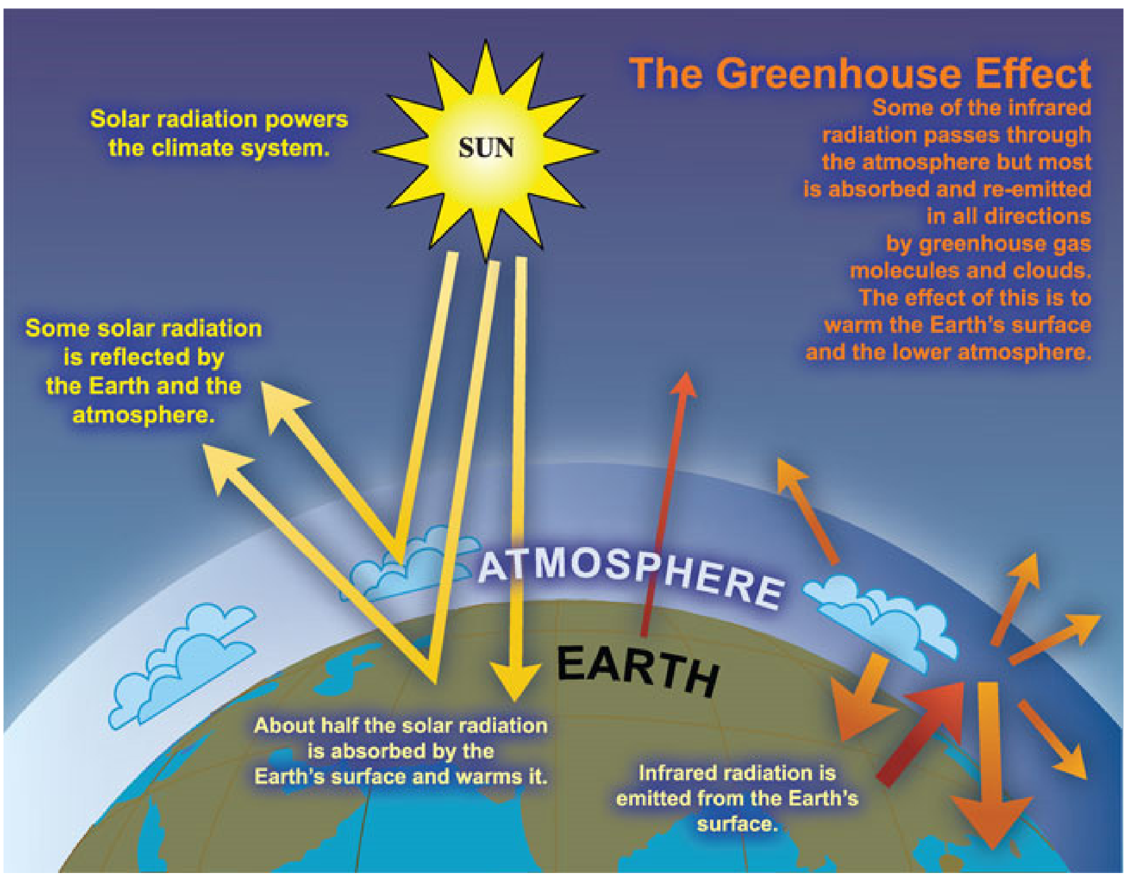
Chapter 2
Existing Conditions

This chapter introduces the greenhouse effect, which is the primary consequence of GHG emissions. The chapter then describes the sources of information and methods used to characterize the existing conditions and assess the potential impacts of the Proposed Action.

2.1 Greenhouse Effect

The Earth retains outgoing thermal energy and incoming solar energy in the atmosphere, thus maintaining heat temperature levels suitable for biological life. This retention of energy by the atmosphere is known as the greenhouse effect. When solar radiation reaches the Earth, most of it is either reflected or absorbed by the Earth's surface—or to a lesser degree, its atmosphere. Simultaneously, the Earth radiates its own heat and energy out into space. Factors such as the reflectivity of the Earth's surface, the abundance of water vapor, or the extent of cloud cover affects the degree to which solar radiation may be absorbed and reflected. Figure 3 shows the energy flows to and from Earth and the role that the greenhouse effect plays in maintaining heat in the atmosphere.

Figure 3. Model of the Natural Greenhouse Effect



Source: Intergovernmental Panel on Climate Change 2007

The composition of gases in the Earth's atmosphere determines the amount of energy absorbed and re-emitted by the atmosphere or simply reflected back into space. The predominant gases in the Earth's atmosphere, nitrogen and oxygen (which together account for nearly 90% of the atmosphere) exert little to no greenhouse effect. Some naturally occurring gases, such as carbon dioxide (CO_2), methane, and nitrous oxide, trap outgoing energy and contribute to the greenhouse effect. Additionally, manufactured pollutants, such as hydrofluorocarbons, can contribute to the greenhouse effect. Unlike most air pollutants (e.g., sulfur dioxide and particulate matter) that have only a local impact on air quality, GHGs affect the atmosphere equally regardless of where they are emitted, and thus they are truly global pollutants. Therefore, a ton of methane emissions in Asia affects the global atmosphere to the same degree as a ton of methane emissions in the United States.

The extent to which a given GHG traps energy in the atmosphere and contributes to the overall greenhouse effect is characterized by its global warming potential (GWP). Some gases are more effective at trapping heat, while others may be longer-lived in the atmosphere. The reference gas against which others are compared is carbon dioxide, and GWP is thus expressed in terms of carbon dioxide-equivalent (CO_2e). CO_2e reflects both a gas's ability to trap heat and the rate at which it breaks down in the atmosphere. Most analyses use 100 years as the period of reference for GWPs, and this technical report conforms to that convention. For example, 1 unit of carbon dioxide has a 100-year GWP of 1, whereas an equivalent amount of methane has a GWP of 25. Over a 500-year period, that same amount of methane has a GWP of 7.6 (Intergovernmental Panel on Climate Change 2007). For the purposes of this analysis, a 100-year period will be used.

GHG emissions occur from both natural as well as human-made (anthropogenic) sources. Examples of natural sources include decomposition of organic matter and aerobic respiration. Anthropogenic GHG emissions are predominantly from the combustion of fossil fuels, although other sources including industrial processes, land-use change, agriculture, and waste management are also significant.

The increase of GHGs in the atmosphere has been determined to pose risks to human and natural systems (Intergovernmental Panel on Climate Change 2014). Atmospheric concentrations of GHGs have increased since the Industrial Revolution, but the natural processes that remove those GHGs from the atmosphere have not scaled proportionally. Additionally, concentrations of long-lived manufactured pollutants such as hydrofluorocarbons have increased in recent decades. As the atmospheric concentrations of GHGs increase, the atmosphere's ability to retain heat increases as well. Since the instrumental record began in 1895, the U.S. average temperature has risen by approximately 1.3 to 1.9 degrees Fahrenheit (°F) (U.S. Global Change Research Program 2014). Furthermore, U.S. average temperatures throughout the 21st century are expected to increase at a faster pace, by 2.5°F to 11°F above pre-industrial levels by 2100 (U.S. Global Change Research Program 2014).

The impacts of higher global surface temperatures include widespread changes in the Earth's climate system. This may affect weather patterns, biodiversity, human health, and infrastructure. A discussion of climate impacts as they relate to the Proposed Action is provided in the SEPA Climate Change Technical Report (ICF International 2016b)

2.2 Methods

This section presents the data sources and methods used to estimate project related GHG emissions for the study area. First, the data sources that were used are summarized. Second, the methods used to estimate each source of GHG emissions are described.

2.2.1 Data Sources

The technical reports supporting the SEPA Draft Environmental Impact Statement (EIS) for the Millennium Bulk Terminals—Longview project provided activity data and emissions data to support the GHG analysis. The following sources of information were used to evaluate the GHG emissions from construction and operation of the Proposed Action, the combustion of coal from coal exported from the Proposed Action, domestic and international transport of the coal, and changes in the use of coal and natural gas in response to the operation of the Proposed Action.

- SEPA Air Quality Technical Report (ICF International 2016c)
- SEPA Coal Market Assessment Technical Report (ICF International 2016d)[4]
- SEPA Energy and Natural Resources Technical Report (ICF International 2016e)
- SEPA Rail Transportation Technical Report (ICF International and Hellerworx 2016)
- SEPA Vessel Transportation Technical Report (ICF International 2016f)

To estimate the GHGs emitted as a result of the processes described in the above reports, ICF used those reports' estimates of fuel consumption and vehicle operation, referred to as activity data, and combined that data with GHG emission factors in order to estimate GHG emissions for the Proposed Action.[5] The GHG emission factors were drawn from the following sources.

- California Air Resources Board (CARB). 2011. Appendix D: Emissions Estimation Methodology for Ocean-Going Vessels.
- Clean Cargo Working Group, 2014. Global Maritime Trade Lane Emissions Factors.
- Energy Information Agency 1994. CO_2 Emission Factors for Coal Study for International Coals.
- U.S. Environmental Protection Agency. 1996. AP-42, Section 3.4 Large Stationary Diesel and All Stationary Dual-fuel Engines.
- U.S. Environmental Protection Agency. 2009a. NONROAD Model (Non-road engines, equipment, and vehicles).
- U.S. Environmental Protection Agency. 2009b. Emission Factors for Locomotives.
- U.S. Environmental Protection Agency. 2014a. MOVES (Motor Vehicle Emission Simulator).

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[4] The SEPA Coal Market Assessment Technical Report (ICF International 2016d), hereafter referred to as the coal market assessment, provides estimates on the net changes in international coal combustion, domestic substitution of natural gas for coal and resulting combustion, domestic transport of coal to the proposed project, and international transport of the coal to importing countries. The report provides estimates for several scenarios to cover a range of potential changes in net GHG emissions because of the Proposed Action.

[5] An activity is a practice or ensemble of practices that take place on a delineated area over a given period of time. Activity data are data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time (e.g., data on energy use, data on equipment used during construction of the Proposed Action) (Intergovernmental Panel on Climate Change 2006).

- U.S. Environmental Protection Agency. 2015c. U.S. Greenhouse Gas Inventory Report: 1990-2013.

2.2.2 Impact Analysis

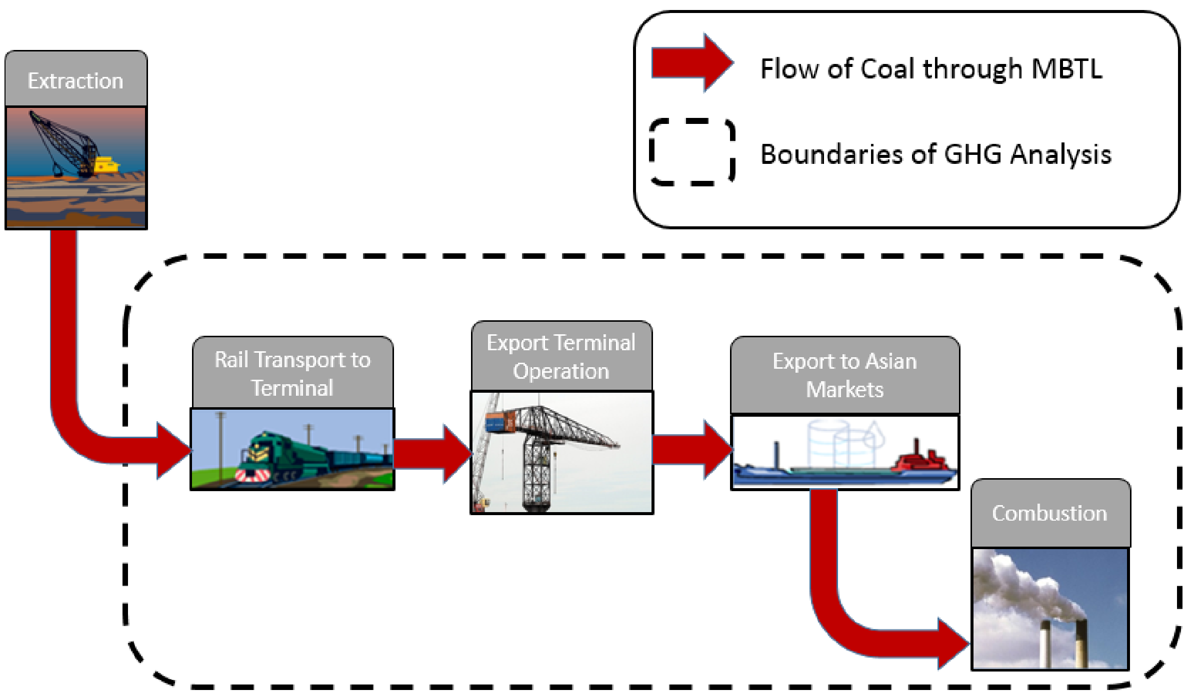
This section describes the methods used to evaluate the potential impacts of the Proposed Action on GHG emissions. The method for estimating the GHG emissions associated with each emissions source is described, along with that source's activity data and the calculations used to estimate its associated GHG emissions. The GHG analysis addresses the same set of sources addressed in the SEPA Air Quality Technical Report (ICF International 2016c), plus several additional sources (e.g., transportation emissions beyond a 5-mile radius, net emissions from changes in domestic and international coal use).

2.2.2.1 Scope of Analysis

The Proposed Action would emit GHGs during construction and operation, both in the United States and abroad. The emissions would come predominantly from the combustion of fossil fuels for construction and operation, as well as changes in the combustion of coal, both domestically and internationally.

This analysis includes activity data from the technical reports described in Section 2.2.1, *Data Sources.* Additionally, the GHG analysis evaluates emissions scenarios based on the ultimate flow of coal to and through the coal export terminal (ICF International 2016d). Figure 4 shows the pathway of coal from extraction to transport to terminal operation to export to its final combustion.

Figure 4. Coal Export Stages and GHG Analysis Boundaries



Geographically, the analysis of GHG emissions from the Proposed Action includes the transportation of Powder River Basin and Uinta Basin coals to Cowlitz County from their points of extraction, bulk terminal operation activity in Cowlitz County, final transport to Asia, and the end-use combustion displacement in China, Hong Kong, Japan, South Korea, and Taiwan. Changes in coal combustion elsewhere in Asia (e.g., India) are included in this analysis where coal use would be affected by the import of coal from the coal export terminal. The substitution of natural gas for coal in the United States because of an increase in domestic coal prices is also evaluated.[6]

This analysis of GHG emissions does not include future coal extraction in the Powder River Basin and the Uinta Basin. This exclusion is based on their coverage in separate GHG analyses as part of the National Environmental Policy Act (NEPA) requirements for these coal mines. Additionally, any future coal mine leases will require separate GHG analyses as part of the NEPA requirements for new coal mines. The EISs and lease applications that mention GHG emissions for coal mines that could provide coal to be shipped through the Proposed Action are summarized in Chapter 4, *Supplementary Data*.

The scope of the GHG emissions analysis considers the following elements.

- **Time horizon.** To be consistent with activity data from the other technical reports, this analysis considers construction, operation, transportation, and fossil fuel combustion emissions from 2018 through 2038.
- **Direct sources of GHG emissions.** Direct emissions refer to GHG emissions from coal export terminal construction, operation, and transportation within Cowlitz County. The following processes are included.
  - Rail transport of coal in Cowlitz County
  - Vehicle-crossing delay
  - Coal export terminal construction
  - Coal export terminal operation—equipment use
  - Vessel idling and tugboat use at the coal export terminal
  - Vessel transport of coal in Cowlitz County
  - Employee commuting
- **Indirect sources of GHG emissions.** Indirect emissions refer to GHG emissions that would result from the Proposed Action but are not concurrent with construction or operation on the project area, or that would occur outside of Cowlitz County. The following are indirect sources of GHG emissions.
  - Rail transport of coal from extraction sites to Washington State
  - Rail transport of coal within Washington State
  - Consumption of electricity used for coal export terminal operations
  - Helicopter and pilot boat trips for pilot transfers to vessels
  - Vessel transport of coal between Cowlitz County and international waters

[6] The proposed coal terminal could increase the demand for U.S. coal, resulting in a corresponding increase in coal prices.

- Vessel transport of coal from the United States to markets in China, Hong Kong, Japan, South Korea, and Taiwan
- Coal combustion in Asia and the United States
- Induced natural gas combustion in the United States

- **Geographic scope.** The geographic scope includes GHG emissions that would occur because of the Proposed Action at multiple geographic scales. Direct emissions that occur on the project area include those from mobile sources during construction and operation. Additional direct emissions would occur in Cowlitz County and Washington State from transport of the coal; in the United States from the transport of coal from extraction sites to the project area; and in international waters from the transport of coal to Asian markets. GHG emissions are also estimated that would result from shifts in coal combustion and demand in Asian markets and from induced natural gas combustion due to the shift from coal as coal prices increase (relative to the no-action as defined in the coal market assessment) in the United States.
- **Induced demand for energy.** This analysis addresses coal combustion in Asia that would result from the increased supply of coal due to the operation of the Proposed Action. The addition of 44 million metric tons to the supply of coal in Asia would increase supply and lower international coal prices. Asian coal markets would respond to lower prices by consuming more coal overall. This additional demand for coal that is a result of shifts due to the shift in the price of coal is referred to as induced demand.
- **Offset energy sources.** Operation of the Proposed Action could offset demand for other energy sources, nationally and internationally. Depending on the scenario, operations could affect production of coal from Australia, China, and Indonesia and its consumption throughout Asia. Additionally, this analysis considers the increased use of U.S. natural gas as a substitute for coal combustion. Consequently, changes in GHG emissions are estimated assuming that coal shipped through the coal export terminal would replace other sources of coal (e.g., coal imported from Australia, China, and Indonesia) and for the substitution of natural gas for U.S. coal.
- **Coal market assessment scenarios.** Each coal market assessment scenario represents a range of GHG emissions estimates, based on economic and policy projections from 2020 to 2040. For each scenario, the GHG emissions from Asian coal combustion, U.S. coal combustion, and U.S. natural gas combustion are influenced by factors such as coal prices, transportation costs, and competing energy sources. Estimates of coal transport, coal consumption, and natural gas substitution are informed by projections in the coal market assessment, which considers four scenarios based on economic and policy projections from 2020 to 2040.[7] The scenarios represent a range of GHG emissions estimates determined using a multi-dimensional model. Two model runs were conducted for each scenario: a no action model and an action model in which the coal export terminal is built. The resulting net GHG emissions are influenced by the relative differences in coal combustion, distribution, and substitution for each of these model runs.

[7] In some other studies, scenarios of economic and policy conditions are compared against a common baseline. For this GHG Analysis, the baseline is redefined for each scenario. This approach is used to capture the range of economic and policy conditions that could exist in the future (i.e., 2025, 2030, and 2040).

The coal market assessment kept the throughput of exported coal constant at 44 million metric tons for the 3 years modeled (2025, 2030, and 2040) for the Proposed Action.[8] However, for the GHG analysis and as described in Section 2.2.2.2, *Method for Assembling an Emissions Time Series,* the coal market assessment results were adjusted to account for changes in quantities of exported coal from 2021 to 2028 when the coal export terminal would be constructed and would ramp up operations. The four scenarios and their key concepts are described below and summarized in Table 2.

- **2015 Energy Policy Scenario.** The 2015 Energy Policy scenario represents the potential impact of an international climate policy.[9] The World Energy Outlook New Policies Scenario represents international coal demand (International Energy Agency 2014). Functionally, this scenario is the same as the Past Conditions (2014) (described below) except for two parameters. First, the international thermal coal demand is taken from the International Energy Agency World Energy Outlook demand forecast for the New Policy scenario.[10] Second, this scenario includes the proposed Clean Power Plan, which will reduce coal consumption in the United States (U.S. Environmental Protection Agency 2014b). This analysis uses the proposed Clean Power Plan in the modeling because the final Clean Power Plan was not released until August, 2015, which was after the modeling was completed for the Coal Market Assessment and GHG analysis. See Table 2 for differences between the proposed and final Clean Power Plan.
- **Past Conditions (2014) Scenario.** The Past Conditions (2014) scenario represents the state of the energy markets as of 2014. Consequently, it does not include the impacts of the Clean Power Plan and does not therefore reflect current energy policy conditions. The international thermal coal demand growth rate varies by country, following trends and "business-as-usual" projections. Of the modeled countries, China's coal consumption continues to grow at the highest rate of 1.7%, while Korea has a negative growth rate of -0.7%. Coal demand elasticity is moderate, with every 1.0% change in delivered coal cost resulting in 0.4% change in demand in the opposite direction.[11]

  Under this scenario, Powder River Basin coal prices are $12 per short ton for 8,800 British thermal units (Btu) per pound of coal, and Uinta Basin coal prices are $40 per short ton for

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[8] As described in the coal market assessment, 44 million metric tons was modeled for each year rather than a gradual increase as the coal export terminal reached full capacity.

[9] This scenario is intended to reflect the November 2014 climate negotiations between the United States and China (i.e., a 26 to 28% decrease in 2005 CO_2 emissions in the United States by 2025, and peak in CO_2 emissions and 20% renewable energy deployment in China by 2030). The World Energy Outlook models a range of scenarios that cover current policies, new policies, and the 450 Scenario. The 450 Scenario is the most aggressive in reducing GHG emissions. Per the International Energy Agency, the 450 Scenario sets out an energy pathway that is consistent with a 50 percent chance of meeting the goal of limiting the long-term increase in average global temperature to 2 °C compared with pre-industrial levels. The New Policies Scenario was used rather than the 450 Scenario as the 450 Scenario significantly exceeds China's goal and would underestimate coal demand and resulting CO_2 emissions.

[10] The International Energy Agency's New Policy Scenario was found to be a more realistic representation of energy markets than the 450 Scenario as the 450 Scenario results in scenario where both China and the United States significantly exceed climate policy goals (i.e., the demand for coal and resulting GHG emissions are lower than the demand that would be expected for the meeting the goals under the U.S.-China Joint Announcement on Climate Change and Clean Energy Cooperation).

[11] Additional details on the data sources used to define each scenario are provided in the SEPA Coal Market Assessment Technical Report (ICF International 2016d).

11,700 Btu per pound coal.[12] Rail transportation costs are $30 to $36 per short ton for coal transported from the Powder River Basin and Uinta Basin to the project area. This scenario assumes that no additional national climate policies will be enacted.

- **Lower Bound Scenario.** Due to uncertainty over future coal consumption trends, the coal market assessment constructed the Upper and Lower Bound scenarios in a way that they produce illustrative results to provide a broad range of outcomes. The Lower Bound scenario represents a plausible low estimate of global CO_2 emissions from coal combustion. This scenario evaluates the net CO_2 emissions of the construction and operation of the Proposed Action in which the induced coal demand from the coal export terminal is minimized. This scenario is designed to be a plausible and reasonable lower bound, and does not attempt to model an absolute lowest bound of CO_2 emissions or CO_2 emissions. The energy market under the Lower Bound scenario could reflect a large component of renewable energy resulting in reduced demand for coal combustion.

  Under this scenario, international coal prices are assumed to be 10% less than the Past Conditions (2014) scenario, reflecting the impact of high renewable energy use (i.e., prices are lower due to less demand for coal). Powder River Basin and Uinta Basin coal prices are assumed to be 25% and 10% higher than the Past Conditions (2014) scenario, respectively. Transportation costs are assumed to be 20% higher than the Past Conditions (2014) scenario. Coal demand is assumed to be less elastic than in the Past Conditions (2014) scenario; a 1.0% change in delivered coal cost results in a 0.11% change in coal demand in the opposite direction. These changes will cause a reduced level of induced demand relative to the Past Conditions (2014) scenario and thus lower CO_2 emissions because the export of coal will cause a smaller, or no reduction, in international delivered coal prices compared to the Past Conditions (2014) scenario.

  International thermal coal demand in the Lower Bound scenario is obtained from the International Energy Agency World Energy Outlook demand forecast for their New Policy scenario, which assumes a climate policy for China (International Energy Agency 2014). The Lower Bound scenario assumes that no U.S. national climate policies will be enacted.

- **Upper Bound Scenario.** The Upper Bound scenario represents an upper bound estimate of global CO_2 emissions and assumes that the induced demand from the Proposed Action is maximized. Coal plant construction and thus coal demand is higher than in the Past Conditions (2014) scenario. This higher demand causes both international coal consumption and prices to increase. This scenario does not attempt to model an absolute upper bound of global CO_2 emissions or CO_2 emissions that would result from the Proposed Action.[13]

  Under this scenario, international coal prices are assumed to be 50% higher than in the Past Conditions (2014) scenario, reflecting a greater demand. Asian markets with high prices react more strongly to the availability of cheaper coal exported from the United States. Additionally, Powder River Basin and Uinta Basin coal prices are assumed to be 10% lower. Transportation costs are assumed to be 20% lower for Powder River Basin and Uinta Basin

[12] British thermal units (Btu) are a standardized measurement of the heat content of coal.

[13] Due to uncertainty over future coal consumption trends, the coal market assessment constructed the Upper and Lower Bound scenarios to illustrate a broad range of outcomes but not the most extreme possibilities.

coal movements to the project area. This scenario will result in higher induced demand and CO_2 emissions.

Under this scenario, coal demand is more elastic than in the Past Conditions (2014) scenario. A 1.0% change in delivered coal cost results in a 1.2% change in coal demand in the opposite direction. To the extent that there is a change in delivered coal costs, this assumption will cause the induced demand to be greater than it would be under the Past Conditions (2014) scenario. International thermal coal demand in the Upper Bound scenario is obtained by increasing the Past Conditions (2014) scenario coal demand growth rates by 50%, unless the country had a negative growth rate. In this case, the negative growth rate was set to zero, to obtain a flat demand. This scenario assumes that no national climate policies will be enacted in the United States.

Table 2. Differences Between the Proposed and final Clean Power Plan

Clean Power Plan Component	Proposed Rule	Final Rule
Implementation	2020	2022
Interim standards	1 step 2020–2029	3 steps, 2022–2024, 2025–2027, 2028–2029
Best System of Emission Reduction (BSER) application	State-specific	Interconnection, to develop national technology specific standards
BSER Building Blocks	Four	Three (removed nuclear and existing RE from BB3 and all of BB4-EE)
State Standard derivation	BSER applied to 2012 baseline	National technology-specific rates applied to 2012 adjusted baseline
Standard types	Rate-based	Rate- and mass-based
Potential for trading	Allowed with joint plan	Allowed with joint plan or trading-ready option

Table 3 summarizes the scenarios modeled for the coal market assessment.[14] Many factors would affect the future export and consumption of coal for the Proposed Action. The scenarios reflect a range of potential outcomes. For each scenario, the table provides the following information.

- Purpose: the phenomena that the scenario is intended to represent,
- U.S. coal markets: the domestic coal market reacts to changes in coal demand due to changes in supply and pricing.
- Asian coal markets: the international coal market reacts to changes in coal demand due to changes in supply pricing.
- Coal prices: a range of coal prices capture increases and decreases in coal production and transportation costs relative to the Past Conditions (2014) scenario.
- Climate policy: one scenario captures the effect of the Proposed Action when the proposed Clean Power Plan and U.S.-China Climate Negotiations of 2014 goals are met.

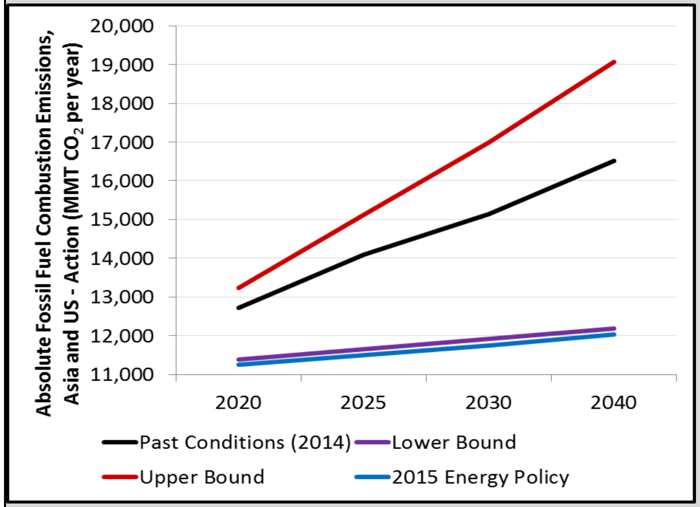
[14] Additional details on the modeling assumptions for each of the scenarios are provided in the SEPA Coal Market Assessment Technical Report (ICF International 2016d).

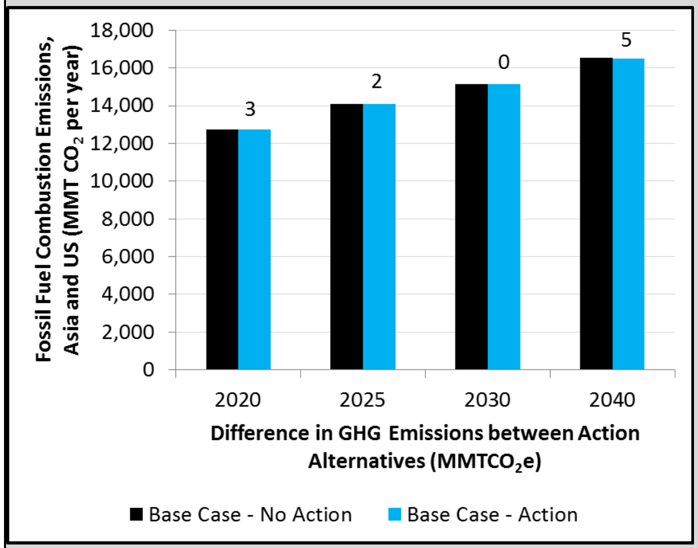
Table 3. Scenarios in the Coal Market Assessment

Scenario	Purpose	U.S. Coal Market Conditions (Relative to Baseline Assumptions)	Asian Coal Market Conditions (Relative to Baseline Assumptions)	Coal Prices Conditions (Relative to Baseline Assumptions)	Climate Policy
2015 Energy Policy	Represents impacts of an international climate policy on the coal market as enacted by 2014 and the proposed domestic Clean Power Plan	Coal demand is *less* sensitive to price changes because coal demand is very low due to climate policies	Coal demand is *less* sensitive to price changes because coal demand is very low due to climate policies	Baseline assumptions	Climate policy resembling implementation of proposed Clean Power Plan and meeting goals of 2014 U.S.-China Climate Negotiations
Past Conditions (2014)	Represents the assumed future state of energy markets in the absence of climate policies	Baseline assumptions	Baseline assumptions	Baseline assumptions	No climate policy
Lower Bound	Represents energy markets where renewable penetration is high and international coal prices and demand are low, making domestic coal exports less attractive to international markets	• Lower coal demand due to higher Powder River Basin and Uinta Basin coal prices • Decreased coal combustion emission factors • Overall *less* sensitive to price changes	• Lower coal demand due to increased renewables • Lower coal prices due to lower demand • Decreased coal combustion emission factors • Overall *less* sensitive to price changes	• Higher Powder River Basin and Uinta Basin coal prices due to assumed higher production costs • Higher U.S. rail transportation costs due to higher overall system utilization	No climate policy; however, assumes significant renewable energy use
Upper Bound	Represents energy markets where coal consumption is high, leading to high international demand and prices, making domestic coal exports	• Higher coal demand due to lower Powder River Basin and Uinta Basin coal prices • Higher coal combustion emission factors	• Higher coal demand resulting in higher coal prices • Higher coal combustion emission factors	• Lower Powder River Basin and Uinta Basin coal prices due to assumed lower production costs	No climate policy

Scenario	Purpose	U.S. Coal Market Conditions (Relative to Baseline Assumptions)	Asian Coal Market Conditions (Relative to Baseline Assumptions)	Coal Prices Conditions (Relative to Baseline Assumptions)	Climate Policy
	more attractive to international markets	• Overall *more* sensitive to price changes	• Overall *more* sensitive to price changes	• Lower U.S. rail transportation costs due to continuing low oil prices and increased competition with trucking	
Cumulative[a]	Represents the impact of other planned export terminals in the Pacific Northwest	Coal demand is *more* sensitive to price changes because coal prices are more affected by multiple coal export terminals	Coal demand is *more* sensitive to price changes because coal prices are more affected by multiple coal export terminals	Baseline assumptions	No climate policy

[a] Further details on the Cumulative Scenario can be found in Section 3.1.1.13, *Net Greenhouse Gas Emissions.*
[b] Scenario conditions are defined relative to the Past Conditions (2014) scenario.





Comparison of GHG Emissions Across Coal Market Assessment Scenarios

Each coal market assessment scenario represents a range of GHG emissions estimates, based on economic and policy projections from 2020 to 2040. For each scenario, the GHG emissions from Asian coal combustion, U.S. coal combustion, and U.S. natural gas combustion are influenced by a variety of factors, such as coal prices, transportation costs, and the penetration of competing energy sources.

The first chart on the left shows absolute emissions under each coal market scenario for the Proposed Action (noted as the Action Alternative). The scenarios display a significant variation in GHG emissions for coal and natural gas combustion. There is a difference of about 7,000 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) between the 2040 GHG emissions in the Upper Bound and 2015 Energy Policy scenarios. The difference in emissions under the first chart is almost entirely due to the underlying market conditions rather than the influence of the proposed coal export terminal.

To illustrate the relatively small influence of the proposed coal export terminal, the second chart on the left indicates the changes in fossil fuel combustion[a] emissions that would occur in Asia and the United States because of the Proposed Action under Past Conditions (2014) scenario conditions. For example in 2040, the no-action under the Past Conditions (2014) scenario would result in combustion emissions of 16,512 $MMTCO_2e$ while the combustion emissions resulting from the Proposed Action under Past Conditions (2014) scenario conditions are 16,507 $MMTCO_2e$. The resulting net difference is 5 $MMTCO_2e$, or 0.03% of emissions. Likewise, changes in absolute emissions between the no-action and the Proposed Action for the other four coal market assessment scenarios are relatively small.

[a] Fossil fuel combustion emissions refer to coal combustion in Asia and the U.S., as well as U.S. natural gas combustion (ICF International 2016d).

2.2.2.2 Method for Assembling an Emissions Time Series

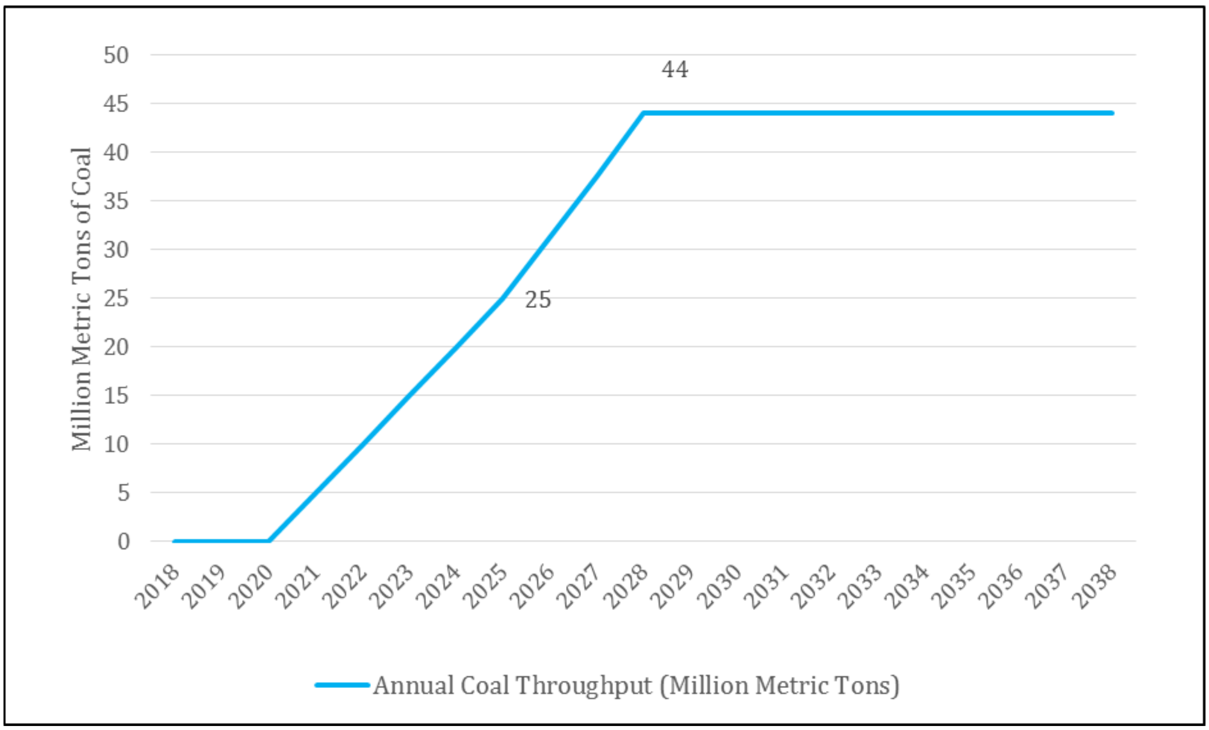
Because GHGs accumulate in the atmosphere, a complete assessment of GHGs associated with the Proposed Action requires a characterization of the GHGs over a full analysis period (2018 to 2038). The GHG analysis estimates emissions for each year during this analysis period as well as for each scenario.

Assembling a complete emissions time series for the GHG analysis required interpolation of estimates from other studies (i.e., coal market, air, and vessel) for the following reasons.

- The coal market assessment provides estimates for 2020, 2025, 2030, and 2040.
- The activity data that characterize coal export terminal operations represents conditions in 2028, when the facility is expected to be fully operational. These data do not reflect coal export terminal start-up, in which the coal throughput increases from zero immediately after construction in 2020 to its full capacity of 44 million metric tons by 2028.

In order to generate estimates of GHG emissions for the full time series, the expected coal throughput was increased linearly from zero in 2020 to 25 million metric tons (27.5 million short tons) in 2025. Between 2025 and 2028, the throughput was increased linearly at a slightly faster rate to reach full capacity at 44 million metric tons (48.4 million short tons) by 2028. For this approach, market-influenced emissions are assumed to be directly proportional to the amount of coal processed by the Proposed Action. The total coal exports for this time series add up to 627 million metric tons of coal, including 7 start-up years between 2021 and 2028 and 11 full years of operation from 2028 to 2038 (Figure 5).

Figure 5. Annual Coal Throughput, 2018-2038



The coal market assessment does not consider a start-up period, so the activity data and emissions estimates for 2025, which assume a full 44 million metric ton throughput, are prorated by 57%; i.e., the ratio of the projected 25 million metric tons of the start-up period and the full 44 million metric ton throughput. This proration factor is applied to all data outputs from the coal market assessment in 2025, including coal throughput, fossil fuel combustion emissions,[15] and ocean vessel traffic. Assuming that *net* emissions and activity from the Proposed Action are zero in 2020, the analysis assumes a linear growth to the prorated 2025 data, reaching full operation in 2028, and linear growth between the 2030 and 2040 data outputs.

Activity data and emissions estimates are derived only for 2028. Emissions estimates are directly proportional to the throughput of the Proposed Action and can be expressed as emissions per unit of coal throughput. The total net emissions from these sources are calculated by scaling the per-unit emissions by the total throughput of the Proposed Action for the entire time series.

2.2.2.3 Method for Impact Analysis

This section describes the method and approach for each emissions source. Multiple emissions sources that are calculated the same way (e.g., locomotive operation) are grouped together.

Vegetation and Wetlands Cover

To estimate the loss of upland and riparian land carbon stocks, estimates of vegetation and soil carbon stocks in the project area were based on average carbon stock per area estimates for Cowlitz County taken from the Carbon Online Estimator (COLE) developed by the National Council for Air and Stream Improvement and the U.S. Department of Agriculture, Forest Service.[16] These average values possibly overestimate the actual carbon stocks in the project area since the average estimates for Cowlitz County likely include areas with higher carbon stocks (e.g., managed production forests).

These estimates of the carbon stock per area for forested, scrub-shrub, and herbaceous[17] upland and riparian land vegetation cover types were multiplied by the corresponding impact areas to estimate the change in carbon stocks associated with construction (i.e., vegetation clearing and surface soil removal). These emission estimates possibly overestimate the actual construction emissions in the project area but are representative for average areas in Cowlitz County.

Loss of ongoing carbon sequestration for the forested, scrub-shrub, and herbaceous[18] upland and riparian land vegetation cover types were then estimated based on IPCC guidelines (Intergovernmental Panel on Climate Change 2006: Volume 4).[19] These estimates of the lost sequestration per area for forested, scrub-shrub, and herbaceous[20] upland and riparian land

[15] Changes in domestic and international coal combustion are assessed separately.

[16] Available online at http://www.ncasi2.org/COLE/.

[17] The same carbon stock density was applied for both herbaceous and managed herbaceous vegetation cover types since the carbon in both of these systems predominantly resides in the soil.

[18] The annual carbon sequestration for the forested and scrub-shrub vegetation types was based on the aboveground net biomass growth in natural temperate continental forests in North America. The annual carbon sequestration for the herbaceous vegetation type was assumed to be zero because the soil carbon gains and losses were assumed to have reached an equilibrium for an established herbaceous system.

[19] Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html.

[20] The same carbon stock density was applied for both herbaceous and managed herbaceous vegetation cover types since the carbon in both of these systems predominantly resides in the soil.

vegetation cover types were multiplied by the corresponding impacts areas and the 20-year analysis period to estimate the lost sequestration. Table 4 shows the emission factors derived for the upland and riparian land cover types.

Table 4. Upland and Riparian Land Emission Factors

Land Cover Category	Vegetation Cover Type	GHG Emission Factor (metric tons CO_2e/acre)	Lost Sequestration Factor (metric tons CO_2e/acre/year)
Upland	Forested	510.5	2.8
	Scrub-shrub	325.6	2.8
	Herbaceous	140.7	0
	Managed herbaceous	140.7	0
Riparian land	Forested	510.5	2.8
	Scrub-shrub	325.6	2.8
	Herbaceous	140.7	0

Notes:
GHG = greenhouse gas; CO_2e = carbon dioxide equivalent

To estimate the loss of wetland carbon stocks, estimates of vegetation carbon stocks in the project area were again based on average carbon stock per area estimates for Cowlitz County taken from the COLE tool, with the soil carbon stocks taken from a study by the U.S. Department of Agriculture Forest Service (Trettin and Jurgensen 2003). These estimates of the carbon stock per area for forested, scrub-shrub, and herbaceous wetland cover types were multiplied by the corresponding impact areas to estimate the change in carbon stocks associated with construction.

To estimate the loss of ongoing carbon sequestration for the forested, scrub-shrub, and herbaceous wetland vegetation cover types, estimates of annual carbon sequestration were taken from a study by Hansen (2009). Based on values reported by Trettin and Jurgensen (2003), these annual carbon sequestration estimates were adjusted to include the reduction in annual CO_2 and methane emissions that would otherwise have been released from the wetland impact areas.

These adjusted estimates of the lost sequestration or reduction in emissions per area for forested, scrub-shrub, and herbaceous wetland vegetation cover types were multiplied by the corresponding impacts areas and the 20-year analysis period to estimate the lost sequestration or reduction in emissions. Table 5 shows the emission factors derived for the wetland cover types.

Table 5. Wetland Emission Factors

Land Cover Category	Vegetation Cover Type	GHG Emission Factor (metric tons CO_2e/acre)	Lost Sequestration Factor (metric tons CO_2e/acre/year)
Wetland	Forested	451.43	-5.51
	Scrub-shrub	266.52	-2.12
	Herbaceous	81.61	1.26

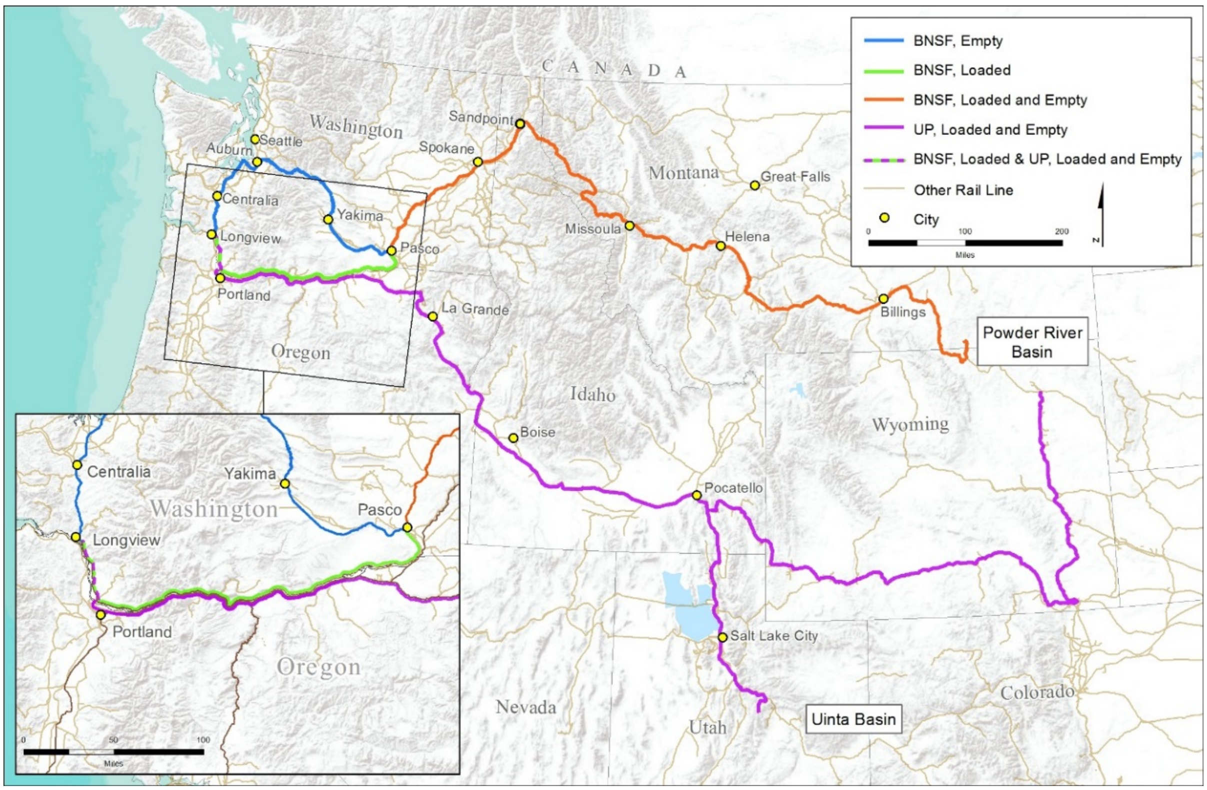
Notes:
GHG = greenhouse gas; CO_2e = carbon dioxide equivalent

Rail Transport

Rail Transport of Coal from Extraction Sites to Washington State

Indirect sources of GHG emissions from coal transport from the Uinta and Powder River Basins to Washington State include diesel combustion emissions from locomotive operation in both directions. The Uinta Basin is located in Colorado and Utah, whereas the Powder River Basin is located in Montana and Wyoming. The distances from five coal extraction sites (one each in Colorado, Montana, and Utah; two in Wyoming) to Washington State range from 627 miles to 946 miles by rail. For this analysis, each train is assumed to consist of three locomotives and 125 rail cars, each loaded with 121 metric tons of coal[21] (ICF International and Hellerworx 2016). For the return trip, this analysis assumes that the train would make a return trip to the coal basins with three locomotives and empty rail cars. Figure 6 provides an illustration of coal train routes from extraction sites to the project area.

Figure 6. Rail Transport of Coal to the Project Area



To calculate emissions, the gross mass of the loaded and empty coal trains was derived from BNSF data to determine the gross ton-miles of rail traffic associated with each scenario.[22] Table 6 provides an overview of the mass associated with the locomotives, the loaded coal, and the rail cars.

[21] The approximate amount of coal that would be required to transport 44 milion metric tons in 8 loaded unit trains, 125 rail cars per day, 365 days per year.

[22] Gross-ton miles refer to ton-miles travelled that include the mass of the railcars and locomotives in addition to the mass of the cargo.

Table 6. Mass of Coal Train Components

Train Component	Mass (Metric Tons)
Locomotive (one)	196
Rail car (one)	19
Coal per car	121
Gross train mass (full)	18,026
Gross train mass (empty)	2,958

Source: ICF International and Hellerworx 2016

The mass of the trains was multiplied by the total distance traveled to bring coal from mines in Colorado, Montana, Utah, and Wyoming to Washington State. The relative amount of train traffic from each extraction site is dependent on the scenario and year. For example, as the coal throughput at the coal export terminal remains constant, the relative shares of coal coming from the Uinta and Powder River Basins shifts. Table 7 provides estimates of rail distances from coal extraction sites to Washington State for the five coal types that would be likely exported from the project area.

Table 7. Coal Types and Distances to Washington State

Coal Type	Rail Distance to Washington State (Miles)
Montana Powder River Basin Coal	797
Wyoming Powder River Basin Coal (8,400 Btu/lb)	946
Wyoming Powder River Basin Coal (8,800 Btu/lb)	946
Colorado Uinta Basin Coal	839
Utah Uinta Basin Coal	1,013

Source: Distances estimated via GIS mapping.
Btu/lb = British thermal units per pound; GIS = geographic information system

The fuel consumption for transport to Washington State is estimated by multiplying the ton-miles travelled for each data year by a fuel consumption per ton-mile factor for average locomotive diesel consumption.[23] The GHG emissions are estimated by multiplying the total fuel consumption by a rail diesel-specific combustion factor, as shown in Table 8.

Table 8. Emission Factors from Rail Diesel Fuel

Greenhouse Gas	Emission Factor ($MtCO_2e$/1,000 gallons)
Carbon dioxide	10.26
Methane	0.01
Nitrous oxide	0.02
Total	**10.29**

Source: U.S. Environmental Protection Agency 2015a
$MtCO_2e$ = metric tons of carbon dioxide equivalent

[23] An estimate of 833 gross-ton miles per gallon of diesel is used (BNSF Railway Company 2013).

Rail Transport of Coal within Washington State (excluding Cowlitz County)

Indirect sources of GHG emissions from rail transport of coal in Washington State include diesel combustion emissions from locomotives. GHG emissions from rail transport of coal within Washington State to the border of Cowlitz County were estimated using the same approach as for transport to the state. Powder River and Uinta Basin coal are transported through Washington State to Cowlitz County on a southern route (through the Columbia River Gorge), entering Cowlitz County from Woodland. However, empty trains returning to the Powder River Basin take a longer northern route (via Stampede Pass) whereas empty trains returning to the Uinta Basin return along the southern route. Therefore, returns to Powder River Basin are slightly longer (Table 9).

Table 9. Coal Types and Distances within Washington State

Coal Type	Loaded Train Distance (Miles)	Empty Train Distance (Miles)
Powder River Basin coal	401	488
Uinta Basin Coal	401	405

Source: Distances estimated via GIS mapping
Note: Estimate does not include distance travelled within Cowlitz County

Rail Transport of Coal from Cowlitz County Border to Project Area

Direct sources of GHG emissions from rail transport of coal in Cowlitz County include diesel combustion emissions from the operation of locomotives to the project area and in the county. Emissions include round-trip emissions from loaded trains entering the county up to the point that empty trains leave the county. Within the county limits, this source includes locomotive travel on the BNSF main line as well as the spur leading to the project area. Loaded trains travel to the project area from Woodland, whereas empty trains travel along the BNSF main line to Vader. GHG emissions from rail transport of coal from the border of Cowlitz County to the project area were estimated using the same approach as for the transport outside the county. Emissions are estimated from the project area to the county border; a distance of 25.1 miles for loaded trains entering Cowlitz County and 28.5 miles for empty trains leaving the county (Table 10).

Table 10. Rail Distances Traveled within Cowlitz County

Rail Route	Loaded Train Distance (Miles)	Empty Train Distance (Miles)
Cowlitz County Border to Longview Junction	17.9	-
Longview Junction to project area	7.1	7.1
Longview Junction to Cowlitz County Border	-	21.4
Total	**25.1**	**28.5**

Source: Distances estimated via GIS mapping

Locomotive Operation

Direct GHG emissions at the project area for the Proposed Action would include emissions from the movement of coal trains around the 1.65- mile loop at the coal export terminal, the on-site idling of coal trains, and the operation of a switch locomotive to move cars and assemble trains for departure. The analysis assumes that it takes 1.85 hours to unload a 125-car unit train, each train has a 5-hour idle period prior to departing the facility, and the switch locomotive operates for 8 hours a day. This emissions source includes the sum of these three activities. Emission factors for line-haul locomotives are based on projected changes in the locomotive fleet over the next 30 years (U.S. Environmental Protection Agency 2009b). These emission factors are based on engine load and associated fuel consumption during transport to and from the facility, time to unload coal from the train cars, and total annual coal throughput. The power demand is proportional to engine load, which varies in intensity depending on whether the locomotive is hauling freight or idling. The fuel consumption is estimated based on the power demand, which is estimated based on the engine load and duration of the activity. That fuel consumption is then multiplied by fuel combustion emission factors for locomotives as provided in Table 11.

Table 11. Emission Factors for Locomotives

Greenhouse Gas	Emission Factor ($MtCO_2e$/ 1,000 gallons)
Carbon dioxide	10.23
Methane	<0.1
Nitrous oxide	0.1
Total	**10.31**

Source: U.S. Environmental Protection Agency. 2009b. *Emission Factors for Locomotives.*
$MtCO_2e$ = metric tons of carbon dioxide equivalent

Vehicle-Crossing Delay

Direct sources of GHG emissions from vehicle-crossing delay include the incremental fuel emissions caused by vehicle delay at grade crossings due to train traffic to the project area. This emissions source is based on existing rail infrastructure. GHG emissions were determined by estimating the gate downtime per day at grade crossings along the BNSF Spur and Reynolds Lead (between the BNSF main line and the project area) and at public at-grade crossings along the BNSF main line in Cowlitz County, and then estimating the average delay per vehicle for each crossing. The emissions estimate does not consider any track improvements to the Reynolds Lead and BNSF Spur. Emissions are estimated based on the average volume of vehicle traffic for each crossing. The fleet mix, or relative shares of vehicle types delayed at the crossing, is assumed representative of Cowlitz County as a whole, and is derived from the MOVES model (U.S. Environmental Protection Agency 2014a). The MOVES model provides emission factors for each vehicle type in grams per mile travelled, which are converted into vehicle delay emissions by multiplying by the assumed average vehicle speed of 2.5 miles per hour.[24] The mix of vehicles and their contribution to the weighted average Cowlitz County vehicle traffic emission factor is shown in Table 12.

[24] The MOVES emission factor for vehicle idling is based on a slow operation speed of 2.5 miles per hour.

Table 12. Weighted Vehicle Fleet Mix for Cowlitz County, 2028

Vehicle Type	Vehicle Speed (mph)	Emission Factor (g/mi)[a]	Fraction of Each Vehicle (%)	Weighted Emission Factor (g CO_2e/ vehicle-hour)
Combination long-haul truck	2.5	1,866	1.13	52.71
Combination short-haul truck	2.5	1,821	0.82	37.33
Intercity bus	2.5	1,909	0.01	0.48
Light commercial truck	2.5	375	8.07	75.57
Motor home	2.5	1,259	0.88	27.70
Motorcycle	2.5	443	3.22	35.67
Passenger car	2.5	273	48.12	328.01
Passenger truck	2.5	367	33.14	304.23
Refuse truck	2.5	1,839	0.15	6.90
School bus	2.5	1,253	0.36	11.28
Single unit long-haul truck	2.5	1,108	0.16	4.43
Single unit short-haul truck	2.5	1,153	3.92	112.99
Transit bus	2.5	1,648	0.04	1.65
Total			**100.00**	**998.95**

Notes: MOVES assumes a vehicle speed of 2.5 miles per hour to simulate idling emissions.
Source: [a] U.S. Environmental Protection Agency 2014a.

The delay was estimated for each road segment in the county and described as the total minutes of delays (in vehicle-hours) as well as the total vehicles affected. The emissions were estimated by multiplying the above fleet mix by vehicle-specific emission factors (in grams per vehicle-hour of delay) and then by the total amount of delay over the period of a year (Table 13).

Table 13. Activity Data for Vehicle Delay in Cowlitz County, 2028

Street	Daily Trains	Avg. Train Length (feet)	Train Speed (mph)	Avg. Daily Traffic in Both Directions (veh/day)	Number of Lanes in Both Directions	Total Delay (min /day)	Vehicles Delayed per Day (veh/day)
Study Crossings along the Reynolds Lead and BNSF Spur							
Industrial Way (SR 432)	16	6,844	10	12,100	2	5,617	1,113
Oregon Way (SR 433)	16	6,844	10	18,770	4	8,304	1,726
California Way	16	6,844	8	4,800	2	3,134	545
3rd Avenue (SR 432)	16	6,844	8	20,720	4	14,219	2,353
Dike Road	16	6,844	10	1,100	2	433	101
Project access (opposite 38th Avenue)	16	6,844	5	1,340	2	1,998	239
Weyerhaeuser Access (opposite Washington Way)	16	6,844	8	3,900	4	2,403	443

Street	Daily Trains	Avg. Train Length (feet)	Train Speed (mph)	Avg. Daily Traffic in Both Directions (veh/day)	Number of Lanes in Both Directions	Total Delay (min /day)	Vehicles Delayed per Day (veh/day)
Weyerhaeuser Norpac Access	16	6,844	10	800	2	312	74
Public At-Grade Crossings along the BNSF Main Line in Cowlitz County							
Taylor Crane Road in Castle Rock	8	6,844	50	50	2	0.6	0.6
Cowlitz Street in Castle Rock	8	6,844	50	1,450	2	18	17
Cowlitz Gardens Road in Kelso	8	6,844	60	850	2	8	8
Mill Street in Kelso	8	6,844	40	3,000	2	55	41
S River Road/ Yew Street in Kelso	8	6,844	40	2,200	2	39	30
Toteff Road/ Port Road in Kalama	8	6,844	60	1,450	2	14	14
W Scott Avenue in Woodland	8	6,844	60	3,100	2	29	31
Davidson Avenue in Woodland	8	6,844	60	2,350	2	22	23
Whalen Road in Woodland	8	6,844	60	1,800	2	17	18

Notes:
Source: U.S. Environmental Protection Agency 2014a.

Coal Export Terminal Construction

Direct sources of GHG emissions from construction would include operation of the construction equipment itself as well as the vehicles to bring employees and construction materials to the project area. Fossil fuels are combusted for the operation of mobile combustion equipment used for demolition and earthwork to prepare the site.

Table 14 summarizes the required equipment and duration of use.

Table 14. Major Construction Activities and Typical Equipment Fleets[a]

	Rail Infrastructure and Rotary Car Dump Station		Conveyors, Transfer Stations and Surge Bins		Shiploader, Dock, and Trestles	
Construction Equipment Type	**Max Qty. per Month**	**Duration (months)**	**Max Qty. per Month**	**Duration (months)**	**Max Qty. per Month**	**Duration (months)**
Mobile cranes (25–50 ton)	2	18	2	18	2	18
Mobile cranes (50–150 ton)	2	18	2	18	2	18
Mobile cranes (150–300 ton)	1	18	1	18	1	18
Water trucks	1	12	1	12	0	0
Dump trucks	3	12	1	12	0	0
Dozers	1	5	0	0	0	0
Excavators	1	9	2	12	1	3
Rollers	2	9	2	12	1	3
Graders	2	9	0	0	1	3
Compactors	2	9	2	12	1	3
Track laying machine	1	2	0	0	0	0
Drill rigs	1	2	2	6	0	0
Impact piling rigs	2	6	2	6	2	6
Loaders	1	12	1	12	1	9
River barge	0	0	0	0	2	18
Generator	2	18	2	18	2	18
Air compressor	2	18	2	18	2	18

Notes:
[a] Typical construction fleet may be modified with equivalent items as construction activities demand.
Sources: URS Corporation 2014b; ICF International 2016c

Combustion emissions estimates were obtained from the NONROAD emissions model (U.S. Environmental Protection Agency 2009a) for the nonroad equipment. Construction activity was assumed to occur 8 hours per day, 5 days a week, 52 weeks per year, with the exception of the track- laying machine, which operates 4 hours per day. Emission factors were applied to the maximum numbers of equipment operated, duration of use, and horsepower, to obtain annual emissions.

Table 15 provides information on the emission factors for construction equipment.

Table 15. Construction Equipment Activity Data and Emission Factors

Equipment Type	Engine Size	Fuel Type	Number of Units	Emission Factor ($MtCO_2e$/year per Unit)[c]
Crane, 50-ton	165	Diesel	2	109.3
Crane, 150-ton	280	Diesel	2	183.0
Crane, 300-ton	450	Diesel	1	195.4
Water trucks	350	Diesel	1	98.8
Dump trucks	350	Diesel	4	98.8
Dozers	185	Diesel	0.4	396.5
Excavators	230	Diesel	2	886.6
Rollers	350	Diesel	3.8	100.3
Graders	185	Diesel	1.8	132.7
Compactors	25	Diesel	3.8	0.2
Track laying machine	[a]	Diesel	0.5	416.8
Drill Rigs	(NONROAD Default)[b]	Diesel	1.2	57.1
Impact Piling Rigs	(NONROAD Default)[b]	Diesel	3	57.1
Loaders	140	Diesel	1	416.8
Generator	30	Diesel	6	108.8
Air Compressor	25	Diesel	6	0.3

Notes:

[a] Assumes track-laying machine uses one diesel locomotive and one front end loader engine. Assumes full-time locomotive used 4 hours/day, 5 days/week.

[b] Horsepower and weight estimates are based on capacity ratings and industry specifications, or average ratings per equipment type. Where horsepower could not be assumed, an average horsepower rate in NONROAD for the equipment type was used.

[c] To calculate annual emissions, this emission factor is multiplied by 1.5 years to estimate the emissions for 18 months of construction.

Source: ICF International 2016c

$MtCO_2e$ = metric tons of carbon dioxide equivalent

The impact of construction employee commuting was calculated using the MOVES model (U.S. Environmental Protection Agency 2014a), assuming that construction workers would use single-occupant vehicles with a mean round-trip travel time of 48.2 minutes. The analysis assumes that the 200 workers would be commuting during construction. At an estimated speed of 35 miles per hour, this amounts to 1,462,067 miles per year travelled. This distance was multiplied by emission factors for typical commuting vehicles provided by the MOVES model to calculate annual emissions.[25]

For the construction barges (operating under their own power or pushed/towed by another vessel), emissions were calculated using the U.S. Environmental Protection Agency's (EPA) AP-42 method for large diesel engines (U.S. Environmental Protection Agency 1996). The analysis assumes that the construction barges would have a positioning time of 1 hour with 1 round trip per day, 5 days per week, 52 weeks per year. Summaries of the barge activity and emission factors are available in Table 16 and Table 17, respectively.

[25] The analysis assumes a 50/50 mix of gasoline and E-85 for construction employee commuting vehicles.

Table 16. Barge Activity and Energy Use for Coal Export Terminal Construction

Barge Activity	Energy Consumption Variables
Barges used	2
Engine size (propulsion)	3,500 hp
Positioning time	1 hour
Total power per trip	7,000 hp
Construction trips	260 trips per year
Annual power	1,820,000 MMBtu per year

Notes:
Source: ICF International 2016c
hp = horsepower; MMBtu= million British thermal units per year

Table 17. Emission Factors for Construction Barges

Greenhouse Gas	$kgCO_2e$ per MMBtu	Emission Factor ($MtCO_2e$/ 1,000 gallons)
Carbon dioxide	74.8	10.23
Methane	0.1	0.1
Nitrous oxide	0.1	0.1
Total	75.0	10.25

Notes:
Source: U.S. Environmental Protection Agency 1996
$kgCO_2e$ = kilograms of carbon dioxide equivalent; MMBtu = million British thermal units; $MtCO_2e$ = metric tons of carbon dioxide equivalent

The project area does not have an existing barge dock. Therefore, the material from incoming barges would be off-loaded at an existing dock elsewhere on the Columbia River and transported to the project area by truck. Emissions from trucks hauling construction material to the project area were estimated by determining the annual miles traveled by trucks going to and from the construction site and then multiplying those miles traveled by a per-mile emission factor from EPA's MOVES model. The peak annual trips for the Proposed Action are assumed to be 56,000 round trips (88,000 throughout the entire construction period) (URS Corporation 2015). Short-haul combination tractor-trailer trucks were assumed to move construction material with 47 roundtrip miles of travel in the county. The GHG emission factor was taken from a MOVES model run for Cowlitz County, Washington, for the year 2018 (i.e., 1,561 to 1,930 grams of CO_2e per mile, depending on operating conditions).

Coal Export Terminal Operation—Equipment Operation

Direct sources of GHG emissions from equipment operation include fossil fuel emissions. Examples of equipment used for coal export terminal operation include loaders, maintenance vehicles, and cranes. This equipment uses diesel, gasoline, and propane fuels. Emissions from mobile combustion sources were estimated by first determining the equipment necessary for typical operation and maintenance and then using the NONROAD model (U.S. Environmental Protection Agency 2009a) to estimate annual exhaust emissions from that mobile equipment (Table 18).

Table 18. Coal Export Terminal Equipment and Emission Factors

Equipment Type	Engine Size	Fuel Type	Number of Units	Emission Factor ($MtCO_2e$/year per Unit)
Loader	300 hp	Diesel	1	671.7
Bobcat	50 hp	Diesel	2	16.6
10-Ton Truck	300 hp	Diesel	2	98.8
Crane	50 hp	Diesel	1	0.0
Forklift	40 hp	Propane	1	0.1
Maintenance Trucks	300 hp	Gasoline	4	0.2

Notes:
Source: U.S. Environmental Protection Agency 2009a
$MtCO_2e$ = metric tons of carbon dioxide equivalent; hp = horsepower

Coal Export Terminal Operation—Electricity Consumption

Indirect sources of GHG emissions for electrical consumption include fuel combustion emissions at off-site power plants to produce electricity consumed at the coal export terminal. The local energy grid would provide electricity for operation of coal export terminal facilities. The additional electricity consumption that would be required for the Proposed Action is assumed to be similar to the annual energy use for the existing bulk product terminal (Chany pers. comm.). To estimate net annual increase in GHG emissions from electricity consumption, the monthly electricity demand for the existing bulk product terminal was annualized in kilowatt-hours, as shown in Table 19.

Table 19. Monthly and Annual Electricity Demand for Coal Export Terminal

Time Period	Usage	Unit
Monthly	552,000	kWh
Annual	6,624	MWh

Notes: Additional demand is assumed to occur throughout the entire project period, including construction.
Source: Chany pers. comm.
kWh = kilowatt hour; MWh = megawatt hour

To derive additional GHG emissions from electricity consumption for coal export terminal operations, the electricity fuel mix for an average water year was obtained from the Cowlitz Public Utility District (PUD). Emission factors for each fuel type were then derived from individual plant data for each fuel in the Western Electricity Coordinating Council Northwest subregion as provided in the Emissions & Generation Resource Integrated Database (eGRID). These individual fuel emission factors were combined using the Cowlitz PUD fuel mix to obtain a weighted average emission factor to apply to electricity consumption from the Proposed Action. Table 20 provides the fuel mix and emission factors used to derive GHG emissions from electricity consumption for coal export terminal operations.

Table 20. Average Fuel Mix and Fuel-Specific Emission Factor for the Cowlitz PUD Region

Fuel Source	Share of Electricity Fuel Mix (%)	Carbon Dioxide (kg CO_2e/MWh)	Methane (kg CO_2e/MWh)	Nitrous Oxide (kg CO_2e/MWh)	Total (kg CO_2e/MWh)
Hydro	84.64%	0	0	0	0
Nuclear	9.70%	0	0	0	0
Wind	2.66%	0	0	0	0
Coal	2.08%	1,095.8	0.3	5.5	1,101.5
Natural Gas	0.79%	436.8	0.2	0.3	437.3
Other[a]	0.13%	302.0	0.1	1.4	303.5
Weighted Average	**100%**	**26.6**	**0.01**	**0.1**	**26.8**

[a] Other is made up of biomass, cogeneration, geothermal, landfill gas, petroleum, solar, and waste incineration.
Source: Cowlitz PUD 2015, U.S. Environmental Protection Agency 2015b

Employee Commuting

Direct sources of GHG emissions from employee commuting include the emissions from fossil fuel combustion associated with the daily commuting traffic for employees to and from the site. The GHG emissions from employees commuting to the project area were calculated using the MOVES model (U.S. Environmental Protection Agency 2014a), assuming that employees would use single-occupant vehicles with a mean round-trip travel time of 48.2 minutes. The analysis assumes that there are 135 employees, with 25 commuting 5 days per week and 110 commuting 7 days per week. At an estimated speed of 35 miles per hour, this amounts to 1,092,051 miles per year travelled. This distance was multiplied by emission factors for typical commuting vehicles provided by the MOVES model to calculate annual emissions.[26]

Vessel Idling and Tugboat Use at Coal Export Terminal

Direct sources of GHG emissions from vessel idling and tugboat use at the coal export terminal include current vessel operations at the coal export terminal, as vessels use main and auxiliary motors to maneuver in and out of the loading area. Additionally, this source includes fossil fuel combustion emissions from tugboats that are used to assist in vessel maneuvering at the project area.

GHG emissions from vessel idling and tugboat use were calculated by estimating the power consumed by idling vessels, converting the power demand into fuel consumption, and multiplying that fuel consumption by a fuel combustion emission factor. An average of 13 hours would be needed to load each vessel with coal, and during this period, the vessel would be hoteling using auxiliary engines. For each vessel, the typical main and auxiliary engine size was based on Lloyd's Register of Ships Sea-web, which has a database of ship characteristics for ships over 100 gross tons (Sea-web 2015). Each vessel receiving coal is assumed to need three tugs to maneuver the ship. These tugs would operate for 3 hours to assist with docking and departing. The time spent operating the vessels in each mode, multiplied by the estimated engine load and size provided power demand for both the idling vessels and tugboats. The power demand was then multiplied by the emission factors provided in Table 21.

[26] The analysis assumes a 50/50 mix of gasoline and E-85 for employee commuting vehicles.

Table 21. Emission Factors for Idling Vessels and Tugboats

Greenhouse Gas	Main Engine Emission Factor (g CO_2e per kWh)	Auxiliary Engine Emission Factor (g CO_2e per kWh)
Carbon dioxide	588	690
Methane	1.75	2.25
Nitrous oxide	0.12	0.12
Total	**590**	**692**

Notes:
Source: California Air Resources Board (CARB). 2011. *Appendix D: Emissions Estimation Methodology for Ocean-Going Vessels.*
gCO_2e = grams of carbon dioxide equivalent; kWh = kilowatt-hour

Helicopter and Pilot Boat Trips

Indirect sources of GHG emissions for helicopter and pilot boat transfers include fossil fuels burned to pilot vessels along the Columbia River. GHG emissions from helicopter and pilot boat trips that transfer pilots to vessels were calculated as described in the SEPA Vessel Transportation Technical Report (ICF International 2016f). The trips for both vehicle types were multiplied by the distance for each trip to derive the total mileage and fuel consumption for each trip. Assuming that at full capacity, the Proposed Action would service 840 vessels annually and each vessel would require piloting in and out of the Columbia River, this use equates to 1,680 pilot transfers per year. However, because the pilot is both dropped off and picked up in separate trips, the total number of trips would be 3,360. Helicopters are used for offshore transfer of Columbia River Bar pilots 70% of the time, with the remaining 30% of the offshore transfers conducted using a pilot boat due to more challenging weather conditions (Table 22).

Table 22. Annual Helicopter and Pilot Boat Transfers per Vessel, 2028

Project Year	Total Number of Vessels Exiting and Entering the Columbia River	Number of Pilot Transfers		Total Number of Pilot Transfers
		Helicopter	**Pilot Boat**	**All**
2028	840	2,352	1,008	3,360

Notes:
Source: ICF International 2016f

Incoming and outgoing vessels are piloted 15 nautical miles (17 standard miles) from the mouth of the harbor, for an average distance of 30 nautical miles (34 standard miles) per trip. The trips are multiplied by the distance to estimate the total nautical miles travelled per mode of transport, as shown in Table 23.

Table 23. Helicopter and Pilot Boat Trips and Nautical Miles Travelled

Project Year	Helicopter		Pilot Boat	
2028	**Trips**	**Total Miles**	**Trips**	**Total Miles**
	2,352	81,200	1,008	34,800

Notes:
Source: ICF International 2016f

GHG emissions from each mode of transport were based on the time of travel from shore to the vessels. The average trip time for helicopters was assumed to be 18 minutes (Ellenwood pers. comm.). For pilot boats, an average speed of 14 miles per hour was assumed (Columbia River Bar Pilots 2015), resulting in a roundtrip travel time of 2.5 hours. For helicopters, the fuel consumption rate of 1 gallon per minute was obtained directly from Brim Aviation (Ellenwood pers. comm.). Fuel consumption and aviation gasoline emission factors are presented in Table 24 and Table 25, respectively. The emissions were calculated by first estimating the amount of fuel consumed per helicopter trip, multiplying that by the emission factor for aviation gasoline, and then by the number of helicopter trips.

Table 24. Helicopter Fuel Consumption

Aircraft	Average Fuel Consumption Rate (Gallons per Minute)	Average Trip Time (Minutes)
Sikorsky S-76 "Seahawk"	1	18

Notes:
Source: Ellenwood pers. comm.

Table 25. Combustion Emissions for Aviation Gasoline

Greenhouse Gas	Emission Factor ($MTCO_2e$/1,000 gallons)
Carbon dioxide	8.31
Methane	0.18
Nitrous oxide	0.03
Total	**8.52**

Notes:
Source: U.S. Environmental Protection Agency 2015a
$MTCO_2e$ = metric tons of carbon dioxide equivalent

GHG emissions from pilot boats were based on the energy required for the pilot boat to make one trip based on the estimated round-trip duration of 2.5 hours. Energy was converted into gallons of residual fuel and multiplied by an emission factor for residual fuel combustion in order to calculate the GHG emissions for a single pilot boat trip. This value was then multiplied by the total number of annual pilot boat trips to estimate the total annual GHG emissions. The factors used to estimate the energy consumption and the emissions for pilot boats are shown in Table 26 and Table 27, respectively.

Table 26. Factors for Pilot Boat Fuel Consumption

Factor	Magnitude
Trip duration	2.5 hours
Horsepower of engines[a]	1,800 hp
Average engine load over trip[b]	45%
Energy consumed, hp per hour	2,025 hp per hour
Energy consumed, MMBtu[c]	5.1 MMBtu
Energy in residual fuel[d]	0.15 MMBtu per gallon
Gallons of residual fuel consumed	34.4 gallons per trip

Notes:
[a] Brusco Tug and Barge Undated
[b] California Air Resources Board 2011
[c] Estimated by converting horsepower per hour to MMBtu
[d] U.S. Environmental Protection Agency 2015a
hp = horsepower; MMBtu = million British thermal units

Table 27. Combustion Emissions for Residual Fuel

Greenhouse Gas	Emission Factor ($MtCO_2e$/1,000 gallons)
Carbon dioxide	11.24
Methane	0.003
Nitrous oxide	0.17
Total	**11.41**

Notes:
Source: U.S. Environmental Protection Agency 2015a
$MTCO_2e$ = metric tons of carbon dioxide equivalent

Vessel Transport

Vessel transport of coal is calculated in three phases: the local transport of coal to the border of Cowlitz County, the transport of coal up the Columbia River through Washington State, and lastly, the transport of coal to markets in Asia.

Within Cowlitz County

Direct sources of GHG emissions from vessel transport in Cowlitz County include fossil fuel combustion associated with current vessel transport from the coal export terminal down the Columbia River to the border of Cowlitz County, an 11.35-mile distance. This distance is repeated to account for empty vessels returning to the site. GHG emissions from vessel transport were calculated using the same method as for air emissions and summarized in the SEPA Air Quality Technical Report (ICF International 2016c). This analysis assumes that the coal export terminal would be serviced by a mix of Panamax (80%) and Handymax (20%) vessels. To incorporate this assumption, the engine size was considered a weighted average of Panamax and Handymax vessels. For each vessel, the typical main and auxiliary engine size was based on Lloyd's Register of Ships Sea-web, which has a database of ship characteristics for ships over 100 gross tons (Sea-web 2015).

GHG emissions from vessel idling and tugboat use were calculated by estimating the energy consumed by vessels exiting Cowlitz County, which was a factor of the duration to enter or exit the county, the engine size, and engine load for loaded ships in transit. The annual energy demand was multiplied by an emission factor for main engine vessel use for loaded transit. The one-way transit time within Cowlitz County was assumed to be 0.9 hour. The annual energy demand was then multiplied by the emission factors provided in Table 28.

Table 28. Emission Factors for Vessels in Transit

Greenhouse Gas	Main Engine Emission Factor (g CO_2e per kWh)	Auxiliary Engine Emission Factor (g CO_2e per kWh)
Carbon dioxide	588	690
Methane	1.75	2.25
Nitrous oxide	0.12	0.12
Total	590	692

Notes:

Source: California Air Resources Board (CARB). 2011. *Appendix D: Emissions Estimation Methodology for Ocean-Going Vessels.*

kgCO_2e = kilograms of carbon dioxide equivalent; kWh = kilowatt-hours

Through Washington State

Indirect sources of GHG emissions from vessel transport outside of Cowlitz County but within Washington State include fossil fuel combustion. GHG emissions were calculated by first calculating the ton-miles of shipping, then multiplying that amount by a per-ton-mile emission factor for cross-Pacific Ocean transport. This approach was taken due to the uncertainty of the duration of the trip over longer distances, which creates uncertainty when using estimates that rely on hours of engine operation. This analysis assumes a distance of 51.49 miles, which takes the vessels from the border of Cowlitz County to 3 nautical miles past the mouth of the Columbia River. This distance is repeated for empty vessels returning to the state to pick up coal.

The emission factor for long-distance vessel transport of coal is derived from an emission factor for the unrefrigerated shipping of bulk cargo in Asia, provided in units of CO_2e per each 20-foot equivalent unit of cargo transported 1 mile. A 20-foot equivalent unit refers to a unit of cargo capacity such as an intermodal container. For coal, this unit is estimated to hold 26 short tons (Rodrigue 2012). Table 29 shows the calculation of emission factors for long-distance vessel transport.

Table 29. Calculation of the Emission Factor for Long-Distance Vessel Transport of Coal

Factor	Magnitude
Shipping emission Factor, Intra-Asia [a]	87.5 g CO_2e/TEU-km
Coal per TEU, full capacity [b]	26 short tons
Shipping emission factor, Intra-Asia	0.005 kg CO_2e/ton-mile

Notes:

[a] Clean Cargo Working Group 2014

[b] Rodrigue 2012

TEU = 20-foot equivalent unit—a unit of cargo capacity which denotes one intermodal container; CO_2e/TEU-km = carbon dioxide equivalent per 20-foot equivalent unit per kilometer

To Asian Markets

Indirect sources of GHG emissions from vessel transport from vessel transport to Asian markets include fossil fuel combustion. GHG emissions were based on ton-miles of shipping from the coal market assessment, which provides yearly total ton-miles of coal shipped throughout the Pacific Basin for both the action and no-action models for each scenario. The difference in ship traffic between these scenarios was used to estimate the change in ton-miles attributable to the Proposed Action. The ton-miles travelled for coal exported to Asia were estimated by multiplying the tonnage of coal exported to each destination by the distance to that destination. Depending on the scenario and year, the total ton-miles varied based on the destinations. Table 30 summarizes the distances to Asian markets from the United States.

Table 30. Distances from United States to Asian Markets by Ship

Destination	Distance (miles)
China (Fuzhou)	6,093
Hong Kong	6,530
Japan (Nagoya)	5,003
Korea (Wonsan)	5,161
Taiwan (Kaohsiung)	6,283

Notes:
Source: ICF International 2016d

For changes in coal shipments within the Pacific Basin, GHG emissions were based on an estimate in the coal market assessment of the total net change in ton-miles traveled within the Pacific Basin. This estimate considers the total change in Pacific Basin coal traffic as a result of the Proposed Action, not including the new coal coming from the United States. However, it does include shifts in coal shipments from producers in Indonesia and Australia.

The total change in Pacific Basin ton-miles travelled is multiplied by the same shipping emission factor as the shipping traffic for coal from the Proposed Action. The net impact of this emissions source is the sum of the new emissions (delivery of coal from the Proposed Action) to Asian markets and the emissions offset from changes in Pacific Basin coal traffic. In addition to the five Asian markets importing coal as identified in the coal market assessment, the effect of the Proposed Action on coal markets could cause shifts in additional Asian markets as Australian and Indonesian coals find new markets. The additional countries include India and other smaller consumers in the Pacific Basin.[27] For example, if China displaces some of its consumption of Australian coals with coal exported from the Proposed Action, India may purchase some of the coal displaced from Australia. The return distance from Asia is not modeled for this analysis because vessels traveling back from Asia are assumed to be transporting other goods.

Coal Combustion in Asia and the United States

Indirect sources of GHG emissions from coal combustion include the change in both U.S. and Pacific Basin coal consumption that would result from a new coal export terminal. The coal market assessment estimates the net coal combustion in Asia and the United States. These estimates are presented in the GHG analysis for each scenario relative to the no-action model. This analysis

[27] This category includes Malaysia, Thailand, and Vietnam, as well as smaller importers of coal.

considers the worldwide combustion coal supplied by the Proposed Action, as well as the offsets in coal combustion in Asian markets (China, Hong Kong, Japan, South Korea, and Taiwan) that would result. This analysis considers the indirect effect on coal combustion in other Asian countries (e.g., India) and the United States caused by supply and price changes resulting from the new coal export terminal capacity.

GHG emissions from coal combustion include those associated with market effects, which dictate the total amount of coal produced and combusted in the United States and the Pacific Basin in response to supply and price. Emissions also reflect coal substitution, which is driven by the difference in carbon content between Powder River Basin coal, Uinta Basin coal, and coals produced in the Pacific Basin. Table 31 summarizes the differences in carbon and heat contents among the coals assessed in the coal market assessment.

Table 31. Heat Content and Carbon Coefficients for U.S. and Pacific Basin Reference Coals

Source	Coal Type	Heat Content (MMBtu per ton)	CO_2 Emission Factor (pounds per MMBtu)
Powder River Basin—WY	Subbituminous	17.6	214.3
Powder River Basin—MT	Subbituminous	18.6	215.5
Uinta—CO	Bituminous	21.5	209.6
Uinta—UT	Bituminous	23.4	209.6
Australia	Bituminous	24.1	205.3
Indonesia	Bituminous	23.7	205.3
Indonesia	Subbituminous	19.44	212.7
China	Bituminous	20.88	205.3
China	Lignite	9.79	215.4

Notes:
Source: ICF International 2016d
MMBtu = million metric British thermal units ; CO_2 = carbon dioxide

Induced Natural Gas Consumption in the United States

Indirect sources of GHG emissions from induced natural gas consumption would result from changes in consumption as a function of changes in the coal market. As coal prices increase due to the increased demand by the project for coal to export, the United States' natural gas consumption is expected to increase.

The Proposed Action could result in supply and price shifts in the coal markets, which affect the consumption of natural gas in the United States. The coal market assessment describes the substitution of natural gas for coal and estimates the GHG emissions from induced natural gas consumption in the United States. Depending on the scenario, natural gas consumption changes based on coal prices and U.S. coal consumption. As more coal is exported from the United States, coal prices increase, resulting in increased demand for natural gas.

2.3 Existing Conditions

The existing environmental conditions related to GHG emissions in the study area are described in the sections that follow.

2.3.1 Applicant's Leased Area

The existing bulk product terminal in the Applicant's leased area is already operational and draws electricity from the regional electricity grid, amounting to 552,000 kilowatt hours of electricity demand per month, or 6,624 megawatt hours of electricity annually (Chany pers. comm.). The emissions from this source are already occurring and will continue whether or not the coal export terminal is constructed. Electricity usage results in indirect emissions of approximately 2,545 metric tons of CO_2e annually, as estimated in Section 3.1.1.6, *Coal Export Terminal Terminal Operation—Electricity Consumption.*

The current vessel traffic at Dock 1 is six ships per year. Using the method described in Section 2.2.2.3, *Method for Impact Analysis, Vessel Transport Within Cowlitz County,* and assuming that the vessels are docking for approximately 13 hours per trip, maneuvering for 1 hour, and transiting within Cowlitz County for 0.9 hour, their operation emissions total 66 metric tons of CO_2e annually. Table 32 describes the current vessel transport activity at the project area. The current emissions from the project area for the Proposed Action are relatively small compared to the scale of emissions from the Proposed Action and are thus not taken into account when estimating the net emissions associated with the Proposed Action.

Table 32. Current Vessel Transport Activities in the Project Area

Transport Type	Transport Activity	Facility Activity
Handymax Class Vessel	6 ships per year	Ships currently deliver alumina over Dock 1; the cargo is temporarily stored and then shipped to Chelan County by train

Notes:
Source: ICF International and Hellerworx 2016, and ICF International 2016f

2.3.2 Cowlitz County

Approximately 7 trains per day consisting of approximately 78 cars typically pass between the BNSF Spur and main line (ICF International and Hellerworx 2016). Using the method described in Section 2.2.2.3, *Method for Impact Analysis, Rail Transport of Coal from Cowlitz County Border to Project Area,* and assuming that the trains haul 121 metric tons of material per rail car, use two locomotives, and travel 23.4 miles through Cowlitz County to and from the north on the main line and BNSF Spur, the annual emissions from those trains are currently 7,652 metric tons of CO_2e. Baseline traffic on the Reynolds Lead at the project area in Cowlitz County is about two trains per day. Assuming that the trains traveling on the Reynolds Lead also haul 121 metric tons of material per rail car, use one locomotive, and travel the approximately 5-mile length of the Reynolds Lead, the annual emissions from those trains are currently 1,635 metric tons of CO_2e. These totals include trains delivering grain as well as trains connecting to other port facilities.

2.3.3 Washington State

Washington State's total GHG emissions were 92.0 $MMTCO_2e$ in 2012, the most recent year for which a GHG Inventory was conducted. Of that total, 42.5 $MMTCO_2e$ (46.2%) are attributable to the transportation sector, and 12.1 $MMTCO_2e$ (13.2%) are attributable to coal combustion in the electricity sector (Washington State Department of Ecology 2016).

Rail traffic in Washington is heavy in areas, with some route segments seeing as many as 70 trains per day (ICF International and Hellerworx 2016). Existing rail capacity provides passenger service as well as transport for a variety of goods. The rail network accommodates empty and full coal trains as well as intermodal, grain, and general manifest trains from both BNSF and UP. Similarly, existing vessel traffic along the Columbia River is heavy due to the amount of bulk cargo transported in the region. The gross tonnage of vessel traffic in a 1-year period (averaged from 2010 to 2014) is approximately 91 million gross short tons (ICF International 2016f).

Chapter 3
Impacts and Mitigation

This chapter describes the GHG emissions impacts that would result from construction and operation of the Proposed Action or the ongoing activities of the No-Action Alternative.

3.1 Impacts

Net GHG emissions are presented for the Proposed Action. These net emissions represent the increase in emissions above no-action emissions.

3.1.1 Proposed Action

The GHG emissions are presented in terms of the 2028 emissions and total net emissions over the 2018 to 2038 time series. The total net emissions are the sum of emissions for the total time series, including construction beginning in 2018 and operation through 2038.

The results are presented by emissions sources, which are described in Section 2.2.2.3, *Method for Impact Analysis*. The source emissions are then combined into an estimate of total GHG emissions.

3.1.1.1 Vegetation and Wetlands Cover

As previously mentioned, the vegetation clearing and surface soil removal associated with construction of the Proposed Action would result in the loss of vegetation carbon stocks plus the loss of ongoing carbon sequestration (and reduction in annual emissions in the case of certain wetland vegetation cover types) over the 21-year analysis period. Table 33 presents the estimated emissions associated with construction of the Proposed Action and the ongoing loss of carbon sequestration.

Table 33. Vegetation and Wetlands Emissions (Mt CO_2e)

Emission Source	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Emissions from Carbon Stock Losses During 12-Month Construction Period	11,776	11,776	11,776	11,776
Annual Emissions, 2028	16	16	16	16
Total Emissions, 2018–2038	12,119	12,119	12,119	12,119

Notes:
MtCO_2e = metric tons of carbon dioxide equivalent

Due to the construction of the Proposed Action, carbon stocks losses are estimated to be 11,776 metric tons of CO_2e over the 12-month construction period, and total (2018 to 2038) emissions are estimated to be 12,119 metric tons of CO_2e. The annual emissions of 16 reflect lost sequestration during 2018 to 2038.

3.1.1.2 Rail Transport

Model results indicate that rail transport across the four scenarios is relatively constant, with slight fluctuations occurring depending on the share of Uinta Basin coal exported via the Proposed Action relative to the Powder River Basin coal. Although the distance from the Uinta Basin to Washington State is shorter than the distance from the Powder River Basin, the majority of the transport emissions occur from the transport of Powder River Basin coal, as its lower price results in higher demand despite the longer distances. The largest source of rail transport emissions is from domestic transport of the coal to Washington State. The second largest source of emissions from rail transport is from the transport of coal within Washington, which is approximately half the distance as that from the coal extraction sites to Washington State. Once the return trip is taken into account, the difference in emissions between the two routes taken from the different coal basins increases, as the empty Uinta Basin trains return along the same route. Empty Powder River Basin coal trains, however, travel a longer northern route to the Powder River Basin (ICF International and Hellerworx 2016).

Emissions from transport of coal within Cowlitz County also vary slightly for Powder River Basin and Uinta Basin coal due to the different directions travelled for empty Powder River Basin and Uinta Basin coal trains. However, due to the small distances involved, this difference does not have a large impact on emissions. The coal market assessment captures changes in the transportation routes from extraction sites to the project area due to shifts in coal demand and prices. Consequently, the emissions change across the scenarios. In Table 35 and Table 36, the Lower Bound scenario has slightly higher total emissions than the Past Conditions (2014) and the Upper Bound scenarios because less coal from the Uinta Basin is transported under this scenario. In the Lower Bound scenario, less coal is transported from the Uinta Basin because the higher coal prices assumed under this scenario make the Powder River Basin coal more economical to export than the Uinta Basin coal. Thus, total emissions are higher under the Lower Bound scenario because the total ton-miles of coal transported is greater than in the Past Conditions (2014) or Upper Bound scenarios, as the distance from the Powder River Basin is greater than from the Uinta Basin. The on-site emissions are equal across all scenarios, as those emissions are proportional solely to coal throughput for the Proposed Action. Table 34, Table 35, and Table 36 summarize rail emissions from each scenario.

Table 34. Locomotive Emissions from Extraction Sites to Washington State ($MtCO_2e$)

Period	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Annual Emissions, 2028	627,772	627,772	693,588	627,772
Total Emissions, 2018–2038	9,240,632	9,116,598	9,774,949	9,166,339

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

Table 35. Locomotive Emissions within Washington State (Excluding Cowlitz County) ($MtCO_2e$)[28]

Period	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Annual Emissions, 2028	323,734	323,734	203,740	323,734
Total Emissions, 2018–2038	4,108,952	4,335,086	3,145,776	4,244,399

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

Table 36. Locomotive Operation Emissions within Cowlitz County ($MtCO_2e$)

Emissions Source	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Locomotive Operation, BNSF Main Line & Spur				
Annual Emissions, 2028	20,083	20,083	20,083	20,083
Total Emissions, 2018–2038	286,255	286,255	286,255	286,255
Locomotive Operation, at Terminal Loop				
Annual Emissions, 2028	1,405	1,405	1,405	1,405
Total Emissions, 2018–2038	20,058	20,058	20,058	20,058
Subtotal				
Annual Emissions, 2028	21,489	21,489	21,489	21,489
Total Emissions, 2018–2038	306,313	306,313	306,313	306,313

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

3.1.1.3 Vehicle-Crossing Delay

The GHG emissions from vehicle-crossing delays are consistent across all four scenarios, as they are directly proportional to the throughput of the Proposed Action. After the start-up period, emissions from this source remain constant throughout the time series (Table 37).

Table 37. Vehicle-Crossing Delay Emissions from Fossil Fuel Combustion from Vehicles Idling within Cowlitz County ($MtCO_2e$)

Track Section\Period	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Study Crossings along the Reynolds Lead and BNSF Spur				
Annual Emissions, 2028	221	221	221	221
Total Emissions, 2018–2038	3,161	3,161	3,161	3,161
Public At-Grade Crossings along the BNSF Main Line in Cowlitz County				
Annual Emissions, 2028	1	1	1	1
Total Emissions, 2018–2038	17	17	17	17
All Vehicle Crossings				
Annual Emissions, 2028	223	223	223	223
Total Emissions, 2018–2038	3,178	3,178	3,178	3,178

$MtCO_2e$ = metric tons of carbon dioxide equivalent

[28] Locomotive operation within Cowlitz County is not included in this table, thus results from Table 34, Table 35, and Table 36 are additive.

3.1.1.4 Coal Export Terminal Construction

Coal export terminal construction emissions is assumed to occur in an 18-month period prior to the operation of the Proposed Action. Because construction dates are unknown, the GHG analysis assumes that the 18-month construction period would occur at some point between the years 2018 and 2020. For the purposes of estimating emissions associated with coal export terminal operation, the GHG analysis assumes that construction would be completed before December 31, 2020. As the construction would be structurally similar across the four scenarios, construction GHG emissions are equal across all four scenarios (Table 38). The emissions from the operation of construction equipment would exceed those of the barges used for bringing construction materials to the project area.

Table 38. Coal Export Terminal Construction Emissions ($MtCO_2e$)

	Scenario			
Emissions Source	**2015 Energy Policy**	**Lower Bound**	**Upper Bound**	**Past Conditions (2014)**
Construction Equipment				
Emissions During 12 Months of Construction Period	5,349	5,349	5,349	5,349
Total Emissions, 2018–2038[a]	8,024	8,024	8,024	8,024
Employee Commuting				
Emissions During 12 Months of Construction Period	465	465	465	465
Total Emissions, 2018–2038[a]	698	698	698	698
Construction Trucks Carrying Materials to Project Area				
Emissions During 12 Months of Construction Period	1,081	1,081	1,081	1,081
Total Emissions, 2018–2038[a]	1,621	1,621	1,621	1,621
Construction Barges Carrying Materials to Project Area				
Emissions During 12 Months of Construction Period	955	955	955	955
Total Emissions, 2018–2038[a]	1,433	1,433	1,433	1,433
Subtotal				
Emissions During 12 Months of Construction Period	7,851	7,851	7,851	7,851
Total Emissions, 2018–2038	11,776	11,776	11,776	11,776

Notes:

[a] Construction emissions occur over an 18-month period prior to the operation of the coal export terminal; therefore, emissions from 2021 through 2038 are zero. Given the 18 month period for construction, total construction emissions are those for the 12-month period multiplied by 1.5.

$MtCO_2e$ = metric tons of carbon dioxide equivalent

3.1.1.5 Coal Export Terminal Operation—Equipment Operation

GHG emissions from mobile equipment used for routine operation of the coal export terminal are consistent across all four scenarios, as they are directly proportional to the throughput of the Proposed Action (Table 39). After the start-up period, emissions from this source would remain constant throughout the time series.

Table 39. Coal Export Terminal Operation Emissions from Mobile Combustion ($MtCO_2e$)

	Scenario			
Period	**2015 Energy Policy**	**Lower Bound**	**Upper Bound**	**Past Conditions (2014)**
Annual Emissions, 2028	903	903	903	903
Total Emissions, 2018–2038	12,894	12,894	12,894	12,894

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

3.1.1.6 Coal Export Terminal Operation—Electricity Consumption

Electricity consumption emissions for operation of the new coal export terminal are assumed constant across all years of the time series and for all scenarios (Table 40).

Table 40. Coal Export Terminal Operation—Indirect Emissions from Electricity Consumption ($MtCO_2e$)

	Scenario			
Period	**2015 Energy Policy**	**Lower Bound**	**Upper Bound**	**Past Conditions (2014)**
Annual Emissions, 2028	177	177	177	177
Total Emissions, 2018–2038	3,191	3,191	3,191	3,191

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

3.1.1.7 Employee Commuting

GHG emissions from employee commuting are consistent across all four scenarios, as they are directly proportional to the throughput of the Proposed Action (Table 41). After the start-up period, emissions from this source would remain constant throughout the time series.

Table 41. Employee Commuting ($MtCO_2e$)

	Scenario			
Period	**2015 Energy Policy**	**Lower Bound**	**Upper Bound**	**Past Conditions (2014)**
Annual Emissions, 2028	275	275	275	275
Total Emissions, 2018–2038	3,922	3,922	3,922	3,922

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

3.1.1.8 Vessel Idling and Tugboat Use at Coal Export Terminal

GHG emissions from idling vessels and tugboats are consistent across all four scenarios, as they are directly proportional to the throughput of the Proposed Action (Table 42). Tugboats emit approximately twice as many emissions as idling vessels. After the start-up period, emissions from this source will remain constant throughput the time series.

Table 42. Emissions from Vessel Idling and Tugboat Use at Coal Export Terminal ($MtCO_2e$)

Emissions Source	Scenario			
	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Vessel Idling at Terminal				
Annual Emissions, 2028	2,498	2,498	2,498	2,498
Total Emissions, 2018–2038	35,660	35,660	35,660	35,660
Tugboat Operation				
Annual Emissions, 2028	4,840	4,840	4,840	4,840
Total Emissions, 2018–2038	69,081	69,081	69,081	69,081
Subtotal				
Annual Emissions, 2028	7,338	7,338	7,338	7,338
Total Emissions, 2018–2038	104,740	104,740	104,740	104,740

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

3.1.1.9 Helicopter and Pilot Boat Trips

GHG emissions from pilot transfers are consistent across all four scenarios, as they are directly proportional to the throughput of the Proposed Action (Table 43). Helicopters emit about the same GHGs as pilot boats and are assumed responsible for 70% of the pilot transfers. After the start-up period, emissions from this source would remain constant throughout the time series.

Table 43. Emissions from Helicopter and Pilot Boat Trips for Pilot Transfers to Vessels ($MtCO_2e$)

Emissions Source	Scenario			
	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Helicopter Operation				
Annual Emissions, 2028	361	361	361	361
Total Emissions, 2018–2038	5,148	5,148	5,148	5,148
Pilot Boat Operation				
Annual Emissions, 2028	396	396	396	396
Total Emissions, 2018–2038	5,648	5,648	5,648	5,648
Subtotal				
Annual Emissions, 2028	756	756	756	756
Total Emissions, 2018–2038	10,796	10,796	10,796	10,796

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

3.1.1.10 Vessel Transport

Vessel transport GHG emissions are equivalent across all scenarios within Cowlitz County and Washington State but diverge for international transport (Table 44 and Table 45). The differences in international transport emissions result from different destinations for the exported coal and the extent to which demand for existing sources of Pacific Basin coal is displaced, primarily by coal from Indonesia and Australia. Consequently, the net emissions from international transport of coal include both transport to the Asian market and the adjustment for the displaced vessel transport from Indonesia and Australia to the Asian market (Table 46). In the Upper Bound scenario, for example, the high demand for coal means that the addition of 44 million metric tons of coal per year from the United States would not reduce a similar amount of coal traffic within the Pacific Basin. In other words, prices shift such that there is additional induced demand beyond the 44 million metric tons of coal exported via the Proposed Action.

Table 44. Emissions from Vessel Transport within Cowlitz County ($MtCO_2e$)

	Scenario			
Period	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Annual Emissions, 2028	8,232	8,232	8,232	8,232
Total Emissions, 2018–2038	118,573	118,573	118,573	118,573

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

Table 45. Emissions from Vessel Transport within Washington State (Excluding Transport within Cowlitz County) ($MtCO_2e$)[29]

	Scenario			
Period	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Annual Emissions, 2028	39,495	39,495	39,495	39,495
Total Emissions, 2018-2038	563,696	563,696	563,696	563,696

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

Table 46. Net Emissions from Changes in International Vessel Transport to Asian Markets ($MtCO_2e$)[a]

	Scenario			
Period	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Net Annual Emissions, 2028	256,517	618,096	1,540,555	631,149
Net Total Emissions, 2018–2038	2,595,112	2,168,462	22,161,047	6,947,758

Notes:
[a] Net GHG emissions represent the difference between the Proposed Action and the no-action.
$MtCO_2e$ = metric tons of carbon dioxide equivalent

[29] This table does not include emissions generated from vessel transport within Cowlitz County for the results in Table 44, Table 45, and Table 46 to be additive.

3.1.1.11 Coal Combustion

Coal combustion in the United States and the Pacific Basin is one of the largest and most variable sources of GHG emissions associated with the Proposed Action. Model results indicate that this source of emissions varies significantly throughout the time series and between scenarios, indicating that it is sensitive to policy and market factors. For most scenarios, the coal combustion emissions in the United States decrease while coal combustion emissions in the Pacific Basin increase, to varying degrees. The key factor behind this shift is U.S. and Asian markets' reactions to price and supply shifts for coal. As the Proposed Action exports U.S. coal, prices in the United States go up in response to supply decreasing, thus reducing coal combustion. Likewise, the increased supply of coal in Asia decreases prices and facilitates additional coal combustion.

Coal combustion emissions in Asia are separated in Table 47 into two subcategories: emissions from induced coal demand and emissions from coal substitution. Induced demand emissions would occur because of lowered coal prices in response to an increase in coal supply caused by the Proposed Action. Coal substitution emissions are a result of the of higher-heat-content coal with lower-heat-content coal, which results in a net increase in emissions to generate the same amount of energy.

The differences between scenarios are driven by the following factors.

- Coal combustion emissions in the United States are less than the no-action for all scenarios (that is, the net emissions are negative). Domestic coal prices increase in every scenario in response to the export of Powder River Basin and Uinta Basin coal. The higher prices then reduce the U.S. demand for coal.
- In all but the Lower Bound scenarios, the additional coal exported to the Pacific Basin from the Proposed Action reduces the delivered Pacific Basin coal prices, inducing demand. This increases overall coal consumption even as some Asian coals from Indonesia and Australia are displaced by Powder River Basin and Uinta Basin coals.
- There is a secondary driver of emissions in Asia, as lower-heat-content coal from the United States displaces higher-heat-content coal in each scenario. This displacement of higher-heat-content coal results in additional low-heat-content coal being combusted in order to meet electricity demands (i.e., Btu demands), therefore raising emissions in Asia.[30]
- In the Lower Bound scenario, in which international coal is cheaper than in the Past Conditions (2014) scenario, the increase in coal supplied by the Proposed Action has less of an impact on prices than in the Past Conditions (2014) scenario and therefore does not induce demand in Asia; Pacific Basin emissions increase through coal substitution. This scenario also has a smaller impact on domestic coal displacement in the United States, as there is less price sensitivity domestically relative to the Past Conditions (2014) scenario.
- The Upper Bound scenario (which already has high coal prices) has a higher impact on domestic coal displacement than the Past Conditions (2014) scenario and a higher induced demand in Asian markets than the Past Conditions (2014) scenario.

[30] For example, in Japan in the Past Conditions (2014) scenario, coal consumption increases by 1.5 million metric tons in 2030 over the No-Action Alternative; however, the amount of induced demand is less than 0.5 million metric tons. Thus 1.0 million metric tons of the increase in coal consumption in Japan in 2030 is due to changes in the mix of coal consumed.

- In the 2015 Energy Policy scenario, U.S. coal combustion decreases only slightly for two reasons: First, U.S. coal prices are already very low due to a decrease in consumption from the enactment of a EPA's Clean Power Plan in 2020, as modeled. Therefore, the Proposed Action affects the market significantly less than in the Past Conditions (2014) scenario. Second, the 2015 Energy Policy scenario sees a shift from lower-emitting coals to higher CO_2-emitting coals in the United States. This result can occur because states can respond by switching to higher-emitting coals that are cheaper than natural gas yet still allow states to meet their climate policy obligations.

The SEPA Coal Market Assessment Technical Report (ICF International 2016d) provides a thorough discussion of the market.

Table 47. Net Emissions from Coal Combustion ($MtCO_2e$)[a]

	Scenario			
Emissions Source	**2015 Energy Policy**	**Lower Bound**	**Upper Bound**	**Past Conditions (2014)**
Coal Combustion, United States				
Net Annual Emissions, 2028	-266,185	-4,675,534	-10,065,930	-5,385,639
Net Total Emissions, 2018–2038	-2,518,738	-66,717,663	-160,380,593	-96,403,156
Coal Combustion from Induced Demand, Pacific Basin				
Net Annual Emissions, 2028	867,958	0	37,439,547	2,094,921
Net Total Emissions, 2018–2038	12,406,582	0	535,160,238	29,944,771
Coal Combustion from Coal Substitution, Pacific Basin				
Net Annual Emissions, 2028	1,171,889	1,072,099	-325,724	1,339,453
Net Total Emissions, 2018–2038	8,856,189	12,106,757	-1,644,717	12,964,768
Subtotal				
Net Annual Emissions, 2028	1,773,662	-3,603,435	27,047,892	-1,951,264
Net Total Emissions, 2018–2038	18,744,034	-54,610,906	373,134,929	-53,493,618

Notes:
[a] Net GHG emissions represent the difference between the Proposed Action and the no-action.
$MtCO_2e$ = metric tons of carbon dioxide equivalent

3.1.1.12 Induced Natural Gas Consumption

Natural gas substitution in the United States is a large and highly variable source of emissions. Higher coal prices in the United States induce electricity generators to switch to natural gas. Relative to the no-action, natural gas emissions increase for all scenarios, although the results display significant variation depending on the extent to which coal is displaced (Table 48). The differences among scenarios are driven by the following factors.

- In each scenario, natural gas emissions increase due to higher natural gas consumption in response to the Proposed Action. The higher domestic coal prices caused by the export of Powder River Basin and Uinta Basin coal through the Proposed Action cause a reduction in the U.S. demand for coal. This effect has the highest impact in the Upper Bound scenario, because coal demand is more elastic than in the other scenarios, resulting in higher natural gas substitution.

- The increase in natural gas consumption is smaller in the Lower Bound scenario relative to the Past Conditions (2014) scenario. The lower prices of coal in the Lower Bound scenario create less relative demand for natural gas than in the Past Conditions (2014) scenario. Correspondingly, the Upper Bound scenario has higher net natural gas emissions than the Past Conditions (2014) scenario, due to the higher global coal prices and higher domestic coal prices resulting in higher natural gas consumption.
- The decrease in coal combustion due to higher coal prices is partially offset by natural gas combustion in all but the 2015 Energy Policy scenario. In the other scenarios, the coal is replaced by natural gas, which has a lower combustion emission factor, causing a net decrease in domestic electricity generation emissions. In the 2015 Energy Policy scenario, there is less of a substitution of natural gas for coal because states can still respond to increased coal prices by switching to higher emitting coals, which are cheaper than natural gas yet still meet their climate policy obligations.

Table 48. Net Emissions from Natural Gas Substitution in the United States ($MtCO_2e$)[a]

	Scenario			
Period	**2015 Energy Policy**	**Lower Bound**	**Upper Bound**	**Past Conditions (2014)**
Net Annual Emissions, 2028	170,435	850,628	1,781,076	1,225,279
Net Total Emissions, 2018–2038	1,497,089	12,827,507	33,110,591	23,415,889

Notes:
[a] Net GHG emissions represent the difference between the Proposed Action and the no-action.
$MtCO_2e$ = metric tons of carbon dioxide equivalent

3.1.1.13 Net Greenhouse Gas Emissions

This section presents the aggregated results of each of the emissions sources described previously.

Model results indicate that the direct GHG emissions from the Proposed Action (Table 49) are the same for each of the four scenarios, as they are emitted in proportion to the throughput of the Proposed Action and are not influenced by outside economic factors. The largest contributors to the direct emissions are transportation-related emissions, including locomotive operation and vessel transport within Cowlitz County. Together, these two sources contribute about 74% of direct emissions. For the Past Conditions (2014) scenario, the total direct emissions contributed approximately 0.6 $MMTCO_2e$ (Table 49) of total net emissions of -8.3 $MMTCO_2e$ (Table 53) once market-influenced and indirect sources of emissions were considered (i.e., direct on-site emissions are positive; however, overall net emissions are negative due to domestic coal displacement).

Table 49. Direct Emissions (Generated in Cowlitz County) for the Proposed Action ($MtCO_2e$)[31]

Period	Scenario			
	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Annual Emissions, 2028	38,477	38,477	38,477	38,477
Total Emissions, 2018–2038	573,516	573,516	573,516	573,516

Notes:
$MtCO_2e$ = metric tons of carbon dioxide equivalent

Statewide, emissions are about 9 times as high as the county emissions, largely driven by the greater distances traveled by locomotives and vessels outside of Cowlitz County. Locomotive transport constitutes about 88% of emissions generated within Washington State and outside of Cowlitz County (Table 50).

Table 50. Emissions Generated within Washington State, Excluding Cowlitz County ($MtCO_2e$)

Period	Scenario				
	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)	Cumulative
Annual Emissions, 2028	364,162	364,162	244,169	364,162	354,363
Total Emissions, 2018–2038	4,686,634	4,912,768	3,723,459	4,822,082	4,587,418

Notes:
The Cumulative scenario is provided here for comparison and is addressed in Section 3.1.1.13, *Net Greenhouse Gas Emissions*, under Cumulative Scenario.
$MtCO_2e$ = metric tons of carbon dioxide equivalent

The total net indirect emissions from activities outside the project area and Cowlitz County attributed to the operation of the Proposed Action come from a variety of sources, including:

- Rail Transport
- Coal Export Terminal Operation – Electricty Consumption
- Helicopter and Pilot Boat Trips
- Vessel Transport
- Coal Combustion in Asia and the United States
- Induced Natural Gas Consumption in the United States

These emissions vary depending on the scenario, from a decrease of 25.2 $MMTCO_2e$ in the Lower Bound scenario to an increase of 675.7 $MMTCO_2e$ in the Cumulative scenario (Table 51).

[31] By definition, direct emissions are equivalent to emissions generated in Cowlitz County.

Table 51. Indirect Emissions for the Proposed Action ($MMtCO_2e$)

Period	Scenario				
	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)	Cumulative
Annual Emissions, 2028	3.2	-1.1	31.3	0.9	39.5
Total Emissions, 2018–2038	37.0	-25.2	442.1	-8.9	675.7

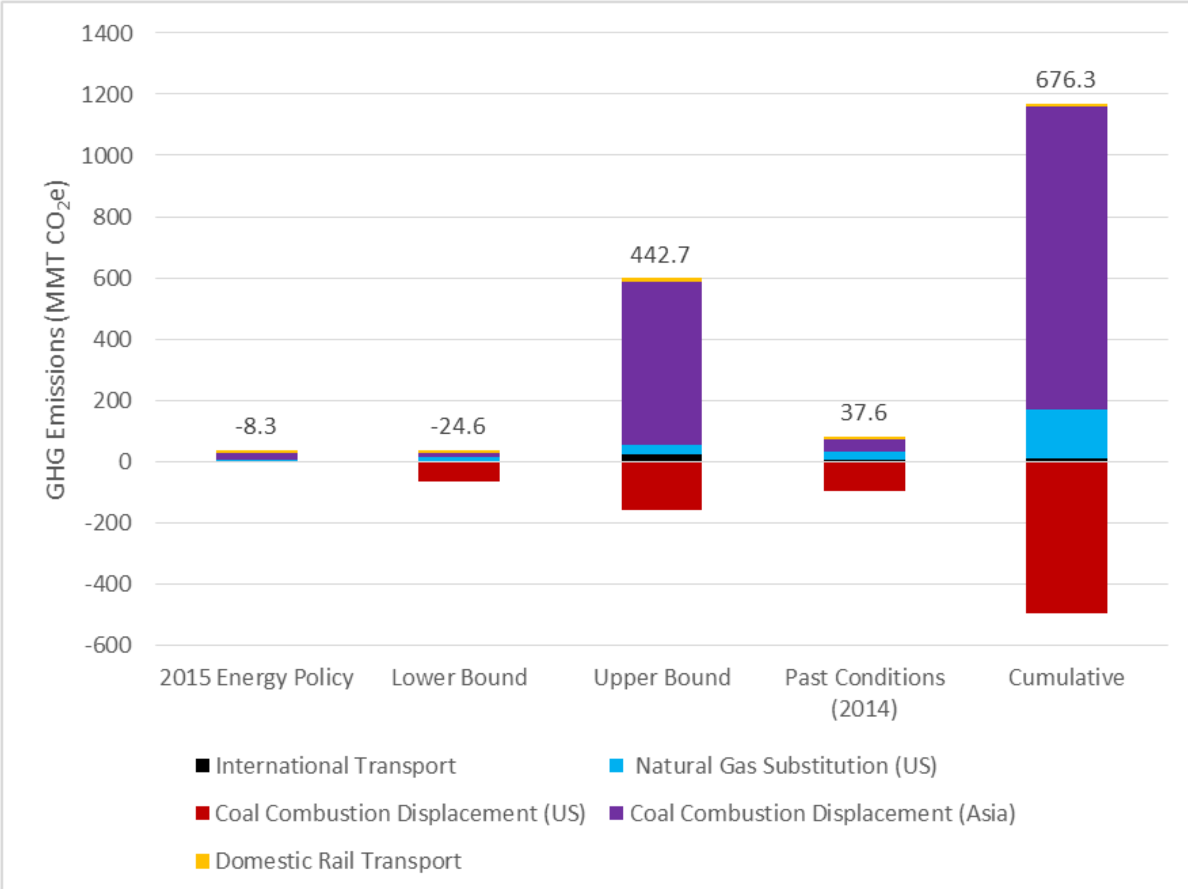
Notes: The Cumulative scenario is provided here for comparison and is addressed in Section 3.1.1.13, *Net Greenhouse Gas Emissions*, under Cumulative Scenario.

$MtCO_2e$ = metric tons of carbon dioxide equivalent

The total net impacts (Direct + Indirect emissions) range from a decrease in emissions of 24.6 $MMTCO_2e$ in the Lower Bound scenario relative to the no-action to an increase in emissions of 676.2 $MMTCO_2e$ (Figure 7) in the Cumulative scenario relative to the no-action. The Past Conditions (2014) scenario, which depicts a "business as usual" projection of market conditions in the absence of climate policy, indicates a total impact of -8.3 $MMTCO_2e$ across the entire time series studied. Figure 7 depicts the range of net total emissions from the operation of the Proposed Action across the different scenarios studied.[32]

[32] The bars in this figure do not include some of the smaller sources of emissions (for instance on-site emissions are not included). However, the number for each bar denotes the total net emissions for each scenario modeled and includes all emission sources.

Figure 7. Total Net Emissions for Each Scenario, 2018-2038 ($MMTCO_2e$)[a]



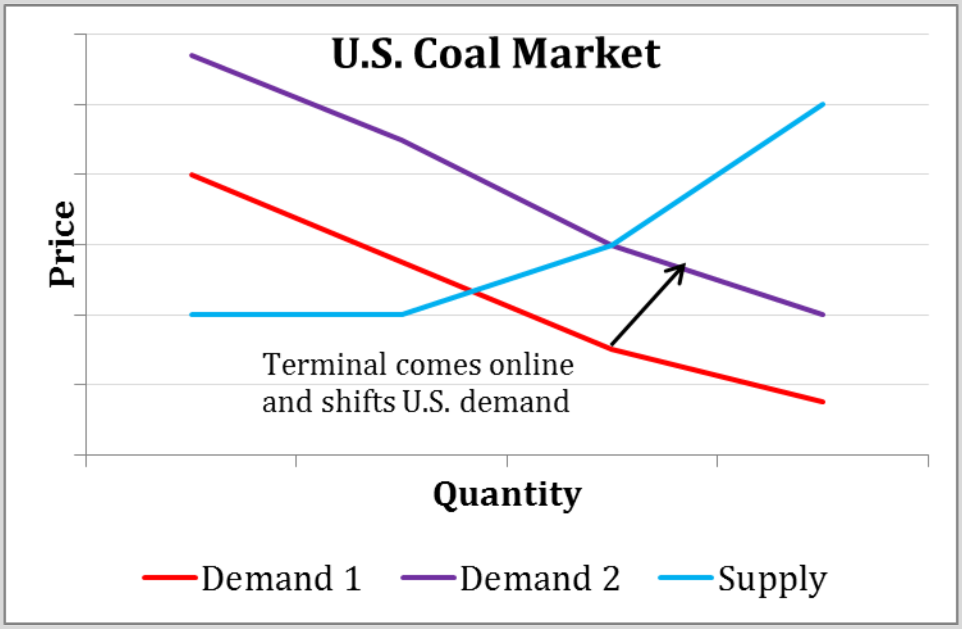
Notes: [a] Net GHG emissions represent the difference between the Proposed Action and the no-action. The bars in this figure do not include some of the smaller sources of emissions (for instance on-site emissions are not included). However, the number for each bar denotes the total net emissions for each scenario modeled and includes all emission sources. The Cumulative scenario is provided here for comparison and is addressed in Section 3.1.1.13, *Net Greenhouse Gas Emissions*, under Cumulative Scenario.

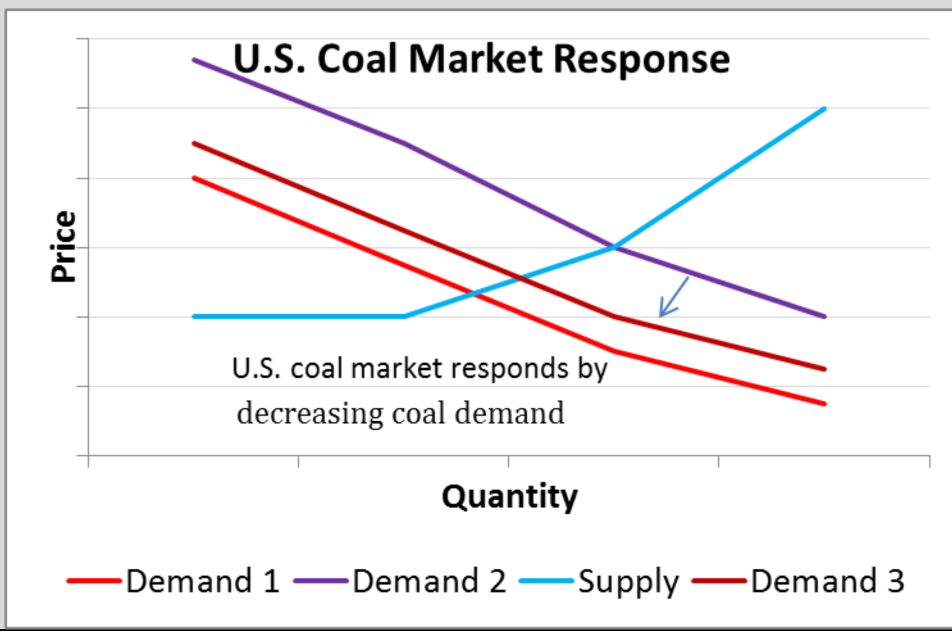
The shift in coal prices both domestically and internationally have a major impact on the resulting net GHG emissions for each scenario compared to the no-action. The textboxes that follow illustrate key concepts on the shift in coal prices. These shifts are mentioned as they influence the net change in GHG emissions as described below. For additional details, see the SEPA Coal Market Assessment Technical Report (ICF International 2016d).

Impact of the Proposed Action on Domestic Coal Supply and Demand, Assuming Coal Export Terminal Operates at Full Capacity

The operation of the Proposed Action would have the effect of improving integration of the U.S. and Asian coal markets. However, to the extent that Asian coal prices are higher than U.S. coal prices, operation of the Proposed Action would cause Asian coal prices to decline, while U.S. coal prices would increase. These changes in price would cause Asian coal demand to increase and U.S. coal demand to decrease.

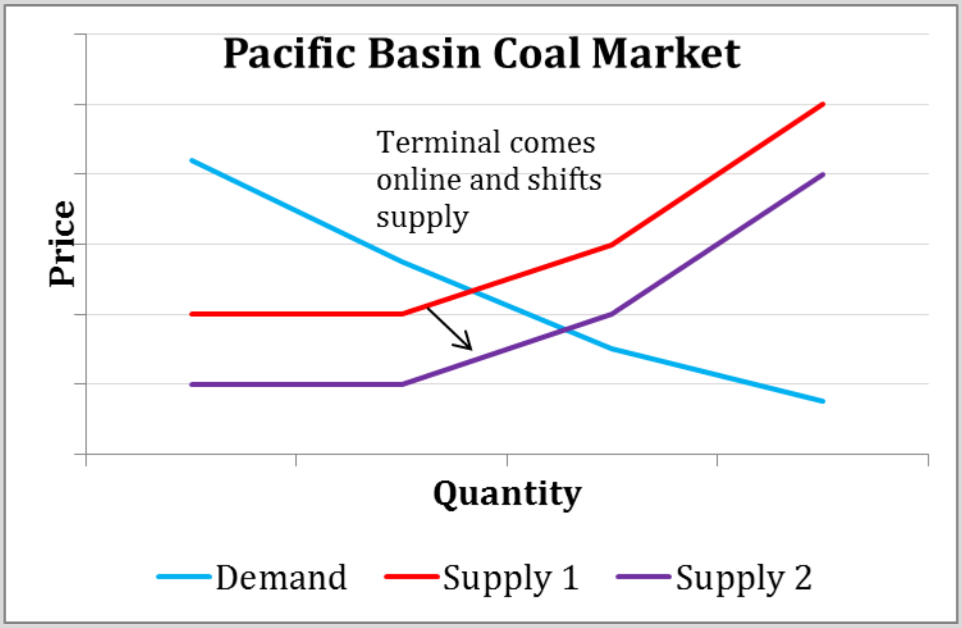
Increase in demand for U.S. coal as coal is exported from the Proposed Action would result in higher U.S. coal prices and a subsequent decrease in domestic coal demand compared to the no-action. (The coal "demand" from the coal export terminal is inelastic, while the domestic demand from coal plants is elastic and will decrease with an increase in coal prices.)

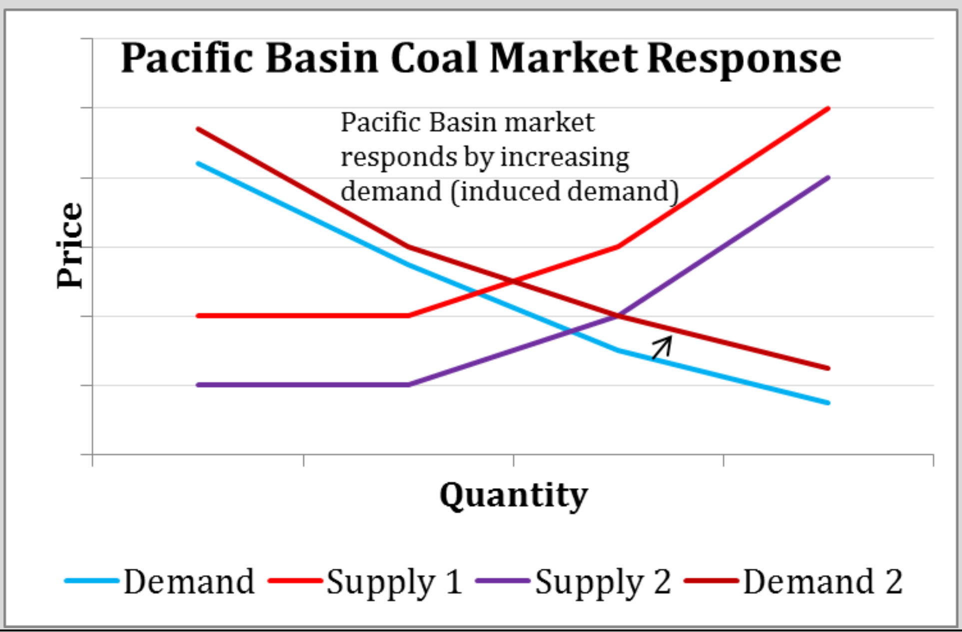




Impact of the Proposed Action on International Coal Supply and Demand, Assuming Coal Export Terminal Operates at Full Capacity

1. Increase in coal supplied to international market from the Proposed Action.
2. This increase in the coal supply in the Pacific Basin would result in lower international coal prices and a subsequent increase in international coal demand compared to the No- Action Alternative.





The diagrams above explain the general impact of the Proposed Action on coal markets regardless of the scenario. What makes each scenario different, however, is that the supply and demand curves for coal each have different slopes. The slopes of the demand curves vary based on economic and policy conditions dictated by each scenario. For example, the Lower Bound scenario has a lower slope for coal demand than the Past Conditions (2014) scenario, indicating a lower elasticity of demand in response to supply changes. In effect, the differences in supply and demand curves differentiate the emissions between each scenario.[33] Table 52 compares how coal and natural gas combustion change in response to market and policy conditions. The Past Conditions (2014) scenario row compares the emissions relative to the no-action, whereas the rest of the rows compare each scenario's emissions to the Past Conditions (2014) scenario.

Table 52. Impacts on Coal and Natural Gas Combustion across Scenarios

Scenario	U.S. Coal Markets	Asian Coal Markets	U.S. Natural Gas Markets
2015 Energy Policy	Decrease in domestic coal emissions in early years, followed by a slight increase from 2030. In 2030 and later, coal is not replaced by natural gas to the same extent as other scenarios.[a]	Increase in Asian coal emissions. The Proposed Action causes a decrease in Asian coal prices from increased supply, creating induced demand. The magnitude is smaller than in the Past Conditions (2014) scenario because coal prices are already low in this scenario, and the market reacts less sharply.	Decrease in domestic natural gas emissions. Due to the high renewable penetration and the Clean Power Policy, power operators will find it more economical to switch to cheaper, higher-emitting coals than natural gas in response to price effects from the Proposed Action.
Past Conditions (2014)	Decrease in domestic coal emissions. The Proposed Action causes an increase in domestic coal prices, reducing consumption.	Increase in Asian coal emissions. The Proposed Action causes a decrease in Asian coal prices from increased supply, creating induced demand.	Increase in domestic natural gas emissions. The Proposed Action causes an increase in domestic coal prices, increasing natural gas substitution for coal to meet energy demands.
Lower Bound	Decrease in domestic coal emissions. The Proposed Action causes an increase in domestic coal prices, reducing consumption. The magnitude is smaller than the Past Conditions (2014) scenario because coal prices are already low in this scenario, and the market reacts less sharply.	Increase in Asian coal emissions. The Proposed Action causes an increase in emissions due solely to changes in the coal mix consumed.	Increase in domestic natural gas emissions. The Proposed Action causes an increase in domestic coal prices, increasing natural gas substitution for coal to meet energy demands. The magnitude is lower than in the Past Conditions (2014) scenario because domestic coal markets are less sensitive to the Proposed Action.
Upper Bound	Decrease in domestic coal emissions. The Proposed Action causes an increase in domestic coal prices, reducing consumption. The magnitude is higher than the Past Conditions	Increase in Asian coal emissions. The Proposed Action causes a decrease in Asian coal prices from increased supply, creating induced demand. The magnitude is higher than in	Increase in domestic natural gas emissions. The Proposed Action causes an increase in domestic coal prices, increasing natural gas substitution for coal to meet energy demands. The

[33] The net emissions associated with the Proposed Action in the 2015 Energy Policy scenario are higher than in the Past Conditions (2014) scenario (i.e., 38 versus -8 $MMTCO_2e$), but occur against baseline emissions that are substantially lower than the Past Conditions (2014) scenario (see textbox entitled *Comparison of GHG Emissions Across Coal Market Assessment Scenarios* in Section 2.2.2.1, *Scope of Analysis,* for graphic of baseline emissions).

Scenario	U.S. Coal Markets	Asian Coal Markets	U.S. Natural Gas Markets
	(2014) scenario because coal prices are already high in this scenario, and the market reacts more sharply.	the Past Conditions (2014) scenario because coal prices and demand are already high; adding coal from The Proposed Action to Asian markets will create induced demand with low rates of coal substitution.	magnitude is higher than in the Past Conditions (2014) scenario because domestic coal markets are more sensitive to the Proposed Action.

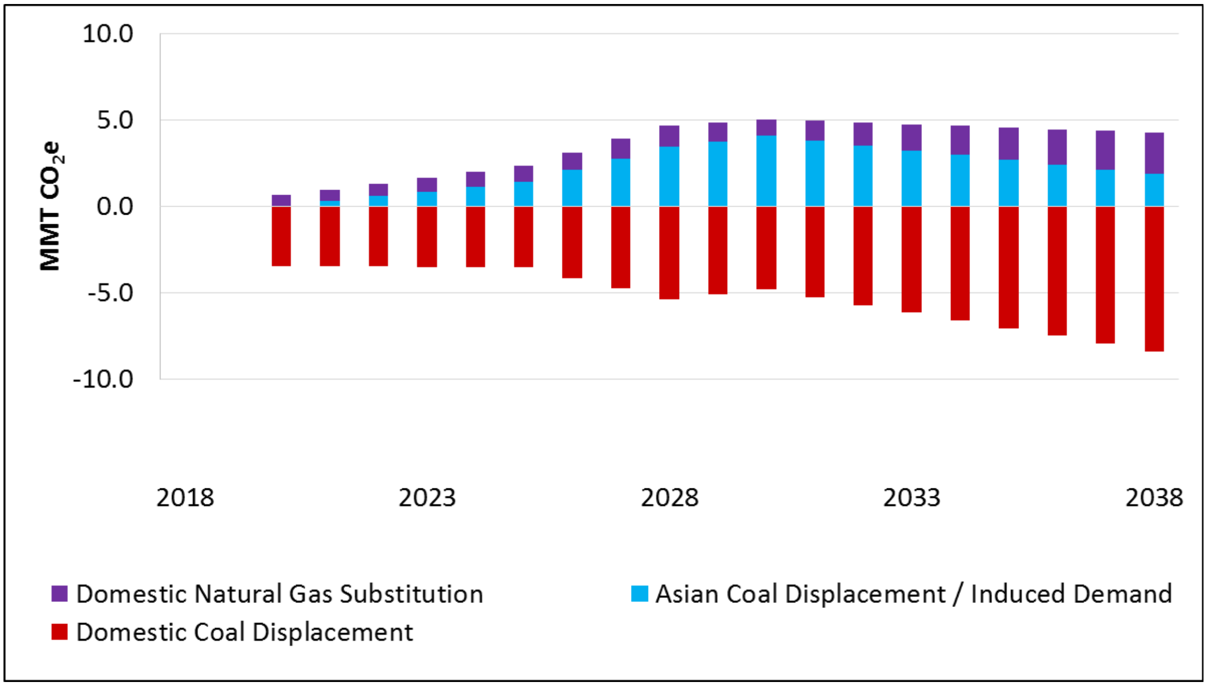
Notes:

[a] The coal emissions in the 2015 Energy Policy scenario increase in 2030 and later because the proposed Clean Power Plan modeled for this analysis is a rate-based approach, which means that the rate of emissions as measured in pounds CO_2 per megawatt-hour (MWh) must be less than the target set by EPA. Over time more renewable capacity is added to the system, which increases the denominator (MWh) without adding to the numerator (lbs CO_2). Thus as more renewables come online, additional coal or natural gas emissions can be generated without exceeding the rate limit. For example, assume a state with a target rate of 900 lbs CO_2/MWh and the state has only coal and renewable generation with emission rates of 1,800 lb CO_2/MWh and 0 lb CO_2/MWh, respectively. Then if the coal and renewable generation are equal at 1,000 MWh, the state will meet its rate of 900 lb/MWh (=(1,000 MWh x 1,800 lb/MWh + 1,000 MWh x 0 lb/MWh) / (1,000 MWh + 1,000 MWh)). Thus when the renewable generation increases, the coal generation could also increase to the same level without exceeding the rate limit.

In Figure 8, which identifies the major sources of emissions, it is clear that the largest contributors to net emissions are the extent to which coal and natural gas combustion are influenced in Asia and the United States; i.e., domestic rail transport and international transport play a much smaller role in net emissions. In the Past Conditions (2014) and Lower Bound scenarios, the single largest contributor to the net emissions is the displacement of coal combustion in the United States, driven by higher coal prices in response to the Proposed Action. In the Upper Bound scenario the emissions induced demand from lower coal prices in Asia in response to the Proposed Action outweighs the emissions from domestic coal displacement, resulting in positive net emissions.

Emissions estimated in the coal market assessment occur along a time series from when the coal export terminal would begin operating in 2021 through 2040. As shown in Figure 8, there is significant variation from year to year, as well as a ramp-up period where the coal export terminal would increase exports from zero to 44 million metric tons of coal per year.

Figure 8. Past Conditions (2014)—Net Annual Emissions, 2018–2038



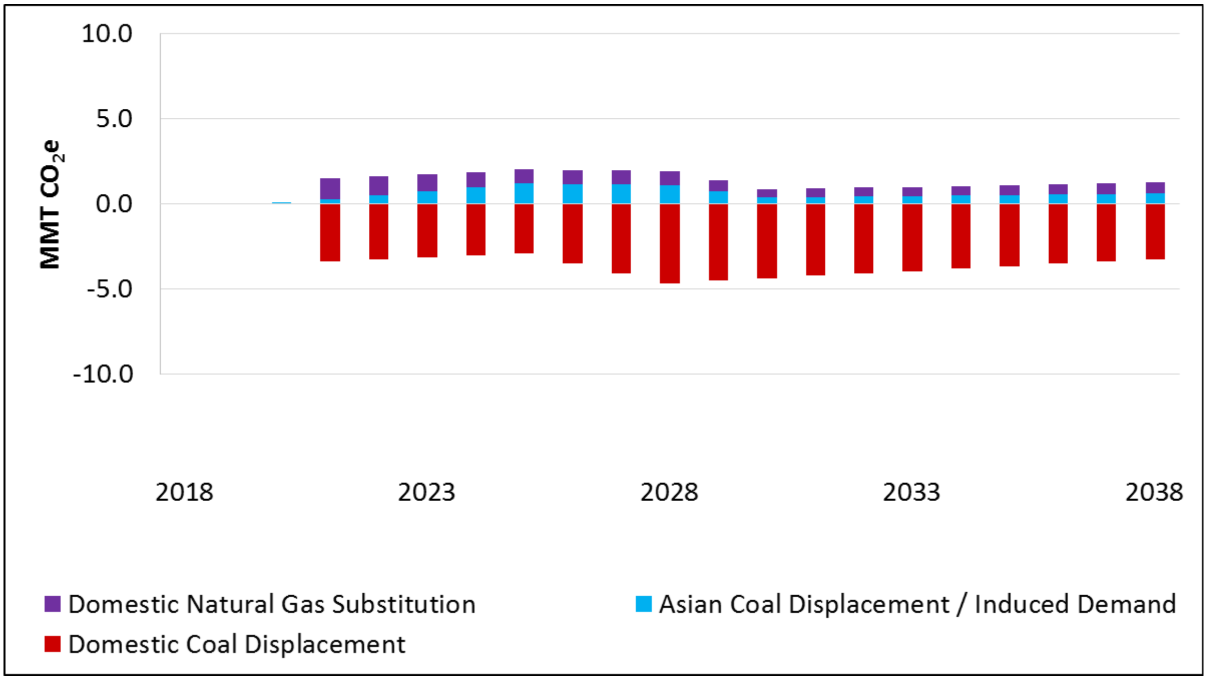
Note: Net GHG emissions represent the difference between the Proposed Action and the no-action.

Lower Bound Scenario

In the Lower Bound scenario (Figure 9), coal displacement in the United States results in a significant reduction of GHG emissions. Similarly, the lack of induced demand in Asia reduces Asian coal GHG emissions, as the increase is solely due to a shift to lower-heat-content coals. Compared to the Past Conditions (2014) scenario, the Lower Bound scenario results in higher natural gas emissions in the United States due to the deeper reduction of coal use domestically. In summary, the Lower Bound scenario results in the following emissions conditions.

- Emissions are lower than in the Past Conditions (2014) scenario.
- Coal emissions in Asia rise less than in the Past Conditions (2014) scenario because demand is not induced
- Natural gas substitution is lower because domestic prices are less sensitive to coal price changes.

Figure 9. Lower Bound – Net Annual Emissions, 2018–2038



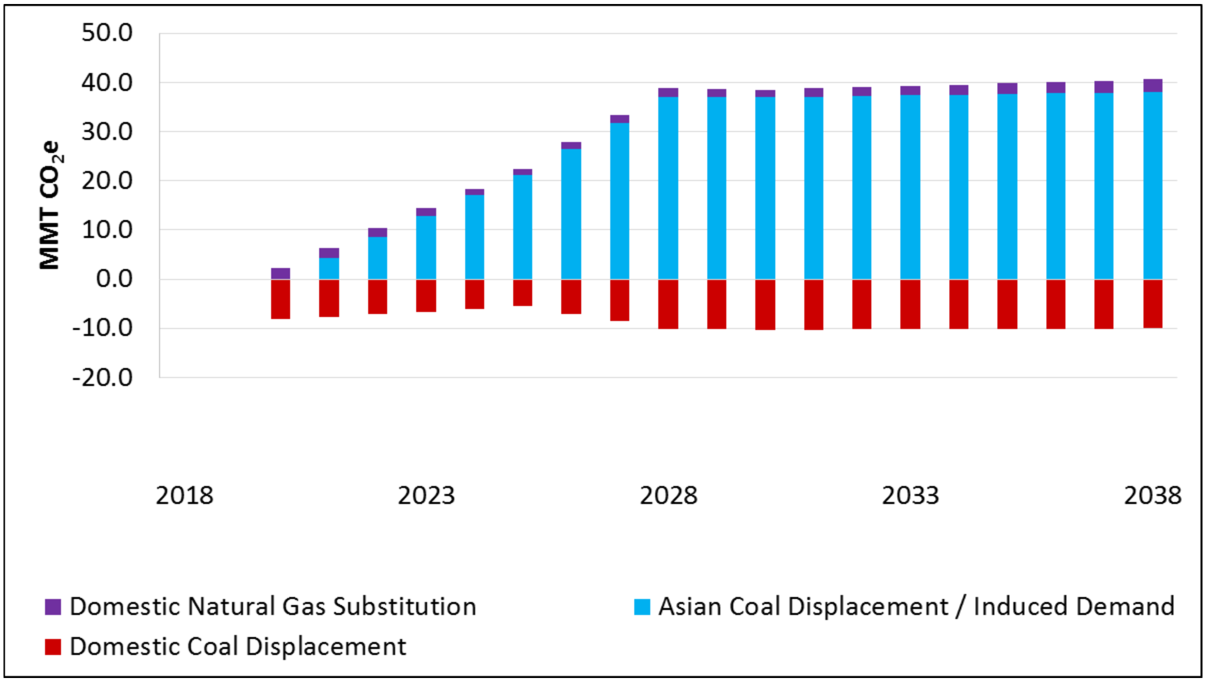
Note: Net GHG emissions represent the difference between the Proposed Action and the no-action.

Upper Bound Scenario

The Upper Bound scenario (Figure 10), which has a higher sensitivity to coal prices, exhibits stronger induced demand from Asia, resulting in higher Asian coal emissions than the Past Conditions (2014) scenario. Similarly, the sensitivity to coal prices is higher in the United States in this scenario, so more coal is displaced by natural gas relative to the Past Conditions (2014) scenario. In summary, the Upper Bound scenario results in the following emissions conditions.

- Emissions are higher than in the Past Conditions (2014) scenario.
- Coal emissions in Asia rise more than in the Past Conditions (2014) scenario because more demand is induced.
- Natural gas substitution is higher because domestic prices are more sensitive to coal price changes.

Figure 10. Upper Bound – Net Annual Emissions, 2018–2038



Note: Net GHG emissions represent the difference between the Proposed Action and the no-action.

2015 Energy Policy Scenario

The 2015 Energy Policy scenario (Figure 11) does not resemble the other scenarios, as U.S. coal displacement is significantly lower. This shift in coal displacement occurs because of the climate policy in the United States is assumed to depress coal prices and reduce coal combustion. Therefore, in this scenario, domestic coal emissions and natural gas emissions stay relatively flat throughout the time series. Net emissions in Asia increase less than in the Past Conditions (2014) scenario and are driven by a switch to lower-heat-content coals rather than by induced demand. (One important note is that, although state climate emissions goals drive up the use of renewables relative to the Past Conditions (2014) scenario, use of some coal is permissible.) The low cost of coal in the 2015 Energy Policy scenario reduces the substitution of natural gas for coal relative to the Past Conditions (2014) scenario. In summary, the 2015 Energy Policy scenario results in the following emissions conditions.

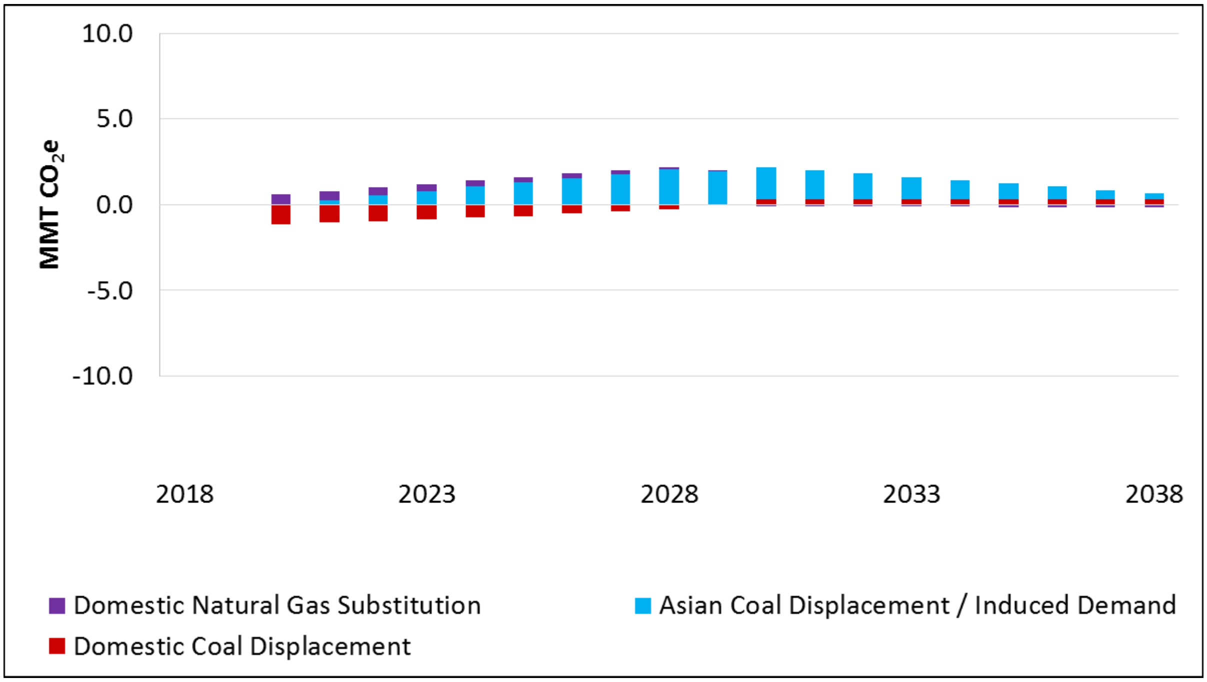
- Net emissions[34] from domestic coal combustion are less than in the Past Conditions (2014) scenario because the 2015 Energy Policy scenario is less sensitive to changes in coal prices due to lower coal demand.
- Net emissions from coal combustion in Asia increase less than in the Past Conditions (2014) scenario because coal demand under the 2015 Energy Policy scenario is less sensitive to changes in coal prices and thus there is less induced demand than in the Past Conditions (2014) scenario.
- Net GHG emissions from coal combustion in the 2015 Energy Policy scenario are primarily driven by changes in coal types consumed (i.e., low heat content versus high heat content coal)

[34] Net GHG emissions represent the difference between the Proposed Action and the No-Action.

rather than induced demand. In contrast, for the Past Conditions (2014) scenario, the induced demand drives the change in net GHG emissions from coal combustion.

- Net GHG emissions from coal combustion in the 2015 Energy Policy scenario are driven by changes in coal types consumed because induced demand is lower than in the Past Conditions (2014) scenario, where the induced demand drives the net change in GHG emissions from coal combustion.
- Net emissions from domestic natural gas combustion are lower than in the Past Conditions (2014) scenario because of the lower price of coal in the 2015 Energy Policy scenario.

Figure 11. 2015 Energy Policy—Net Annual Emissions, 2018–2038



Note: Net GHG emissions represent the difference between the Proposed Action and the no-action.

Overall, the net annual emissions across the four scenarios in 2028 range from a decrease of 1.1 $MMTCO_2e$ to an increase of 31.3 $MMTCO_2e$ relative to the no-action. Table 53 summarizes the net direct and indirect GHG emissions for each scenario.

Table 53. Net Emissions (Direct + Indirect) ($MMTCO_2e$)[a]

	Scenario			
	2015 Energy Policy	Lower Bound	Upper Bound	Past Conditions (2014)
Net Annual Emissions, 2028	3.2	-1.1	31.3	0.9
Total Net Emissions, 2018–2038	37.5	-24.6	442.7	-8.3

Notes:
[a] Net GHG emissions represent the difference between the Proposed Action and the no-action.
$MMTCO_2e$ = million metric tons of carbon dioxide equivalent

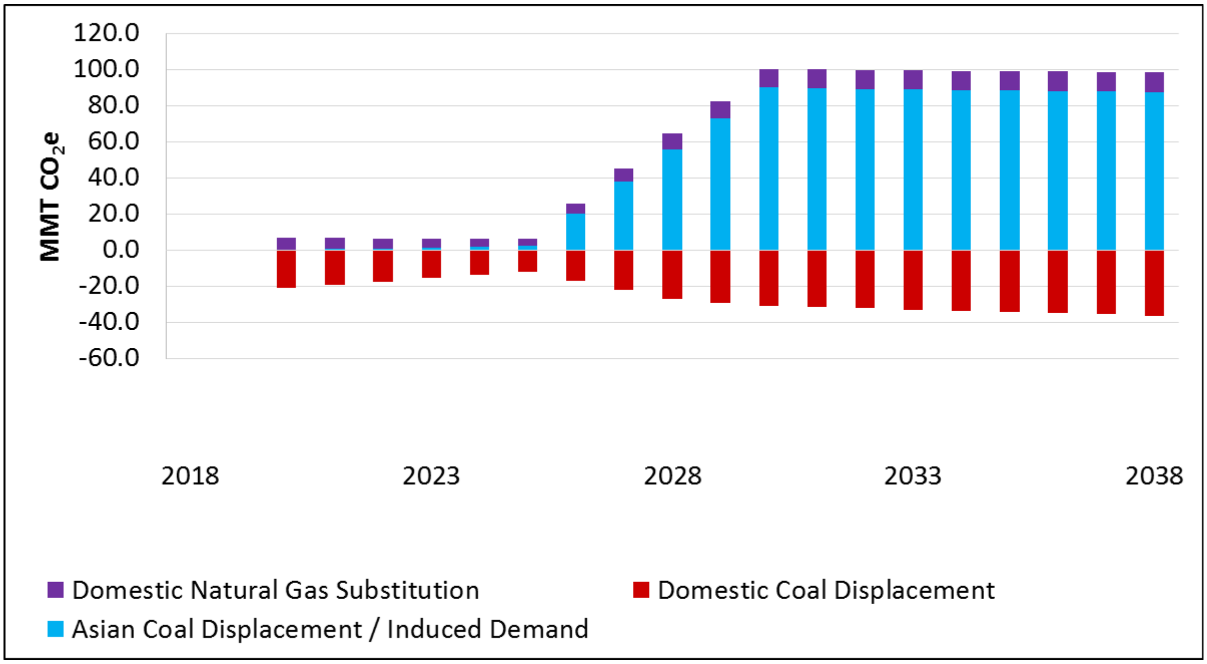
Cumulative Scenario

The Cumulative scenario includes other planned export coal terminals in the Pacific Northwest. Each terminal would operate at full capacity, for a total export tonnage of 201.3 million short tons, which includes both thermal and metallurgical coal. The emissions from the operation of the other coal export terminals are not included in the cumulative emissions analysis. Their impact is solely limited to their ability to influence coal supplies and prices. All other assumptions are the same as the Past Conditions (2014) scenario. The Cumulative scenario compares the no-action without the additional coal export terminals against the Proposed Action that includes the other coal export terminals.

Similar to the 2015 Energy Policy scenario, the Cumulative scenario displays some unique behavior relative to the Past Conditions (2014) scenario (Figure 12.). The operation of multiple coal export terminals drives down domestic coal consumption more than in any other scenario, which is only partially offset by increased natural gas consumption in the United States. Consequently, this scenario has even lower net domestic emissions than the Lower Bound scenario, despite an economic and policy context that resembles the Past Conditions (2014) scenario. However, Asian coal displacement from a large increase in induced demand outweighs any reduction in domestic emissions. In summary, the Cumulative scenario results in the following emissions conditions.

- Net emissions relative to the no-action are higher than the Past Conditions (2014) scenario (676.3 $MMTCO_2e$ versus -8.3 from 2018 to 2038).
- Induced demand is higher than the Past Conditions (2014) scenario due to the effects of all coal export terminals.
- Coal use in the United States declines more relative to the Past Conditions (2014) scenario because domestic prices are more sensitive to multiple coal export terminals.
- Natural gas substitution is *significantly* higher than in the Past Conditions (2014) scenario because domestic prices are more sensitive to coal price increases from the combined impact of multiple coal export terminals.

Figure 12. Cumulative Scenario—Net Annual Emissions, 2018–2038



Note: Net GHG emissions represent the difference between the Proposed Action and the no-action.

3.1.2 No-Action Alternative

Under the No-Action Alternative[35], the Applicant would not construct the coal export terminal and GHG emissions would not be affected by construction or operation. However, the Applicant has indicated that the operation of the current bulk product terminal would continue and increase on the project area. The Applicant would not construct Docks 2 and 3. Dock 1 would continue to be used for bulk cargo, primarily alumina, and might be used for general cargo.

Alternative uses of the project area would be expected to result in minimal increases in GHG emissions relative to current conditions in Cowlitz County. Under the No-Action Alternative, the Applicant anticipates importing from Asia up to 600,000 tons of calcined pet coke a year. This material would arrive by vessel and be stored in a building at the facility. Approximately 200,000 tons of coal tar pitch per year could also be imported by vessel, as well as an undetermined amount of cement. Future operations also result in two additional daily trains arriving and departing the facility with an average rail car length of 30 cars carrying bulk product. Each train is composed of two locomotives. In addition, an average of 26 Panamax-sized vessels arrive and depart each year, an increase of 20 vessels compared to the 6 vessels that currently arrive and depart. Truck haul emissions associated with the transport of coal to the nearby Weyerhaeuser facility are also included. Emissions from the consumption of electricity at the bulk product terminal would increase due to the planned terminal expansion; however, the extent of this increase is uncertain. The estimated emissions are shown in Table 54.

Table 54. No-Action Alternative Annual Average Emissions from Rail, Vessel and Haul Trucks Operating within Cowlitz County

Source	Maximum Annual Average Emissions ($MtCO_2e$)
Locomotive Combustion	593
Vessel Combustion	411
Haul Trucks	238
Total	**1,242**

The no-action in coal market assessment contains different boundaries than the emission sources above. While the no-action for the coal market assessment examines the implications of not building the coal export terminal, net emissions between a given coal market scenario and the no-action do not consider changes in emissions from emission sources described in Table 54. In particular, the coal market analysis no-action does not evaluate net impacts associated with existing vessel traffic and traffic.

3.2 Emissions in Context

To provide a frame of reference for these emissions estimates, the projected direct and total net emissions from the Proposed Action are compared to emissions from the transportation and coal combustion sectors in the United States as well as to GHG reduction targets from state and federal programs.

Across all scenarios, the total direct (construction, operation on site, transportation within Cowlitz County)[36] emissions associated with the Proposed Action are 573,516 $MtCO_2e$ from 2018 to 2038, with annual emissions of 38,477 $MtCO_2e$ occurring in 2028 when the coal export terminal reaches full export capacity (see Table 49). This is equivalent to adding 8,100 passenger cars on the road (U.S. Environmental Protection Agency 2015c). Washington State's total GHG emissions were 92.0 $MMTCO_2e$ in 2012, the most recent year for which a GHG inventory was published. Of that total, 42.5 $MMTCO_2e$ (46.2%) are attributable to the transportation sector and 12.1 $MMTCO_2e$ (13.2%) are attributable to coal combustion in the electricity sector (Washington State Department of Ecology, 2016). Based on 2012 emissions data, if the Proposed Action were operating today, direct annual emissions would amount to 38,477 $MtCO_2e$, or less than 0.05% of Washington State's total annual emissions.

In 2015, the EPA finalized state-specific targets to reduce CO_2 emissions in the power sector by 32% below 2005 levels by 2030. The statewide mass-based CO_2 performance goal for Washington state is approximately 10.74 million short tons (U.S. Environmental Protection Agency 2015d). The 2028 direct emissions for the Proposed Action would be approximately 0.3% of that total.

After factoring the indirect emissions, the net emissions from the Proposed Action in 2028 would range from an emissions reduction of 1.1 $MMTCO_2e$ to an emissions increase of 31.3 $MMTCO_2e$, with a net of 0.9 $MMTCO_2e$ emissions for the Past Conditions (2014) scenario (Table 53). Coal

[36] Direct emissions refer to GHG emissions from bulk terminal construction, operation, and transportation within Cowlitz County, including rail transport of coal in Cowlitz County, vehicle-crossing delay, bulk terminal construction, bulk terminal operation—equipment use, vessel idling and tugboat use at terminal, and vessel transport of coal in Cowlitz County.

combustion emissions in the United States were 1,658.1 $MMTCO_2$ in 2013, whereas the total transportation emissions in the United States were 1,718.4 $MMTCO_2$ (U.S. Environmental Protection Agency 2015a).

Washington State legislation, Revised Code of Washington (RCW) 70.235.050, Limiting Greenhouse Gas Emissions, requires annual GHG emissions to be reduced to 1990 levels (88.4 $MMTCO_2e$) by 2020. The Washington State goal represents an annual reduction of 3.3 MMTCO2e below the 2011 state emissions levels. The statewide emissions associated with the Proposed Action, approximately 0.4 $MMTCO_2e$ across the four scenarios, are about 12% of the emissions reduction goal.

The United States has committed to reduce its GHG emissions by approximately 17% from 2005 levels (7,350.2 $MMTCO_2e$) by 2020—a decrease of about 1,250 $MMTCO_2e$ (Executive Office of the President 2013). As part of the nonbinding climate policy agreement with China, the United States has set an emissions reduction target to reduce emissions 26 to 28% below 2005 emissions (6,428 MMTCO2e) by 2025 (White House Office of the Press Secretary 2014). This policy would therefore reduce annual emissions to a level of 4,628 to 4,757 MMTCO2e by 2025. The reduction in annual emissions would range from 1,035 to 1,163 $MMTCO_2e$ below 2013 annual emissions. If the target were reached through consistent annual reductions, the United States would have to reduce annual emissions by 86 to 97 $MMTCO_2e$ each consecutive year, beginning in 2014.

On the global scale, the International Energy Agency's 450 Scenario projects an energy pathway that is consistent with a 50% chance of meeting the goal of limiting the long-term increase in average global temperature to 2°C compared with preindustrial levels (International Energy Agency 2011). The 450 Scenario results in energy-related CO_2 emissions decreasing from 31.6 gigatons in 2012 to 25.4 gigatons in 2030.

3.3 Mitigation

Based on the findings in this technical report, the co-lead agencies (Cowlitz County and Washington State Department of Ecology) developed potential Applicant mitigation measures. The SEPA Draft EIS presents these mitigation measures.

Chapter 4
Supplementary Data

4.1 Interpolated Results from Coal Market Assessment

The coal market assessment evaluated changes in domestic and international coal demand for 2020, 2025, 2030, and 2040. For the GHG analysis, the years 2020, 2025, 2028, and 2038 are extracted from the full, interpolated time series and presented below. As mentioned in 2.2.2.2, *Method for Assembling an Emissions Time Series,* the coal market analysis values were adjusted to capture the gradual increase in coal exports from 2020 to 2025 (from zero to 25 million metric tons) and 2028 (full capacity of 44 million metric tons). This chapter presents the interpolated results based on the coal market assessment results. The following tables are presented.

- Table 55. Interpolated Coal Market Assessment Results, 2015 Energy Policy
- Table 56. Interpolated Coal Market Assessment Results, Lower Bound
- Table 57. Interpolated Coal Market Assessment Results, Upper Bound
- Table 58. Interpolated Coal Market Assessment Results, Past Conditions (2014)
- Table 59. Interpolated Coal Market Assessment Results, Cumulative

Table 55. Interpolated Coal Market Assessment Results, 2015 Energy Policy

	2020	2025	2028	2038
Coal Exported Through the Proposed Action (million metric tons)	0.0	25.0	44.0	44.0
Coal by Origin exported Through the Proposed Action (million metric tons)	0.0	0.0	0.0	0.0
Powder River Basin - Total	0.0	25.0	44.0	27.8
MT PRB	0.0	25.0	44.0	27.8
Powder River Basin WY 8400	0.0	0.0	0.0	0.0
Powder River Basin WY 8800	0.0	0.0	0.0	0.0
Uinta Basin - Total	0.0	0.0	0.0	16.2
Colorado	0.0	0.0	0.0	0.0
Utah	0.0	0.0	0.0	16.2
Total U.S. CO_2 Emissions - Coal (thousand metric tons)	**-1,141.4**	**-654.4**	**-266.2**	**316.9**
Total Pacific Basin CO_2 Emissions - Coal (thousand metric tons)	**0.0**	**1,315.1**	**2,039.8**	**359.8**
Asia - Other	0.0	0.0	-2.9	-1.0
Australia	0.0	0.0	0.0	0.0
China	0.0	4.4	3.1	0.0
Hong Kong	0.0	0.0	0.0	0.0
India	0.0	0.0	0.0	0.0
Indonesia	0.0	0.0	0.0	0.0
Japan	0.0	0.5	1.0	-1.0
Korea	0.0	0.1	0.1	-0.1
Taiwan	0.0	0.0	0.1	0.1
Total U.S. Natural Gas Consumption (TBtu)	**11.2**	**5.9**	**3.2**	**-3.0**
Total U.S. CO_2 emissions - Natural Gas (thousand metric tons)	**597.1**	**313.1**	**170.4**	**-156.7**
Pacific Basin Coal Exported by Vessel (non-project) by Destination (million Metric Ton-Miles)	0.0	-75,514.6	-165,711.7	-181,598.4
Asia - Other	0.0	0.0	-45,908.0	-15,302.7
Australia	0.0	0.0	0.0	0.0
China	0.0	0.0	0.0	0.0
Hong Kong	0.0	19.8	34.8	34.8
India	0.0	0.0	0.0	0.0
Indonesia	0.0	0.0	0.0	0.0
Japan	0.0	-75,737.0	-120,195.2	-161,477.1
Korea	0.0	131.5	231.4	-5,179.0
Taiwan	0.0	71.2	125.2	325.6

Table 56. Interpolated Coal Market Assessment Results, Lower Bound

	2020	2025	2028	2038
Coal exported through the Proposed Action (million metric tons)	0.0	25.0	44.0	44.0
Coal by Origin (million metric tons)	0.0	0.0	0.0	0.0
Powder River Basin - Total	0.0	25.0	44.0	35.0
MT PRB	0.0	25.0	44.0	35.0
Powder River Basin WY 8400	0.0	0.0	0.0	0.0
Powder River Basin WY 8800	0.0	0.0	0.0	0.0
Uinta Basin - Total	0.0	0.0	0.0	9.0
Colorado	0.0	0.0	0.0	0.0
Utah	0.0	0.0	0.0	9.0
Net Total U.S. CO_2 Emissions - Coal (thousand metric tons CO_2)	**-2,155.8**	**-2,934.5**	**-4,675.5**	**-3,248.9**
Net Total Pacific Basin CO_2 Emissions - Coal (thousand metric tons)	**0.0**	**1,203.2**	**1,072.1**	**608.5**
Asia - Other	0.0	0.0	0.0	0.0
Australia	0.0	0.0	0.0	0.0
China	0.0	6.4	4.5	0.0
Hong Kong	0.0	0.0	-0.2	-0.1
India	0.0	0.0	0.0	0.0
Indonesia	0.0	0.0	0.0	0.0
Japan	0.0	0.5	0.9	-3.1
Korea	0.0	0.0	-0.9	-2.6
Taiwan	0.0	0.0	0.0	0.0
Total U.S. Natural Gas Consumption (TBtu)	**15.0**	**15.1**	**16.0**	**11.8**
Total U.S. CO_2 Emissions - Natural gas (thousand metric tons)	**795.4**	**802.6**	**850.6**	**625.9**
Pacific Basin Coal Exported by Vessel (non-project) by Destination (million metric ton-miles)	0.0	-61,478.1	-129,664.0	-272,009.7
Asia - Other	0.0	0.0	0.0	0.0
Australia	0.0	0.0	0.0	0.0
China	0.0	0.0	0.0	0.0
Hong Kong	0.0	0.0	-3,674.4	-1,224.8
India	0.0	0.0	0.0	0.0
Indonesia	0.0	0.0	0.0	0.0
Japan	0.0	-61,478.1	-108,201.5	-202,060.9
Korea	0.0	0.0	-17,788.0	-68,724.0
Taiwan	0.0	0.0	0.0	0.0

Table 57. Interpolated Coal Market Assessment Results, Upper Bound

	2020	2025	2028	2038
Coal Exported Through the Proposed Action (million metric tons)	0.0	25.0	44.0	44.0
Coal by Origin Exported Through the Proposed Action (million metric tons)	0.0	0.0	0.0	0.0
Powder River Basin - Total	0.0	11.8	26.9	33.0
MT PRB	0.0	11.8	26.9	33.0
Powder River Basin WY 8400	0.0	0.0	0.0	0.0
Powder River Basin WY 8800	0.0	0.0	0.0	0.0
Uinta Basin - Total	0.0	13.2	17.1	11.0
Colorado	0.0	0.0	0.0	0.3
Utah	0.0	13.2	17.1	10.6
Net Total U.S. CO_2 Emissions - Coal (thousand metric tons CO_2)	**-8,222.8**	**-5,519.4**	**-10,065.9**	**-10,042.3**
Net Total Pacific Basin CO_2 Emissions - Coal (thousand metric tons)	**0.0**	**21,245.4**	**37,113.8**	**38,023.8**
Asia - Other	0.0	0.0	0.0	0.0
Australia	0.0	0.0	0.0	0.0
China	0.0	0.9	-1.5	-0.2
Hong Kong	0.0	0.1	0.2	0.2
India	0.0	8.1	13.2	15.8
Indonesia	0.0	0.0	0.0	0.0
Japan	0.0	1.4	1.5	2.7
Korea	0.0	0.6	1.6	2.5
Taiwan	0.0	0.5	0.9	1.0
Total U.S. Natural Gas Consumption (TBtu)	**43.3**	**22.5**	**33.5**	**48.8**
Total U.S. CO_2 Emissions - Natural Gas (thousand metric tons)	**2,296.9**	**1,194.3**	**1,781.1**	**2,592.2**
Pacific Basin Coal Exported by Vessel (non-project) by Destination (million metric ton-miles)	0.0	-34,785.9	-38,610.2	-49,520.2
Asia - Other	0.0	0.0	0.0	0.0
Australia	0.0	0.0	0.0	0.0
China	0.0	0.0	-5,443.7	-43,002.3
Hong Kong	0.0	203.6	358.3	724.2
India	0.0	25,027.2	64,246.5	15,542.4
Indonesia	0.0	0.0	0.0	0.0
Japan	0.0	-62,223.1	-101,408.3	-24,198.5
Korea	0.0	1,452.8	719.5	-2,564.4
Taiwan	0.0	753.5	2,917.6	3,978.4

Table 58. Interpolated Coal Market Assessment Results, Past Conditions (2014)

	2020	2025	2028	2038
Coal Exported Through the Proposed Action (million metric tons)	0	25.0	44.0	44.0
Coal by Origin (million metric tons)	0	0.0	0.0	0.0
Powder River Basin - Total	0	25.0	44.0	32.1
MT PRB	0	25.0	44.0	32.1
Powder River Basin WY 8400	0	0.0	0.0	0.0
Powder River Basin WY 8800	0	0.0	0.0	0.0
Uinta Basin - Total	0	0.0	0.0	11.9
Colorado	0	0.0	0.0	0.0
Utah	0	0.0	0.0	11.9
Net Total U.S. CO_2 Emissions - Coal (thousand metric tons CO_2)	**-3,454.4**	**-3,539.4**	**-5,385.6**	**-8,390.4**
Net Total Pacific Basin CO_2 Emissions - Coal (thousand metric tons)	**0.0**	**1,418.8**	**3,434.4**	**1,856.1**
Asia - Other	0.0	0.0	0.0	0.0
Australia	0.0	0.0	0.0	0.0
China	0.0	1.3	3.6	0.9
Hong Kong	0.0	0.0	0.0	0.0
India	0.0	0.0	0.0	-1.0
Indonesia	0.0	0.0	0.0	0.0
Japan	0.0	0.6	1.3	-0.9
Korea	0.0	0.1	0.2	0.2
Taiwan	0.0	0.1	0.2	0.2
Total U.S. Natural Gas Consumption (TBtu)	**11.9**	**17.1**	**23.1**	**45.3**
Total U.S. CO_2 Emissions - Natural Gas (thousand metric tons)	**630.2**	**906.4**	**1,225.3**	**2,404.5**
Pacific Basin Coal Exported by Vessel (non-project) by Destination (million metric ton-miles)	0.0	-74,888.8	-128,362.7	-174,822.3
Asia - Other	0.0	0.0	0.0	0.0
Australia	0.0	0.0	0.0	0.0
China	0.0	0.0	0.0	0.0
Hong Kong	0.0	46.2	81.3	164.4
India	0.0	0.0	0.0	0.0
Indonesia	0.0	0.0	0.0	0.0
Japan	0.0	-75,435.1	-129,415.7	-176,838.8
Korea	0.0	329.8	580.4	1,042.2
Taiwan	0.0	170.3	391.3	809.9

Table 59. Interpolated Coal Market Assessment Results, Cumulative

	2020	2025	2028	2038
Coal Exported Through the Proposed Action (million metric tons)	0.0	25.0	44.0	44.0
Coal by Origin exported Through the Proposed Action (million metric tons)	0.0	0.0	0.0	0.0
Powder River Basin - Total	0.0	25.0	42.6	28.1
MT PRB	0.0	25.0	42.6	28.1
Powder River Basin WY 8400	0.0	0.0	0.0	0.0
Powder River Basin WY 8800	0.0	0.0	0.0	0.0
Uinta Basin - Total	0.0	0.0	1.4	15.9
Colorado	0.0	0.0	0.0	0.0
Utah	0.0	0.0	1.4	15.9
Net Total U.S. CO_2 Emissions - Coal (thousand metric ton CO_2)	**-20,880.3**	**-12,240.5**	**-27,234.2**	**-36,326.1**
Net Total Pacific Basin CO_2 Emissions - coal (thousand metric tons)	**51.5**	**2,267.9**	**55,510.8**	**87,508.1**
Asia – Other	0.0	0.0	-1.3	-3.9
Australia	0.0	0.0	0.0	0.0
China	0.3	3.0	5.0	0.9
Hong Kong	0.0	0.0	0.1	-0.7
India	0.0	0.0	28.9	48.2
Indonesia	0.0	0.0	0.0	0.0
Japan	0.0	0.7	2.5	0.8
Korea	0.0	0.3	2.0	-1.9
Taiwan	0.0	0.2	-2.4	-3.1
Total U.S. Natural Gas Consumption (TBtu)	**126.4**	**71.0**	**168.1**	**202.1**
Total U.S. CO_2 emissions - Natural gas (thousand metric tons)	**6,711.5**	**3,769.2**	**8,926.0**	**10,731.9**
Pacific Basin Coal Exported by Vessel (non-project) by Destination (million metric ton-miles)	1,998.4	-60,582.8	-65,178.0	-260,674.3
Asia – Other	0.0	0.0	-21,176.5	-62,107.2
Australia	0.0	0.0	0.0	0.0
China	0.0	0.0	-11,605.3	-3,868.4
Hong Kong	0.0	67.1	176.4	-13,390.3
India	0.0	0.0	0.0	0.0
Indonesia	0.0	0.0	0.0	0.0
Japan	1,998.4	-46,156.0	-4,739.3	-66,240.4
Korea	0.0	-14,741.4	-16,310.3	-119,896.4
Taiwan	0.0	247.4	-11,522.9	4,828.5

4.2 Evaluation of Coal Extraction Studies

The GHG emissions from induced coal extraction in the Powder River Basin and the Uinta Basin because of the Proposed Action are not included in the GHG analysis. This exclusion assumes that any future coal mine leases would require separate GHG analyses as part of the NEPA process for new coal mine leases. This section identifies EISs and lease applications that mention GHG emissions for coal mines relevant to the Proposed Action. The scopes of these EISs and lease applications for coal mines in the Powder River Basin and Uinta Basins are compared to the scope of this GHG analysis (Table 60). This table demonstrates that the emissions from mining associated with the Proposed Action are accounted for in separate analyses. As indicated, several EISs address GHGs from coal extraction, coal processing, rail transport, and operations of the coal mine.

Table 60. Comparison of Coal Mine Environmental Impact Statements and Lease Applications to Scope of This GHG Analysis

Mine	Extraction	Processing	Rail Transport to/from Project Area	Rail Transport within Project Area	Infrastructure Operation—Electricity Use
Quantitative Analysis					
West Antelope II Coal Lease Application EIS	✓	✓	✓	✓	✓
West Hay Creek EIS	✓	✓			
South Gillette Area Coal Lease Application EIS	✓	✓			✓
Spring Creek Coal Mine EIS	✓	✓	✓		✓
Wright Area Coal Lease Application EIS	✓	✓			✓
Qualitative Analysis					
Maysdorf Coal Lease Application EIS	✓	✓			
North Jacobs Ranch EIS	✓	✓			

Chapter 5
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MILLENNIUM BULK TERMINALS—LONGVIEW SEPA ENVIRONMENTAL IMPACT STATEMENT

SEPA CLIMATE CHANGE TECHNICAL REPORT

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Acronyms and Abbreviations

°F	degrees Fahrenheit
Applicant	Millennium Bulk Terminals—Longview
BNSF	BNSF Railway Company
CFR	Code of Federal Regulations
CMIP5	Fifth Coupled Model Intercomparison Project
GHG	greenhouse gas
RCP	Representative Concentration Pathway
RCW	Revised Code of Washington
SEPA	State Environmental Policy Act
USC	United States Code
WAC	Washington Administrative Code

Chapter 1
Introduction

This technical report discusses the potential impacts of climate change related to increased greenhouse gas emissions from the proposed Millennium Bulk Terminals—Longview project (Proposed Action). This technical report also assesses the potential impacts on the Proposed Action and the No-Action Alternative as a result of climate change.

1.1 Project Description

Millennium Bulk Terminals—Longview, LLC (Applicant) proposes to construct and operate a coal export terminal in Cowlitz County, Washington, along the Columbia River (Figure 1). The coal export terminal would receive coal from the Powder River Basin in Montana and Wyoming and the Uinta Basin in Utah and Colorado via rail, then load and transport the coal by ocean-going ships via the Columbia River and Pacific Ocean to overseas markets in Asia. The coal export terminal would be capable of receiving, stockpiling, blending, and loading coal by conveyor onto ships for export. Construction of the coal export terminal would begin in 2018. For the purpose of this analysis, it is assumed the coal export terminal would operate at full capacity in 2028.

The following subsections present a summary of the Proposed Action and No-Action Alternative. For detailed information on these alternatives, see the Washington State Environmental Policy Act (SEPA) Alternatives Technical Report (ICF International 2016).

1.1.1 Proposed Action

The Proposed Action would develop a coal export terminal on 190 acres (project area). The project area is located within an existing 540-acre area currently leased by the Applicant at the former Reynolds Metals Company facility (Reynolds facility), and land currently owned by Bonneville Power Administration. The project area is adjacent to the Columbia River in unincorporated Cowlitz County, Washington near Longview city limits (Figure 2).

The Applicant currently and separately operates, and would continue to separately operate, a bulk product terminal on land leased by the Applicant. Industrial Way (State Route 432) provides vehicular access to the Applicant's leased land. The Reynolds Lead and the BNSF Spur, both operated by Longview Switching Company,[1] provide rail access to the Applicant's leased area from a point on the BNSF Railway Company (BNSF) main line (Longview Junction, Washington) located to the east in Kelso, Washington. Ships access the Applicant's leased area via the Columbia River and berth at an existing dock (Dock 1) operated by the Applicant in the Columbia River.

[1] Longview Switching Company is jointly owned by BNSF and Union Pacific Railroad.

Figure 1. Project Vicinity

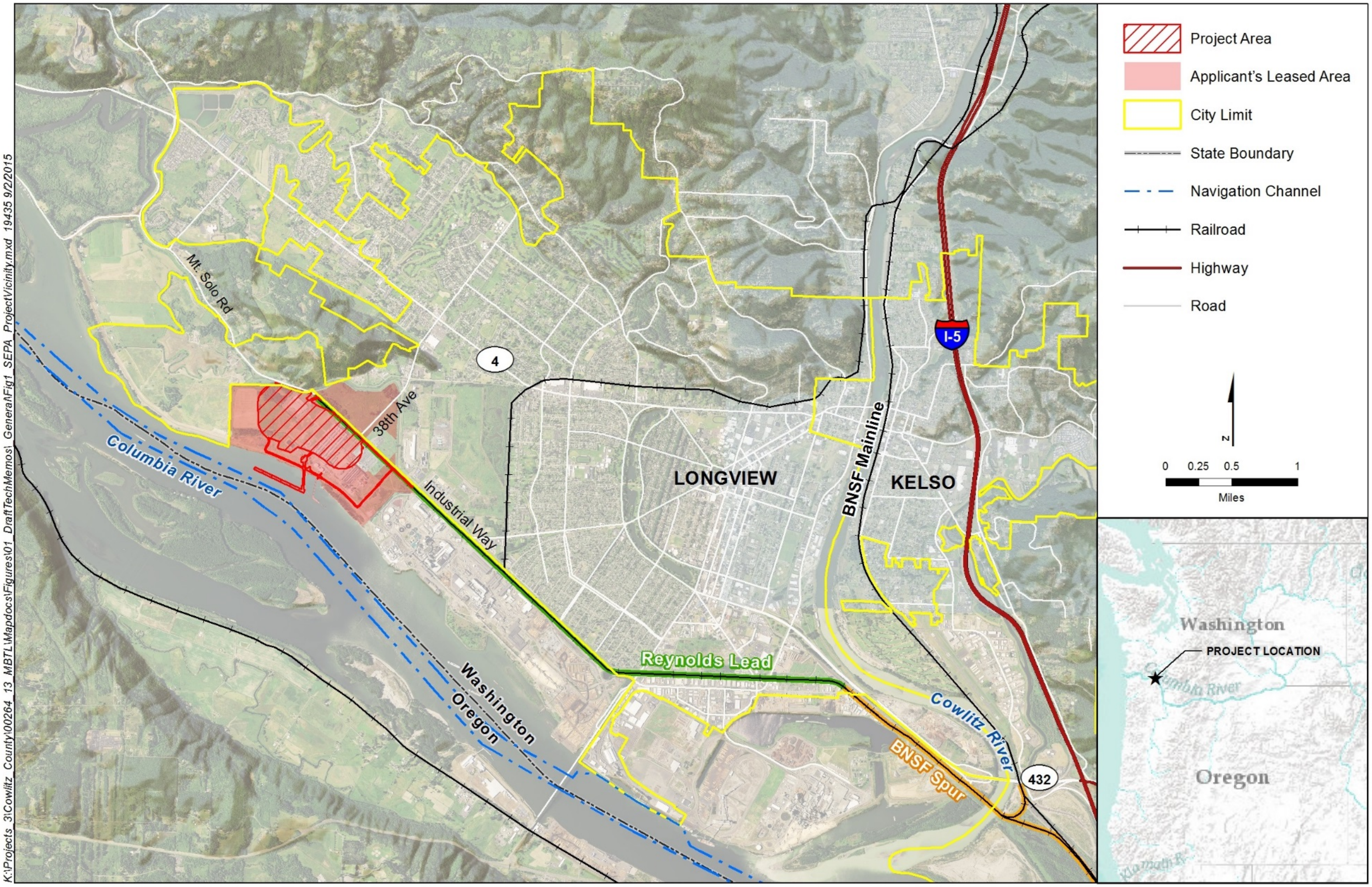
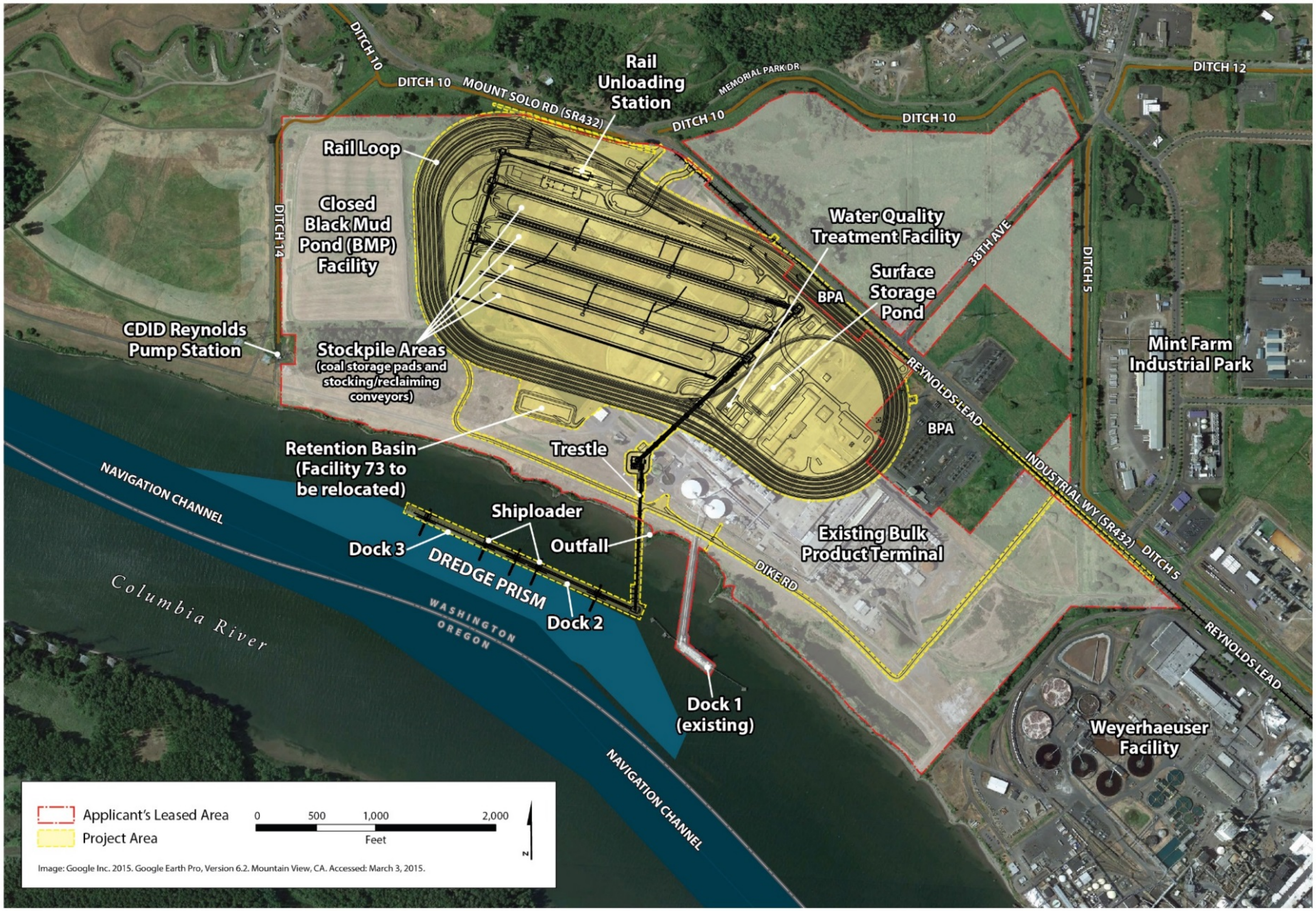


Figure 2. Proposed Action



Under the Proposed Action, BNSF or Union Pacific Railroad trains would transport coal in rail cars from the BNSF main line at Longview Junction, Washington, to the project area via the BNSF Spur and Reynolds Lead. Coal would be unloaded from rail cars, stockpiled and blended, and loaded by conveyor onto ocean-going ships at two new docks (Docks 2 and 3) on the Columbia River for export.

Once construction is complete, the Proposed Action would have an annual throughput capacity of up to 44 million metric tons.[2] The coal export terminal would consist of one operating rail track, eight rail tracks for the storage of rail cars, rail car unloading facilities, stockpile areas for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks 2 and 3), and ship-loading facilities on the two docks. Dredging of the Columbia River would be required to provide access to and from the Columbia River navigation channel and for berthing at the two new docks.

Vehicles would access the project area from Industrial Way (State Route 432). Ships would access the project area via the Columbia River and berth at one of the two new docks. Terminal operations would occur 24 hours per day, 7 days per week. The coal export terminal would be designed for a minimum 30-year period of operation.

1.1.2 No-Action Alternative

Under the No-Action Alternative, the proposed export terminal would not be constructed. Current operations of the bulk product terminal, which include the storage and transport of alumina and up to 150,000 metric tons per year of coal. Importing of alumina would continue and increase in the project area using Dock 1. The Applicant could expand the existing bulk product terminal onto the 190-acre project area, developing storage and shipment facilities to bulk product terminal operations. Coal and alumina would continue to be stored, transferred, and shipped. Additional bulk product transfers activities involving products such as calcine pet coke, coal tar pitch, cement, fly ash, and sand or gravel could also be pursued, and new or revised permits could be required. These operations would involve storage and upland transfer of bulk products, which would use existing or new buildings. Construction of new buildings could involve demolition and replacement of existing buildings and new or modified permits. Any new construction would be limited to uses allowed under existing Cowlitz County development regulations and federal and state permits.

1.2 Regulatory Setting

The jurisdictional authorities and corresponding regulations, statutes, and guidance for determining potential climate change impacts are summarized in Table 1.

[2] A metric ton is the U.S. equivalent to a tonne per the International System of Units, or 1,000 kilograms or approximately 2,204.6 pounds.

Table 1. Regulations, Statutes, and Guidelines for Climate Change

Regulation, Statute, Guideline	Description
Federal	
National Environmental Policy Act (42 USC 4321 *et seq*.)	Requires the consideration of potential environmental effects. NEPA implementation procedures are set forth in the President's Council on Environmental Quality's Regulations for Implementing NEPA (49 CFR 1105).
Clean Air Act of 1963 (42 USC 7401)	Directs the control of air pollutants nationally. The U.S. Supreme Court in 2007 established that greenhouse gases are air pollutants, and are therefore covered under this Act.
State	
Washington State Environmental Policy Act (WAC 197-11, RCW 43.21C)	Requires state and local agencies in Washington to identify potential environmental impacts that could result from governmental decisions.
Requirements of Strategy—Initial Climate Change Response Strategy (RCW 43.21M.020)	Directs state agencies to develop an integrated climate change response strategy to enable state, tribal, and local governments and public and private organizations to prepare for and adapt to the impacts of changing climate conditions. *Preparing for a Changing Climate: Washington State's Integrated Climate Change Response Strategy* outlines strategies for protecting human health, safeguarding infrastructure and transportation systems, improving water management, reducing losses to agriculture and forestry, protecting sensitive and vulnerable species, and supporting communities by involving the public.
Washington State's Growth Management Act (WAC 365-195-920)	Requires counties and cities to include the "best available science" when developing policies and development regulations. Suggests the use of adaptive management as an interim approach for managing scientific uncertainty.
Local	
Cowlitz County SEPA Regulations (CCC 19.11)	Provide for the implementation of SEPA in Cowlitz County.

Notes:
USC = United States Code; RCW = Revised Code of Washington; WAC = Washington Administrative Code; CCC = Cowlitz County Code

1.3 Study Area

The study area for potential impacts from climate change effects is defined as the project area for the Proposed Action and the access roads and rail leading to the project area.

Chapter 2
Climate Change and Projected Changes to Climate

This section summarizes the recent and projected future climate conditions in the study area. Trends and projections in temperature, precipitation, and snowfall are provided for current and historical conditions (generally from 1950 to 2005), the near-term future (2025 to 2049), and the midterm future (2050 to 2075)[3]. Midterm future conditions are typically considered in climate change analyses and are consistent with the likely operation of the Proposed Action. Future changes in climate will depend on the concentration of greenhouse gases (GHG) released to the atmosphere by human activities in the coming decades. As a result, climate projections are provided for both moderate and high GHG concentration scenarios.[4]

2.1 Greenhouse Effect

The Earth retains outgoing thermal energy and incoming solar energy in the atmosphere, thus maintaining heat temperature levels suitable for biological life. This retention of energy by the atmosphere is known as the greenhouse effect. When solar radiation reaches the Earth, most of it is either reflected or absorbed by the Earth's surface—or to a lesser degree, its atmosphere. Simultaneously, the Earth radiates its own heat and energy out into space. Factors such as the reflectivity of the Earth's surface, the abundance of water vapor, or the extent of cloud cover affects the degree to which solar radiation may be absorbed and reflected. Figure 3 shows the energy flows to and from Earth and the role that the greenhouse effect plays in maintaining heat in the atmosphere.

The composition of gases in the Earth's atmosphere determines the amount of energy absorbed and re-emitted by the atmosphere or simply reflected back into space. The predominant gases in the Earth's atmosphere, nitrogen and oxygen (which together account for nearly 90% of the atmosphere) exert little to no greenhouse effect. Gases such as carbon dioxide, methane, and nitrous oxide, trap outgoing energy and contribute to the greenhouse effect. These greenhouse gases are pollutants under the federal Clean Air Act. Additionally, manufactured pollutants, such as hydrofluorocarbons, can contribute to the greenhouse effect. Unlike most air pollutants (e.g., particulate matter) that have only a local impact on air quality, GHGs affect the atmosphere equally regardless of where they are emitted, and thus are global pollutants. A ton of methane emissions in Asia affects the global atmosphere to the same degree as a ton of methane emissions in the United States.

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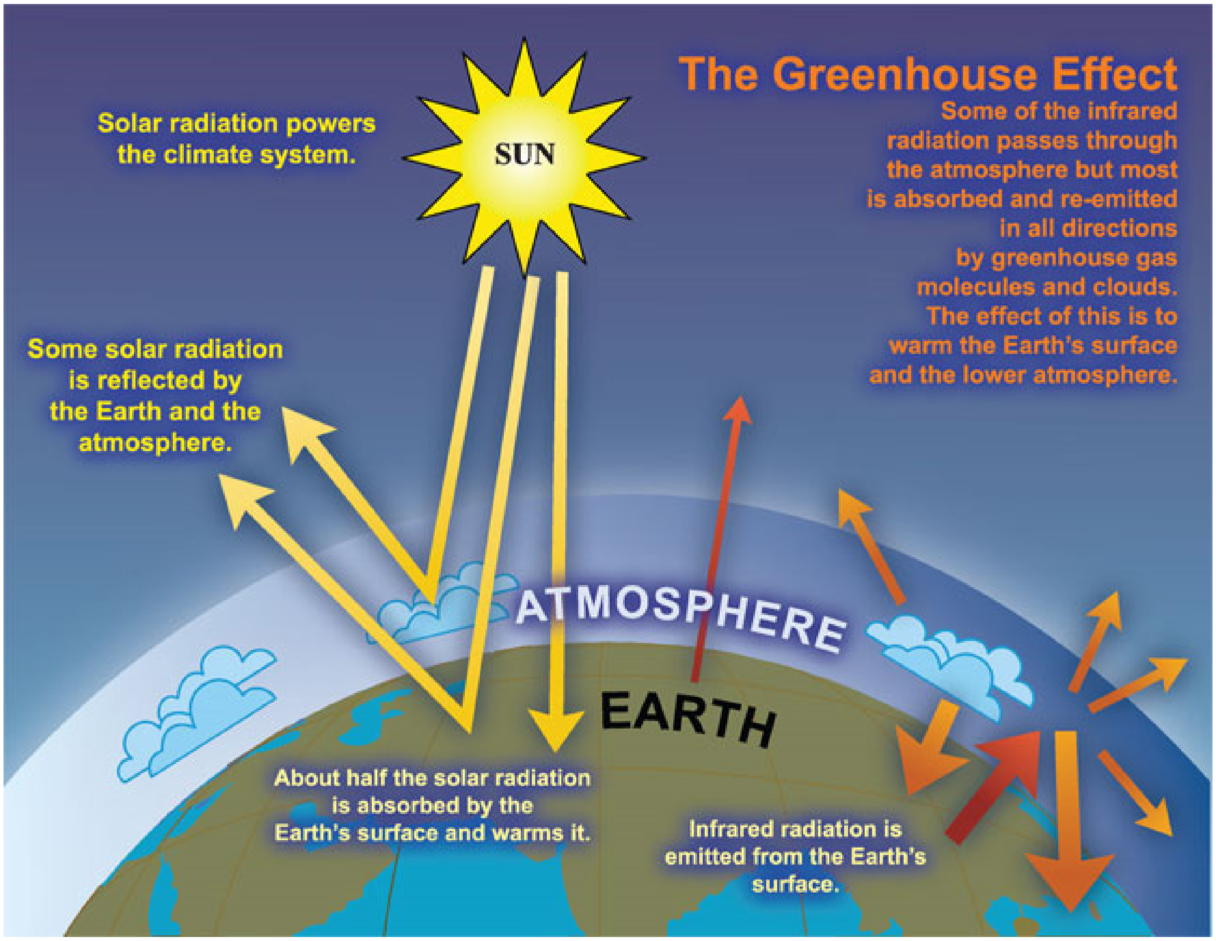
[3] The very near term 2006–2024 is not addressed here. This term is typically covered by existing procedures and examination of current conditions are adequate for planning purposes. Further, the very near term does not allow for future climatic changes to be realized and assessed. Hence this time period is excluded from consideration in this report.

[4] Unless otherwise noted, the moderate concentration scenario corresponds to Representative Concentration Pathway (RCP) 4.5; the high concentration scenario corresponds to RCP 8.5. RCPs project increases in atmospheric concentrations of GHGs between now and 2100. They are used in international climate modeling to develop consistent future scenarios of climate change and have been adopted by the Intergovernmental Panel on Climate Change in its Fifth Assessment Report.

Figure 3. An Idealized Model of the Natural Greenhouse Effect



Source: Intergovernmental Panel on Climate Change 2007

As the atmospheric concentrations of GHGs increase, the atmosphere's ability to retain heat increases as well. Since the instrumental record began in 1895, the U.S. average temperature has risen by approximately 1.3 to 1.9 degrees Fahrenheit (°F) (U.S. Global Change Research Program 2014). Furthermore, U.S. average temperatures throughout the 21st century are expected to increase at a faster pace, by 3°F to 10°F by 2100 above a 1970 to 1999 baseline (U.S. Global Change Research Program 2014).

The impacts of higher global surface temperatures include widespread changes in the Earth's climate system. Increased surface temperatures is causing sea level to rise both from thermal expansion of seawater as well as increased melting of ice sheets in the most northerly and southerly reaches. It is also changing weather patterns, including the frequency, severity, and duration of heat waves, drought and extreme precipitation events. Incidences of drought are expected to become more frequent.

Climate change also affects the natural environment and virtually all aspects of society, including biodiversity, invasive species, human health, cultural resources, infrastructure, and other sectors. The impacts will vary by location and depend on the nature of the hazards experienced. Coastal areas are particularly at risk because of their exposure to sea level rise.

2.2 Climate Change Projections

This section describes the data and methods used to identify projected changes in climate and to evaluate the impacts of climate change on the Proposed Action and No-Action Alternative.

This report assesses available information on historical climate and projected changes in climate change for southwestern Washington State using[5] the U.S. Geological Survey National Climate Change Viewer (2014) and the 2014 National Climate Assessment (Melillo et al. 2014).

- **National Climate Change Viewer.** The National Climate Change Viewer contains historical and future climate projections at watershed, state, and county levels for the continental United States. The viewer contains *multimodel ensemble data* (*mean model*), combining the results from 30 independent climate models developed by researchers around the world under the coordination of the Fifth Coupled Model Intercomparison Project (CMIP5).[6] Multimodel data increases the robustness of projections and provides information on the level of uncertainty in the direction and magnitude of future climate trends. Climate information in the viewer has been *downscaled*, or processed using statistical analysis to provide projections with higher geographic resolution of temperature, precipitation, and snowfall. Historical values and future projections of temperature were examined for Cowlitz County where the Proposed Action would be located. Historical values and future projections of precipitation and snowfall were examined for the Lower Columbia River Basin.
- **2014 National Climate Assessment.** The 2014 National Climate Assessment was conducted by the U.S. Global Change Research Program (Melillo et al. 2014). This assessment summarizes the current and future impacts of climate change on the United States. Its findings, which have undergone extensive public and expert peer review, were compiled by a team of more than 300 experts guided by the 60-member Federal Advisory Committee of the National Academy of Sciences. The report uses multimodel ensemble projections developed under CMIP5, supplemented by information from an earlier phase of the project, CMIP3, where necessary. This report relies heavily on the chapters devoted to impacts in the Pacific Northwest whose convening lead authors were Phillip Mote, Oregon State University and Amy Snover, Climate Impacts Group, University of Washington.

This section provides an overview of the likely climate impacts affecting the Pacific Northwest. The following sections focus more directly on the anticipated impacts at the project's location.

Temperatures have already increased across the Pacific Northwest by 1.3°F since 1895. Precipitation has, as well, but to date these increases are small and vary with location within the region. Under the changing climate, temperatures could rise by as much as 9.7 °F by the end of the century. Future trends in average precipitation are very uncertain and may increase or decrease, but summer precipitation is projected to decrease by as much as 30% by 2100.

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[5] Both information sources rely on climate information developed by CMIP5. CMIP5 is the fifth phase of the World Climate Research Programme's Coupled Model Intercomparison Project, which has established a standard set of simulations for coordinated climate experiments among international climate modeling groups. CMIP5 data is accessible over the internet and has been used in the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report, an internationally vetted and authoritative report on global climate change.

[6] A list of the climate models can be found in Appendix 5 of the National Climate Change Viewer Tutorial (U.S. Geological Survey 2014b).

Snow pack averaged over the Cascade Mountains has declined by about 20% since 1950 (Mote et al. 2014). In the future, snowpack is expected to continue its downward trend, causing declines in snowmelt. According to Eisner, et al., The snow water equivalent on April 1 could decline by almost half (46%) by the 2040s and virtually disappear by the 2080s, greatly reducing streamflow in some areas. The incidence of extreme precipitation, which causes important impacts on infrastructure in the region, may have increased over time, but it has not yet been demonstrated to be statistically significant. It varies with location within the region. Under the changing climate in the Pacific Northwest, the number of days with daily rainfall greater than one inch could increase by 13% in the 2041–2070 period (Mote et al. 2014).

Sea levels are rising but uplift of the land in parts of the Pacific Northwest mitigates possible impacts from sea-level rise. By contrast, areas around Puget Sound are subsiding and causing larger than average increases in sea levels. For the Pacific Northwest, sea level rise is expected to be as little as five inches or less to greater than four feet by the end of the century. The impacts of the El Nino South Oscillation phenomenon on climate variability can be significant. During El Nino years regional sea levels can increase by 4 to 12 inches and last for many months (Mote et al. 2014).

Climatic changes in precipitation could have far-reaching effects for the Pacific Northwest. Reduced summer rainfall and reductions in snowmelt – demonstrated under all emission scenarios and with near 100% likelihood -- will probably result in reduced streamflow. This trend could cause trade-offs among the many water uses, including transport, agriculture, recreation, and others, and a possible reduction in hydropower. Human activities have extracted so much water that conflicts have already occurred in dry years. Despite these summertime reductions, increases in extreme precipitation could lead to increased flooding, especially in basins that derive their water from both rain- and snowfall. Rising sea-levels could also lead to flooding of public and private property including ferry terminals, and roads and railways in coastal areas. Increasing temperatures and reduced precipitation could lead to an increase in wildfires which are driven in part by water deficits. By the 2080s the median area burned annually in the Pacific Northwest could quadruple compared to the 1916 to 2007 period (Mote et al. 2014).

2.3 Existing and Future Conditions

This section presents the historical and projected changes in temperature, precipitation, and the snowfall for the study area. Ocean acidification is not addressed here since its impacts on the Proposed Action are anticipated to be minimal.

2.3.1 Historical and Projected Changes in Temperature

Washington State has a varied climate with significant differences in temperature and precipitation on the east and west sides of the Cascade Mountains. Temperatures across the Pacific Northwest have increased from 1895 to 2011 by 1.3°F (Mote et al. 2014). West of the Cascades, where the study area is located, the climate is characterized by mild temperatures, and heavy annual rain and snow. From 1950 to 2005, the highest monthly average temperatures[7] in Cowlitz County were more than 75°F, cooler than Washington State as a whole (77.5°F) but warmer than the lower Columbia

[7] The highest temperatures and precipitation are taken as the top 10% (i.e., 90th percentile) of temperature and precipitation readings or projections. The lowest temperatures and precipitation values are the bottom 10% (i.e., 10th percentile) of all readings or projections.

River Basin of which it is part (73.4°F). The highest monthly average temperature in Cowlitz County over this period was a moderate 77.2°F (August) (U.S. Geological Survey 2014a). In general, the lowest monthly average temperatures in Cowlitz County during winter[8] were below 31.6°F from 1950 to 2005. The area has experienced a warming trend in the past five decades; the annual average maximum temperatures have increased by 0.9°F (U.S. Geological Survey 2014a).

In the near-term future, seasonal temperatures in the study area are projected to increase. In Cowlitz County, hot summer temperatures could rise by as much as 4.3°F in the high GHG concentration scenario from 2025 to 2049, compared to baseline (U.S. Geological Survey 2014a)[9]. Cold winter temperatures are projected to increase by 2.4 to 3.0°F in moderate and high GHG concentration scenarios over this period (U.S. Geological Survey 2014a). This warming trend continues into the midterm future (2050 and 2075), where hot summer temperatures in Cowlitz County are projected to increase by 5.4 to 7.2°F. Coldest temperatures are expected to increase by as much as 5.2°F (U.S. Geological Survey 2014a). These increases will likely bring the coldest temperatures near to or above the freezing point[10]. While some models project higher or lower increases in temperature, all 30 models agree that temperatures will increase in Cowlitz County. Table 2 summarizes these historical and projected changes in temperature.

Table 2. Historical and Projected Changes in Temperature in Cowlitz County, WA

Historical climate and observed changes (1950–2005)	Near-term projected changes (2025–2049 compared to 1950–2005)	Midterm projected changes (2050–2075 compared to 1950–2005)	Level of certainty in projections
The average monthly summer and winter temperatures (approximately 75°F and 32°F, respectively) reflect the moderate climate of the area.	Summer and winter temperature extremes are projected to increase.	Summer and winter temperature extremes are projected to increase.	There is excellent agreement across models on the direction of change.
Highest average monthly summer temperatures (top 10%, or 90th percentile) were above 75.0°F. Max monthly average temperature for August was 77.2°F.	90th percentile temperature is projected to increase by 3.8 to 4.3°F under moderate and high emissions scenarios.	90th percentile temperature is projected to increase by 5.4 to 7.2°F under moderate and high emissions scenarios.	Monthly average temperature is projected to increase in all months across all models compared to 1950–2005.
Lowest monthly average winter temperatures (10th percentile) were below 31.6°F.	10th percentile temperature is projected to increase by 2.4 to 3.0°F under moderate and high emissions scenarios.	10th percentile temperature is projected to increase by 4.0 to 5.2°F under moderate and high emissions.	

[8] For seasonal results, winter averages December, January, and February; spring averages March, April, and May; summer averages June, July, and August; and fall averages September, October, and November.

[9] The baseline is defined as 1950 to 2005 which is thought to represent a period during which relatively few changes had occurred as a result of climate change.

[10] Note that while the average monthly temperatures during winter will likely rise above 32°F, cold temperatures on any given day could still be below freezing.

2.3.2 Historical and Projected Changes in Precipitation

Extreme precipitation especially during the winter months has frequently led to flooding events in the Pacific Northwest. These storms have resulted in billions of dollars of loss and were responsible for about two-thirds of the presidential disaster declarations since 1955. Major flooding in January 2009 closed Interstate 5, heavily damaged the Howard Hanson Dam and put tens of thousands of people at risk. (Warner et al. 2012) A key driver of these precipitation events is the phenomenon of atmospheric rivers that form in the Pacific Ocean and move eastward toward the Pacific Northwest. In December 2105, an atmospheric river formed and made landfall along the Washington coast, resulting in almost 16 inches of precipitation over three days across Oregon, Washington, and British Columbia, Canada.

The Columbia River is the fourth largest river in North America. It is influenced by multiple river basins from multiple states and British Columbia. The geographic and hydrologic characteristics of the river, which drains a 259,000 square mile basin, are suited to beneficial multiple-purpose storage development. Since the 1930s, numerous dams, both Federal and private, have been built to store water for flood control, to generate hydroelectric power, and for other purposes. Total storage capacity of these dams is about 25 percent of the 156 million acre foot average annual runoff volume for the Columbia River at its mouth. Federal projects in the basin have 19,900 megawatts of existing hydroelectric capacity, and non-federal projects add 10,700 megawatts (USACE 2015)

According to the National Climate Assessment (Mote et al. 2014), the anticipated change in annual precipitation in the Pacific Northwest ranges from decreases (-11%) to increases (+12%) from 2030 to 2059 for the B1, A1B, and A2 scenarios.[11] This variability makes the analysis of potential impacts problematic. Typically, average monthly precipitation is greatest in winter (December through February) and least in summer (June through August) (U.S. Geological Survey 2014a). From 1950 to 2005, precipitation in the lower Columbia River Basin averaged 0.40 inch per day in winter (U.S. Geological Survey 2014a) and about half that in spring (0.22) and fall (0.25). By contrast, only 0.07 inch per day fell during the summer months.

In the near-term future, the mean model indicates slight increases in the winter, spring, and fall compared to the 1950 to 2005 average. The largest increase in precipitation is projected to occur in fall (4.1 to 2.1%)[12] and winter (2.3 to 4.8%). Very little increase is projected for the spring (0 to 1%) (U.S. Geological Survey 2014a). By contrast, summers in the near-term future are projected to become drier by 10 to 12%, although some climate models disagree and instead project that summer precipitation will remain the same or increase (U.S. Geological Survey 2014a). Overall, model agreement on precipitation is not strong. For example, in some cases just 19 models project decreases in June precipitation (and 11 indicate increases) for the near-term future. Agreement for the month of August, however, was closer, with 26 models showing decreases and only four demonstrating increases.

[11] The B1, A1B, and A2 scenarios refer to emissions scenarios from the Intergovernmental Panel on Climate Change's Special Report on Emissions Scenarios (2000). These scenarios have been superseded in the international climate modeling by Representative Concentration Pathway scenarios. The B1 and A2 scenarios are generally considered to be low and high emissions scenarios, respectively. The A1B scenario falls between them. Since not all projections have been updated with the latest GHG concentration scenarios, these scenarios have been retained where new information is not yet available.

[12] By convention, the value from the moderate emissions scenario is presented first even though the value from the high emissions scenario is lower.

Similar changes are projected to continue in the midterm future: the winter, spring, and fall seasons could become wetter, while summers could become drier. In the lower Columbia River Basin, winter and fall precipitation levels are projected to increase by 4.9 to 7.1% and 3.6 to 1.5%, respectively, while spring levels remain relatively constant (0 to 1.8% increase) in moderate and high scenarios compared to the 1950 to 2005 average. Extreme precipitation[13] could increase as the highest events could increase by 5.0 to 6.1% in the near-term future and 6.1 to 8.0% in the midterm future (U.S. Geological Survey 2014a), but studies of past trends in observed changes in extreme precipitation have yielded ambiguous results (Mote et al. 2014). Model discrepancies are similar with most models showing increases and others showing decreases. Table 3 summarizes these historical and projected changes in precipitation.

Table 3. Historical and Projected Changes in Precipitation in the Lower Columbia River Basin

Historical climate and observed changes (1950–2005)	Near-term projected changes (2025–2049 compared to 1950–2005)	Mid-term projected changes (2050–2075 compared to 1950–2005)	Level of certainty in projections
Average annual precipitation was 0.24 inch/day.	Wetter winter, spring, and fall seasons; possible drier summers.	Wetter winter, spring, and fall seasons; possible drier summers.	Some models show increases in precipitation while others show decreases. Incidence of extreme precipitation is more likely to increase.
The highest (90th percentile) monthly average precipitation was 0.43 inch/day.	Change in average precipitation by season under moderate and high emission scenarios. • Winter: +2 to 5% • Spring: 0 to +1% • Summer: -10 to -12% • Fall: +4 to +2%	Change in average precipitation by under moderate and high emission scenarios • Winter: +5 to +7% • Spring: +0 to +2% • Summer: -10 to -16% • Fall: +4 to +2%	A majority of models (18 to 26 of 30, depending on the scenario and timeframe) project that precipitation will decrease in the summer.
The lowest (10th percentile) monthly average precipitation was 0.06 inch/day.	Intensity of extreme precipitation could increase. • 90th percentile precipitation is projected to increase by 5 to 6% under moderate and high emissions scenarios	Intensity of extreme precipitation could increase. • 90th percentile precipitation is projected to increase by 6 to 8% under moderate and high emissions scenarios	Most models (20 of 30) project an increase in extreme precipitation.

[13] Extreme precipitation is determined as the magnitude of rain events in the 90th percentile (i.e., top 10% of all rain events for precipitation in a given period).

2.3.3 Historical and Projected Changes in Snowfall

Snowfall in the Canadian Rockies and the Cascade Mountains provides much of the water flowing in the Columbia River. In contrast to the variable projections in overall precipitation, the anticipated changes in snowfall are large and model agreement is very high.

Average annual snowfall was 5.6 inches per month from 1950 to 2005. Average winter and spring snowfall, when virtually all snowfall occurs, was about 29.7 and 33.3 inches, respectively. These levels are expected to decline by 39 to 45% in the near-term future for the moderate and high GHG emissions scenarios. This substantial decrease is projected to occur within relatively narrow bands (winter: 33 to 40%; spring: 41 to 47%). All models indicate decreases in annual, winter, and spring snowfall (U.S. Geological Survey 2014a).

In the midterm future, these trends are expected to intensify. Winter snowfall could decline by as much as 62% (ranging from 49 to 62% under the moderate and high emissions scenarios); spring snowfall could decrease by as much as 75% under the moderate emissions scenario and 68% under the high emissions scenario.[14] Again, all models agree that snowfall will decline over time. Table 4 summarizes these historical and projected changes in snowfall.

Table 4. Historical and Projected Changes in Snow in the Lower Columbia River Basin

Historical climate and observed changes (1950–2005)	Near-term projected changes (2025–2049 compared to 1950–2005)	Mid-term projected changes (2050–2075 compared to 1950–2005)	Level of certainty in projections
Heaviest snowfall occurs in the winter and spring leading to high average annual snowfall totals	*Average annual, winter and spring snowfall will likely decline under the moderate and high emission scenarios in the near term*	*Average annual, winter and spring snowfall will likely decline under the moderate and high emission scenarios in the mid-term*	*There is excellent agreement on the direction of change*
Average annual snowfall was 5.6 inches/month	Change in average monthly snowfall could decline by 39 to 45%	Change in average monthly snowfall could decline by 54 to 66%	All models agree on the direction of the impact
Average winter and spring snowfall was 29.7 and 33.3 inches, respectively	Change in average winter and spring snowfall under moderate and high emission scenarios • Winter: -33 to -40% • Spring: -41 to -47%	Change in average winter and spring snowfall under moderate and high emission scenarios • Winter: -49 to -62% • Spring: -75 to -68%	All models agree that snowfall will decline in the winter and spring in near- and mid-terms

[14] Higher emissions do not necessarily equate to increases in precipitation. Note that under the higher emissions scenario, average precipitation declines can be either more or less than under the moderate emissions scenario. Existing models must take other variables such as weather patterns and topography into account when projecting future precipitation levels.

Chapter 3
Impacts of Climate Change on the Proposed Action

This chapter describes the potential impacts of climate change effects on the Proposed Action and the No-Action Alternative.

Changes in current and historical patterns of temperature and precipitation may affect the infrastructure, operation, and service of the coal export terminal. Climate change considerations can be incorporated into design, construction, operation, and maintenance plans to provide for robust and resilient service now and in the future.

Impacts on the coal export terminal and to transportation routes could be caused by the following climate change impacts

- **Low water levels.** Decreased snowfall in the lower Columbia River Basin, especially in the winter and spring, coupled with potential declines in rainfall in the summer could lead to abnormally low levels of water in the Columbia River, which could impede the passage of large ships to and from the docks at the project area. With the coal export terminal located some 50 miles inland from the Columbia River estuary, the main impact of sea level rise at the project area is expected to be minimal in and of itself, but may reduce the potential for service disruptions from low water and exacerbate the potential for flooding at discrete project locations.
- **Flooding**. Potential precipitation increases and intense downpours could cause the Cowlitz or Columbia Rivers to flood, affecting the rail lines and docks that access the project area or the project area itself.
- **Wildfire**. Higher temperatures could increase the likelihood of wildfire, although wetter summers with reduced wildfire likelihood cannot be ruled out.

3.1 Potential Service Disruptions from Low Water

Decreased snowfall, especially in the winter and spring, coupled with potential declines in summer rainfall in the Lower Columbia River Basin, could lead to abnormally low levels of water in the Columbia River. Low water levels could impede the passage of large ships to and from the docks of the project area. Low water levels could raise costs for electricity or otherwise force difficult choices on competing water usage. Operational changes to the water management of the Columbia River system may be sufficient to address these potential impacts.

Snowfall is expected to decline substantially in the near and midterm futures (Section 2.3.3, *Historical and Projected Changes in Snowfall*). In the lower basin of the Columbia River, the amount of snow could be reduced by almost half and two-thirds by 2075 (U.S. Geological Survey 2014a). And, while not all models agree, spring and summer precipitation levels could remain flat or decline over the same periods.

Drought is already of concern. Washington State defines drought as 75% of normal water conditions (Revised Code of Washington 43.83B.400). In the past century, drought occurred from 1928 to 1932, 1992 to 1994, and1996 to 1997, and most recently this year (2015). Drought has caused shipping costs to rise, sometimes requiring wheat growers to move their product by rail or truck instead of barge transport. Washington State estimates that it will experience severe or extreme drought 5% of the time in the future and more frequently east of the Cascade Mountains (Washington State Emergency Management Division 2012a). This year's drought emergency includes all of Washington State (Washington State Department of Ecology 2015).

The Proposed Action would require ships of the Panamax class to berth at existing and newly installed docks to receive coal shipments. Panamax ships are midsized cargo ships, the largest that could fit through the Panama Canal prior to expansion. They have a capacity of 60,000 to 100,000 deadweight tonnage and require a draft of 42 to 49 feet. The depth of the Columbia River at Longview varies by season. Periodic dredging, as needed, part of the Proposed Action. If precipitation from snow and rain is reduced and low water levels occur on the Columbia River, shipping may be restricted or more dredging may be required.

At the project area, the Columbia River experiences tidal fluctuation, although less than at the mouth of the river. Tidal forces could replace some or all of the water needed for ship passage in the event of low runoff from reduced snowmelt and rainfall. Nonetheless, the impact of low tides on ship passage should be considered. The potential for low water disruptions may also be reduced by future sea level rise. Sea levels are expected to increase by as much as four feet in the Pacific Northwest, but this could be significantly less if the project area is—as much of the Pacific Northwest is—subject to uplift. The Columbia River is also highly managed to provide water for multiple competing uses. For example, low water levels upstream of the project area have constrained recreational boating at times.

Washington State is heavily dependent on hydropower for electricity. Approximately 75% of its electricity comes from hydropower generated by its systems of rivers and dams. The rivers also supply water for irrigation, municipalities, and industry. Drought-induced loss of hydropower could raise costs. As the supply of locally generated hydropower is reduced, utilities must seek additional sources of electricity, which could drive up prices for the coal export terminal (Washington State Emergency Management Division 2012a). Both the Proposed Action could be similarly affected by these potential impacts, as both would require Panamax ships to berth and electricity for operations.

3.2 Likelihood of Damage and Service Disruptions from Flooding

The project area is directly on the Columbia River about 5 miles from the confluence of the Columbia and Cowlitz Rivers (ICF International 2016b). The study area, including Longview, is protected from flooding by a levee maintained by the Consolidated Diking Improvement District, which is 34 feet above the Columbia River Datum.[15] It is also protected by a system of sloughs, ditches, and drains. The Federal Emergency Management Agency classifies the project area as Zone B in its Flood Insurance Rate Map, meaning the area is expected to flood every 100 to 500 years.

Water levels in the Columbia River vary by season and year, depending on the snow mass in the upper watershed. Historic crests on the Columbia River range from 13 to 24 feet with flood stage at

[15] The Columbia River Datum is the lowest level recorded on the river, which occurred on October 6, 1886. It is about 2.5 feet above the North American Vertical Datum 1988, which is the national standard geodetic reference for heights.

13.5 feet. Historic crests on the Cowlitz River range from 21 to 29.5 feet and have been recorded well above flood stage (21 feet). Above 28.5 feet, major flooding at Kelso (across the river from Longview) is expected. This flood stage could overtop the levee and increase erosion rates (ICF International 2016b).

Under current conditions, flooding is expected to be minimal at the project area for the Proposed Action (ICF International 2016b). In the future, flooding could be of concern, particularly from the Cowlitz River. In August 2014, the U.S. Army Corps of Engineers found that sediment buildup on the Cowlitz River was increasing the potential for flooding, Without further action, the flood risk level on the river (0.6%) would be exceeded by 2018 (U.S. Army Corps of Engineers 2014). While future precipitation is somewhat uncertain, the mean model indicates increases in fall and winter for both the near and midterm futures, which could increase flood risk. Future flood risk could be exacerbated by sea level rise in the Pacific Northwest. Seas are expected to rise by as little as five inches to as much as four feet depending on vertical land movements (either uplift or subsidence).

The BNSF Spur and Reynolds Lead that would carry Proposed Action-related trains to the project area could be subjected to flooding. The rail line crosses the Cowlitz River near the confluence with the Columbia River and runs near the rivers for the 5 miles to the project area. Because historical and recent crests have been reported on the Cowlitz River, flood risk from sedimentation is increasing, and future precipitation could increase, flooding of the Reynolds Lead is possible. Cowlitz River flooding at this location would likely disrupt rail and terminal operations, and ballast supporting the rail line could be dislodged. Therefore, Proposed Action-related trains could be affected by a Cowlitz River flood.

3.3 Possible Service Disruptions from Fires

Wildfire is a threat in Washington. Cowlitz County is considered a high-risk area (Washington State Emergency Planning Division 2012c). Wildfires in Cowlitz County numbered more than 350 from 2004 to 2013, burning more than 561 acres. In late summer and early fall, dry easterly winds can produce extreme fire conditions. This threat has increased over time because of four factors: earlier snowmelt, higher summer temperatures, longer fire season, and an expanded vulnerable area of high-elevation forests. These factors are caused by increases in summer temperatures and past increases can be attributed to climate change (Washington State Emergency Planning Division 2012c). Increasing temperatures, extreme heat events, and drought could have an effect on fire regimes in Washington State by influencing the length of the fire season and contributing to drier conditions and the availability of readily combustible fuel for fires (Mote et al. 2014).

Maximum temperatures are predicted to increase while summer precipitation is predicted to decrease in the study area, although there is some disagreement among the models, and some indicate that summers could become slightly wetter (Section 2.3.1, *Historical and Projected Changes in Temperature;* Section 2.3.2, *Historical and Projected Changes in Precipitation*). Hotter and drier summers will increase the likelihood of wildfires. The Proposed Action would be similarly affected by the risk of wildfire.

3.4 Mitigation

Based on the findings in this technical report, the co-lead agencies (Cowlitz County and Washington State Department of Ecology) determined mitigation measures are not required.

Chapter 4
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Millennium Bulk Terminals—Longview SEPA Environmental Impact Statement

SEPA Coal Market Assessment Technical Report

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Acronyms and Abbreviations

\$/MMBtu	dollars per million British thermal unit
Applicant	Millennium Bulk Terminals—Longview, LLC
BNSF	BNSF Railway Company
Btu/lb	British thermal units per pound
CAIR	Clean Air Interstate Rule
CFR	Code of Federal Regulations
CN	Canadian National
CO_2	carbon dioxide
CP	Canadian Pacific
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
FOB	Free on board
FPL	Florida Power and Light
GHG	greenhouse gas
IEA	International Energy Agency
IPM®	Integrated Planning Model
MMBtu	million British thermal unit
NOx	nitrogen oxides
SO_2	sulfur dioxide
TBtu	trillion British thermal unit

Chapter 1
Introduction

Millennium Bulk Terminals—Longview, LLC (Applicant) proposes to construct and operate a coal export terminal in Cowlitz County, Washington, along the Columbia River (Figure 1). The coal export terminal would receive coal from the Powder River Basin in Montana and Wyoming and the Uinta Basin in Utah and Colorado via rail, then load and transport the coal by ocean-going vessels via the Columbia River and Pacific Ocean to overseas markets in Asia. The coal export terminal would be capable of receiving, stockpiling, blending, and loading coal by conveyor onto ships for export. Construction of the coal export terminal would begin in 2018. For the purpose of this analysis, it is assumed the coal export terminal would operate at full capacity in 2028.

1.1 Project Description

Millennium Bulk Terminals—Longview, LLC (Applicant) proposes to construct and operate a coal export terminal in Cowlitz County, Washington, along the Columbia River (Figure 1). The coal export terminal would receive coal from the Powder River Basin in Montana and Wyoming and the Uinta Basin in Utah and Colorado via rail, then load and transport the coal by ocean-going ships via the Columbia River and Pacific Ocean to overseas markets in Asia. The coal export terminal would be capable of receiving, stockpiling, blending, and loading coal by conveyor onto ships for export. Construction of the coal export terminal would begin in 2018. For the purpose of this analysis, it is assumed the coal export terminal would operate at full capacity in 2028.

The following subsections present a summary of the Proposed Action and No-Action Alternative. For detailed information on these alternatives, see the Washington State Environmental Policy Act (SEPA) Alternatives Technical Report (ICF International 2016).

1.1.1 Proposed Action

The Proposed Action would develop a coal export terminal on 190 acres (project area). The project area is located within an existing 540-acre area currently leased by the Applicant at the former Reynolds Metals Company facility (Reynolds facility), and land currently owned by Bonneville Power Administration. The project area is adjacent to the Columbia River in unincorporated Cowlitz County, Washington near Longview city limits (Figure 2).

The Applicant currently and separately operates, and would continue to separately operate, a bulk product terminal on land leased by the Applicant. Industrial Way (State Route 432) provides vehicular access to the Applicant's leased land. The Reynolds Lead and the BNSF Spur, both operated by Longview Switching Company (LVSW),[1] provide rail access to the Applicant's leased area from a point on the BNSF Railway Company (BNSF) main line (Longview Junction, Washington) located to the east in Kelso, Washington. Ships access the Applicant's leased area via the Columbia River and berth at an existing dock (Dock 1) operated by the Applicant in the Columbia River.

[1] The Longview Switching Company (LVSW) is jointly owned by BNSF Railway Company (BNSF) and Union Pacific Railroad (UP).

Figure 1. Project Vicinity

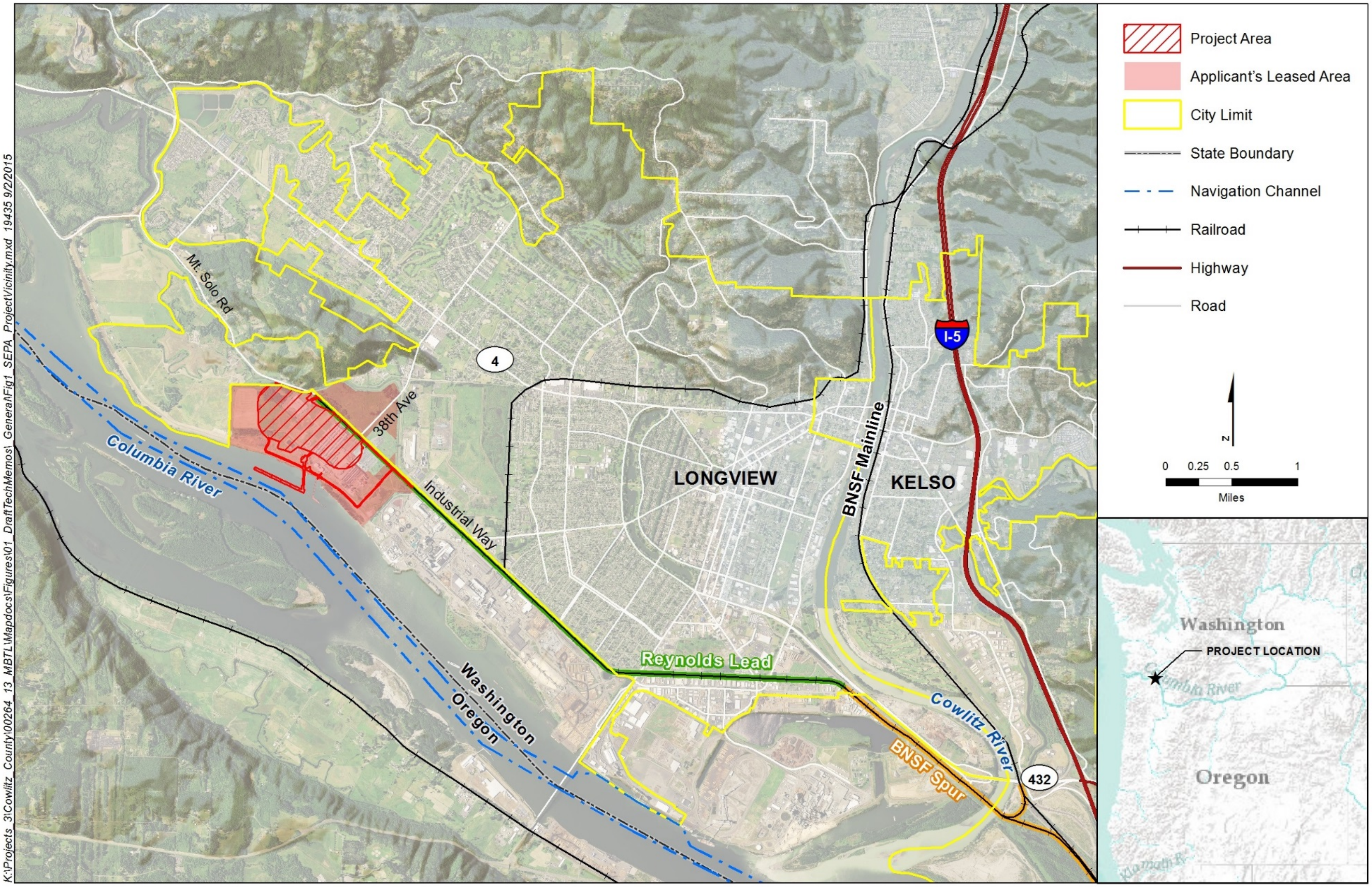
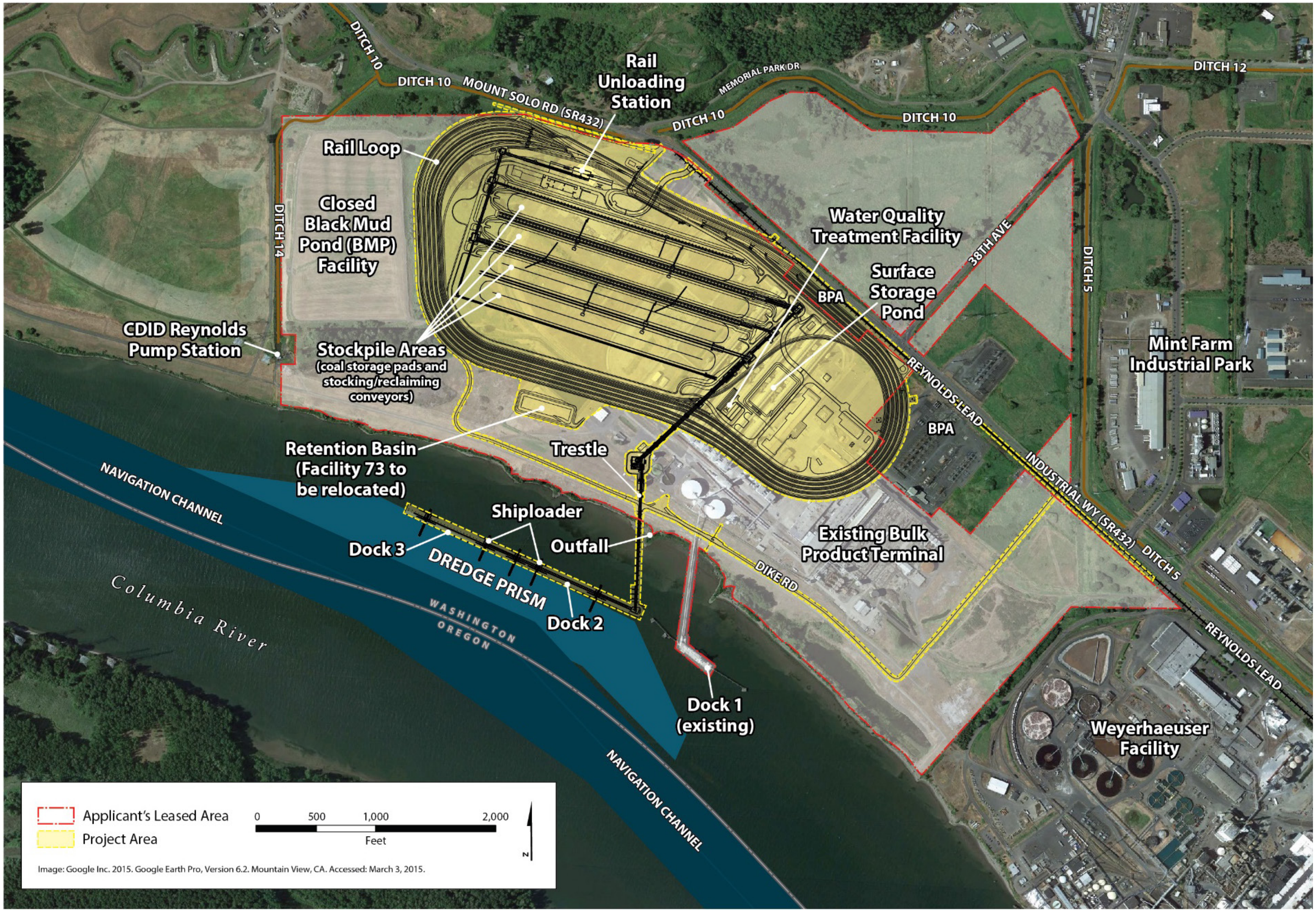


Figure 2. Proposed Action



Under the Proposed Action, BNSF or Union Pacific Railroad (UP) trains would transport coal in rail cars from the BNSF main line at Longview Junction, Washington, to the project area via the BNSF Spur and Reynolds Lead. Coal would be unloaded from rail cars, stockpiled and blended, and loaded by conveyor onto ocean-going ships at two new docks (Docks 2 and 3) on the Columbia River for export.

Once construction is complete, the Proposed Action would have an annual throughput capacity of up to 44 million metric tons.[2] The coal export terminal would consist of one operating rail track, eight rail tracks for the storage of rail cars, rail car unloading facilities, stockpile areas for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks 2 and 3), and ship-loading facilities on the two docks. Dredging of the Columbia River would be required to provide access to and from the Columbia River navigation channel and for berthing at the two new docks.

Vehicles would access the project area from Industrial Way (State Route 432). Ships would access the project area via the Columbia River and berth at one of the two new docks. Terminal operations would occur 24 hours per day, 7 days per week. The coal export terminal would be designed for a minimum 30-year period of operation.

1.2 Overview of Coal Market Analysis

This report presents the analysis of coal production, consumption, distribution, and CO_2 emissions from combustion of coal in relation to the U.S. and Pacific Basin markets. The analysis examines the Proposed Action and No-Action Alternative and documents the methods and data used to develop the results and conclusions.

This analysis examines the movement of coal from the Powder River Basin in Montana and Wyoming, and coal from the Uinta Basin in Colorado and Utah, through the proposed coal export terminal to China, Japan, South Korea, and Taiwan. Only coal from these coal basins were examined based on information provided by the Applicant. To examine the potential impact of the proposed coal export terminal on domestic and Pacific Basin coal markets, a least-cost, linear programming model was used to capture the dynamic interactions between the supply and demand regions within these markets.

Historically, approximately 2% of Powder River Basin coal has been exported.[3] There are four primary reasons that Powder River Basin coal has not been exported in larger quantities in the past.

- The Powder River Basin is far from large U.S. coal export facilities along the Atlantic coast and in the Gulf Coast.
- Canadian coal export facilities in the Pacific Northwest have had limited capacity for Powder River Basin coal or are too far to be economic.

[2] A metric ton is the U.S. equivalent to a tonne per the International System of Units, or 1,000 kilograms or approximately 2,204.6 pounds.

[3] Based on EIA U.S. Domestic and Foreign Coal Distribution by State of Origin.

- Powder River Basin coal has a lower heat content than eastern bituminous coals. Lower heat content increases transportation cost per unit of energy delivered.[4]
- Powder River Basin coal is subbituminous coal that is suitable for use in electric power plants, but is not suitable for coking coal, which limits the marketability of the coal.

The Proposed Action would address the first two reasons Powder River Basin coal has not been exported, and thus would reduce the distance to Pacific Basin markets and make Powder River Basin coal more competitive with other coal delivered to the Pacific Basin. Currently, the largest suppliers of coal in the Pacific Basin are Australia, China, India, and Indonesia. This analysis examines the U.S. and Pacific Basin coal market changes that would take place under the Proposed Action, under five different scenarios. The scenarios examine a wide range of possible future market states that would have an influence on how the proposed coal export terminal would affect these markets

1.2.1 Report Organization and Chapter Summary

The following sections describe the remaining chapters of this report.

1.2.1.1 Chapter 2, U.S. Coal Market and Pacific Northwest Export Terminals

This chapter provides a brief overview of the U.S. coal market and more in-depth information about the Powder River Basin and the Uinta Basin. Information on the type of coal mined in these coal basins is included, as well as the historical distribution of the coal. This chapter also discusses the existing and planned Pacific Northwest coal export terminals.

1.2.1.2 Chapter 3, International Coal Markets

Chapter 3 describes the international coal markets into which the coal exported from the proposed coal export terminal would enter. This chapter provides information on the major coal importing and exporting countries and provides a summary of each country that is a possible destination for coal exported from the terminal. Finally, this chapter provides a brief discussion on international coal prices.

1.2.1.3 Chapter 4, Model Framework, Methods, and Key Assumptions

Chapter 4 provides a summary of the model, methods, and assumptions used in this analysis to estimate coal production, consumption, distribution, and CO_2 emissions. This analysis uses ICF International's Integrated Planning Model (IPM®) to assess coal production, consumption, and distribution patterns that would be affected by the Proposed Action. This computer modeling platform is also used by the U.S. Environmental Protection Agency (EPA), other government entities, electric utilities, independent power producers, coal companies, and environmental groups. The assumptions used in this analysis are largely from publicly available sources.

[4] The cost per unit of energy delivered is proportional to the tons of coal transported and the heat content of the coal. If the energy or heat content per ton is low, then the transportation cost per unit of energy is higher.

1.2.1.4 Chapter 5, Scenarios

This chapter describes the five scenarios analyzed in this report. Under each scenario, both a No-Action Alternative and a Proposed Action were examined to determine the effect of the Proposed Action on the U.S. and Pacific Basin coal markets. The five scenarios analyzed in this report are as follows.

- Past Conditions (2014) Scenario, which represents the business as usual case in early 2015 but does not include the proposed or final Clean Power Plan.
- Lower Bound Scenario, which is designed to result in a reasonable lower bound of global CO_2 emissions from the power sector. The energy markets under the Lower Bound Scenario could be described as a high renewable energy penetration scenario, where international coal demand and prices are lower than in the Past Conditions (2014) Scenario.
- Upper Bound Scenario, which is designed to result in a reasonable upper bound of global CO_2 emissions from the power sector. The energy markets under the Upper Bound Scenario could be described as a high international coal demand scenario, where international coal demand and prices are higher than in the Past Conditions (2014) Scenario.
- 2015 Energy Policy Scenario, which differs from the Past Conditions (2014) Scenario in that it includes implementation of the U.S. Environmental Protection Agency (EPA)'s proposed Clean Power Plan and assumes greenhouse gas (GHG) policies are implemented in other countries, such as China. The Clean Power Plan was not enacted at the time of the model runs in mid-2015 but has since been adopted and there has been additional movement on international climate policies such that this scenario reflects the most probable scenario as of late 2015.
- Cumulative Scenario, which differs from the Past Conditions (2014) Scenario only in that it includes the capacity of other proposed Pacific Northwest coal export facilities.

1.2.1.5 Chapter 6, Modeling Results

Chapter 6 presents the modeling results of the five scenarios analyzed. The results are presented for the No-Action Alternative and Proposed Action and for the difference as calculated by subtracting the No-Action Alternative results from the Proposed Action results. Results are presented for coal production from the U.S. and non-U.S. producing regions; coal consumption in the U.S. and the Pacific Basin; the distribution of coal in the Pacific Basin; and CO_2 emissions from the combustion of coal. In addition, natural gas usage at electric power plants in the U.S. and the CO_2 emissions from natural gas combustion are reported as natural gas is a substitute fuel when coal consumption decreases.

1.2.1.6 Chapter 7, Conclusions

Chapter 7 provides a summary of the conclusions from the analysis.

Chapter 2
U.S. Coal Market and Pacific Northwest Export Terminals

2.1 General U.S. Coal Market

The United States is the world's second largest coal producer and consumer, with total coal production of 1 billion short tons in 2014. The largest coal producer and consumer is China, with total coal production of 4 billion short tons. This chapter discusses the U.S. coal market to provide context for the focus of this analysis, which is coal produced from the Powder River Basin and the Uinta Basin to be exported through the proposed terminal. The goal of this chapter is to provide a basic understanding of the U.S. coal markets, and Chapter 3, *International Coal Markets*, provides an overview of the international coal markets, both of which will help the reader to understand and interpret the modeling results

2.1.1 Total Production

Since 1990, total U.S. coal production has been over 1 billion tons, except for only 4 years. In this period, coal production has averaged 1.07 billion tons and peaked at 1.17 billion tons in 2008. Historically, about 90% of U.S. coal has been used domestically for power generation, with the remainder being used for industrial processes, steel production, or export. The Powder River Basin is the leading source of U.S. coal, at 40% of U.S. total coal production. The majority of Powder River Basin coal is used in domestic power plants, with only 1% to 2% being exported. Exports from the United States have been primarily to Europe.

Coal production and consumption have both decreased since 2011, when natural gas prices first fell below $3.5 per million British thermal unit (MMBtu). Natural gas is a competing fuel for electric generation and thus when natural gas prices are below $3.5/MMBtu the cost of generating electricity from natural gas is below the cost of generating electricity from some types of coal.

Coal is produced in four major coal basins within the United States, along with several smaller coal basins. The four major coal basins are the Powder River Basin, Rocky Mountains, Illinois Basin, and Appalachia. The Appalachian coal basin is further divided into a Northern, Central, and Southern section. The Rocky Mountain area includes the Uinta Basin, which includes Utah and the western part of Colorado, the Wyoming Green River area, and parts of Colorado not in the Uinta Basin.

2.1.2 Types of Coal

Coal has two primary uses: metallurgical and thermal. Coal used to produce coke (a hard porous residue used in steel manufacturing) is called metallurgical coal. Non-metallurgical coal is referred to as thermal or steam coal, because it is used to generate electricity through steam turbines. Metallurgical coal in the United States is found in the Appalachian basin. Thermal coal is produced in all regions.

Coal is also categorized by rank, with three ranks used in the United States. The coal ranks are, from hardest and highest heat content to softest and lowest heat content, bituminous, subbituminous, and lignite. Bituminous coal is mined in the Appalachian and Illinois Basins as well as in the Rocky Mountains.[5] Subbituminous coal is primarily mined in the Powder River Basin. Lignite coal is primarily found in Texas and the Great Plains area of North Dakota and Montana.

Within each rank, coal is graded by the heat content as well as the trace elements found in the coal, such as sulfur, mercury, and chlorine. Generally, higher heat content coal sells at a higher price, and coal with lower concentrations of trace elements sells for a higher price, all else being equal.

2.1.3 Exports

The United States imports small amounts of thermal coal and exports both metallurgical and thermal coal. Appalachia is the focal point of U.S. coal exports. This is due to high coal quality, nearby infrastructure (i.e., ports), and locational proximity to Atlantic Basin markets. In the past, Appalachian coal demand has increased when international markets strengthened. However, there is large and growing energy demand and coal industry demand around the Pacific Basin. Delivered Pacific Basin coal prices were 2.1 times higher between 2010 and 2013 versus 2000 and 2006. The coal trade around the Pacific Basin is seaborne.

2.2 Powder River Basin

The Powder River Basin, located in Montana and Wyoming, is the largest source of coal production in the United States, accounting for 40% of national coal production (Figure 3). Powder River Basin coal is all subbituminous coal that is mined from large surface mines. Since 1970, Powder River Basin coal production has increased at an average annual rate of 10% per year (Figure 4). Between 1993 and 2008, production more than doubled, from 228 million tons per year to a record high of 496 million tons per year. Coal production in the Powder River Basin was able to expand so quickly because the coal seams are thick compared to all other coal-producing regions in the United States, and because the coal is close to the surface and can be mined using surface mining techniques. The largest Powder River Basin coal seams are 100 feet thick, while seams in other coal basins in the United States are typically less than 8 feet thick.

Between 2009 and 2011, coal production averaged 464 million tons per year, and ranged from 452 million tons in 2009 to 473 million tons in 2010 (U.S. Energy Information Administration 2013a). In 2012, production decreased to 425 million tons, driven down by the lowest natural gas prices in 15 years and lower electric power demand (Mine Safety and Health Administration 2014). This trend continued in 2013 with production decreasing to 416 million tons. The U.S. Energy Information Administration (EIA) expects total 2014 and 2015 production to meet or exceed 2013 production, but remain below 2012 production (U.S. Energy Information Administration 2014).

[5] The Uinta Basin is part of the Rocky Mountain coal production area.

Figure 3. Powder River Basin (Montana and Wyoming)

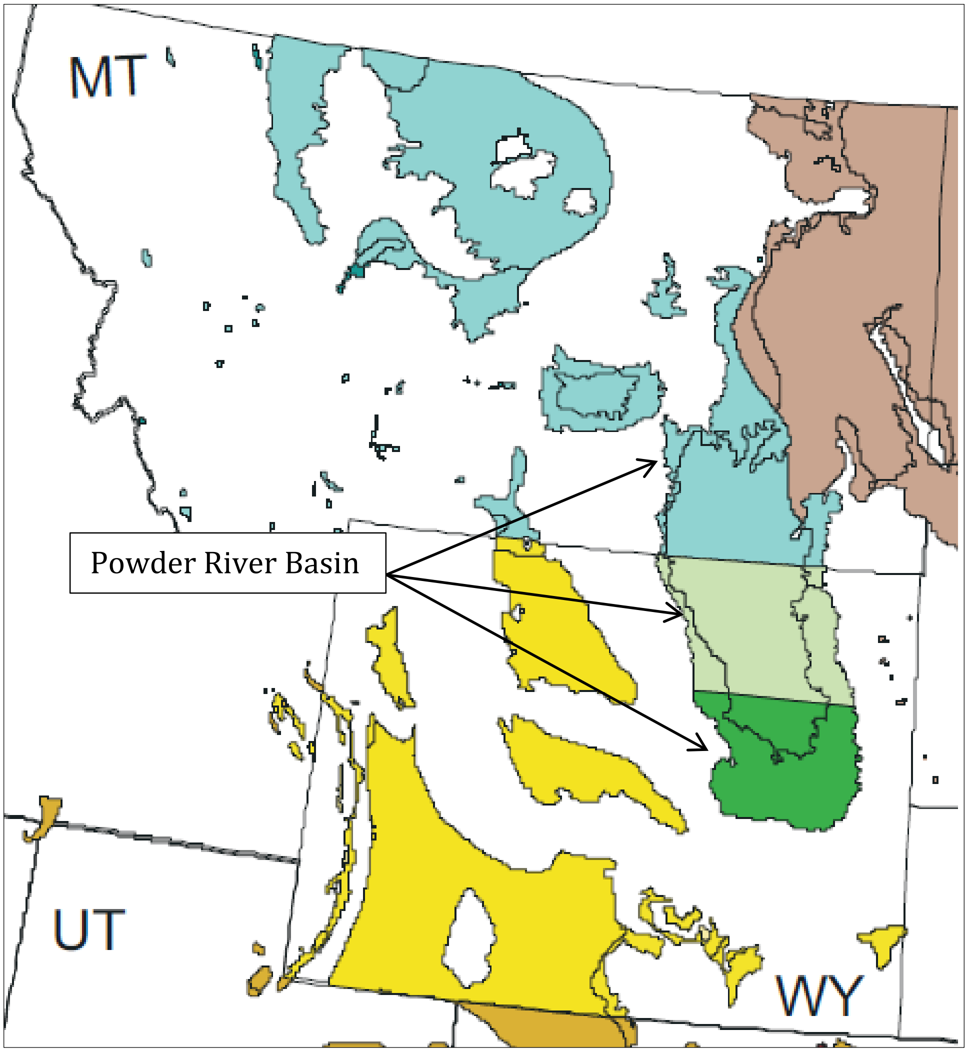
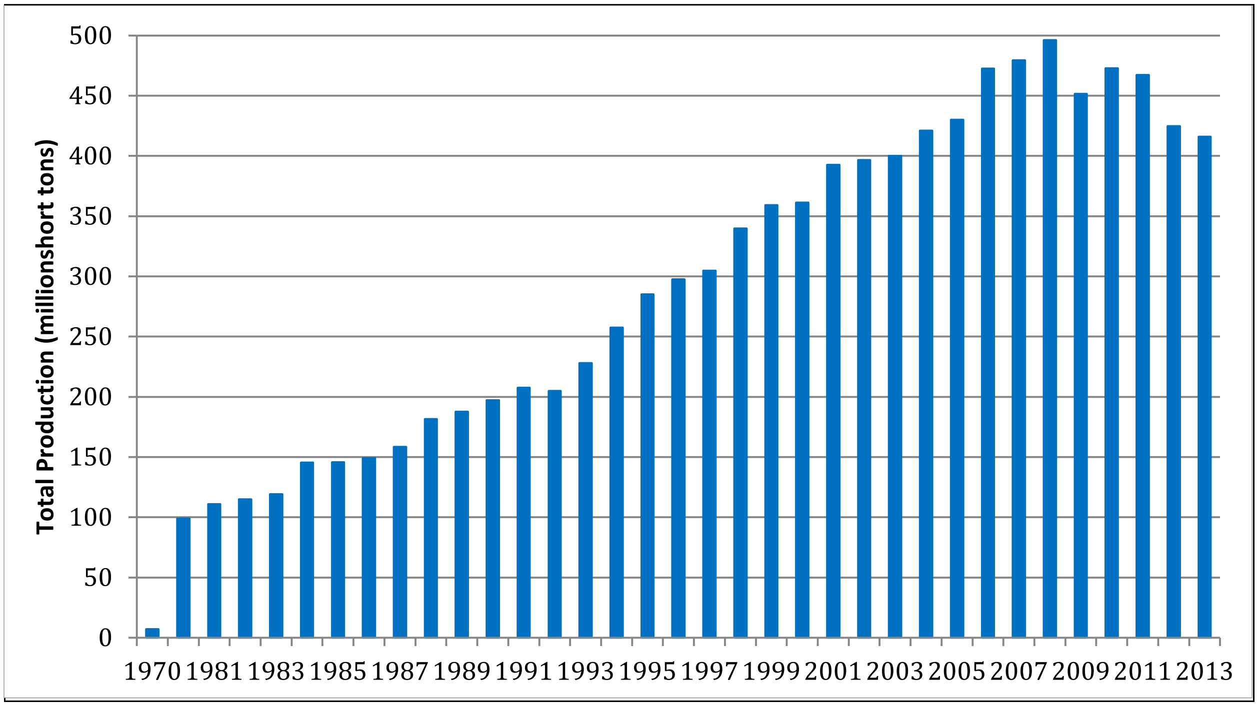


Figure 4. Historical Powder River Basin Coal Production (Montana and Wyoming)



Source: BXG Publications 1993 (1970–1982 data); Mine Safety and Health Administration 2014 (1983–2013 data).

This analysis considers the following three sources of Powder River Basin coal.

Montana coal: Coal produced in Montana with a heat content of 9,300 British thermal units per pound (Btu/lb).

Wyoming 8400 coal: Coal produced in Wyoming with a heat content of 8,400 Btu/lb.

Wyoming 8800 coal: Coal produced in Wyoming with a heat content of 8,800 Btu/lb.

Since 2008, Wyoming coalfields have produced about 91% of Powder River Basin coal, with the remaining 9% produced in Montana (Table 1). However, because Montana coal has a higher heat content, it is more likely to be exported. Higher heat content coals are more likely to be exported because they contain more heating potential per ton of coal, thus, users have to transport fewer tons of high heat content coal than they would have to import lower heat content coal. For example, a coal consumer would have to import 5.7% more Wyoming 8800 coal than they would the higher heat content Montana coal.

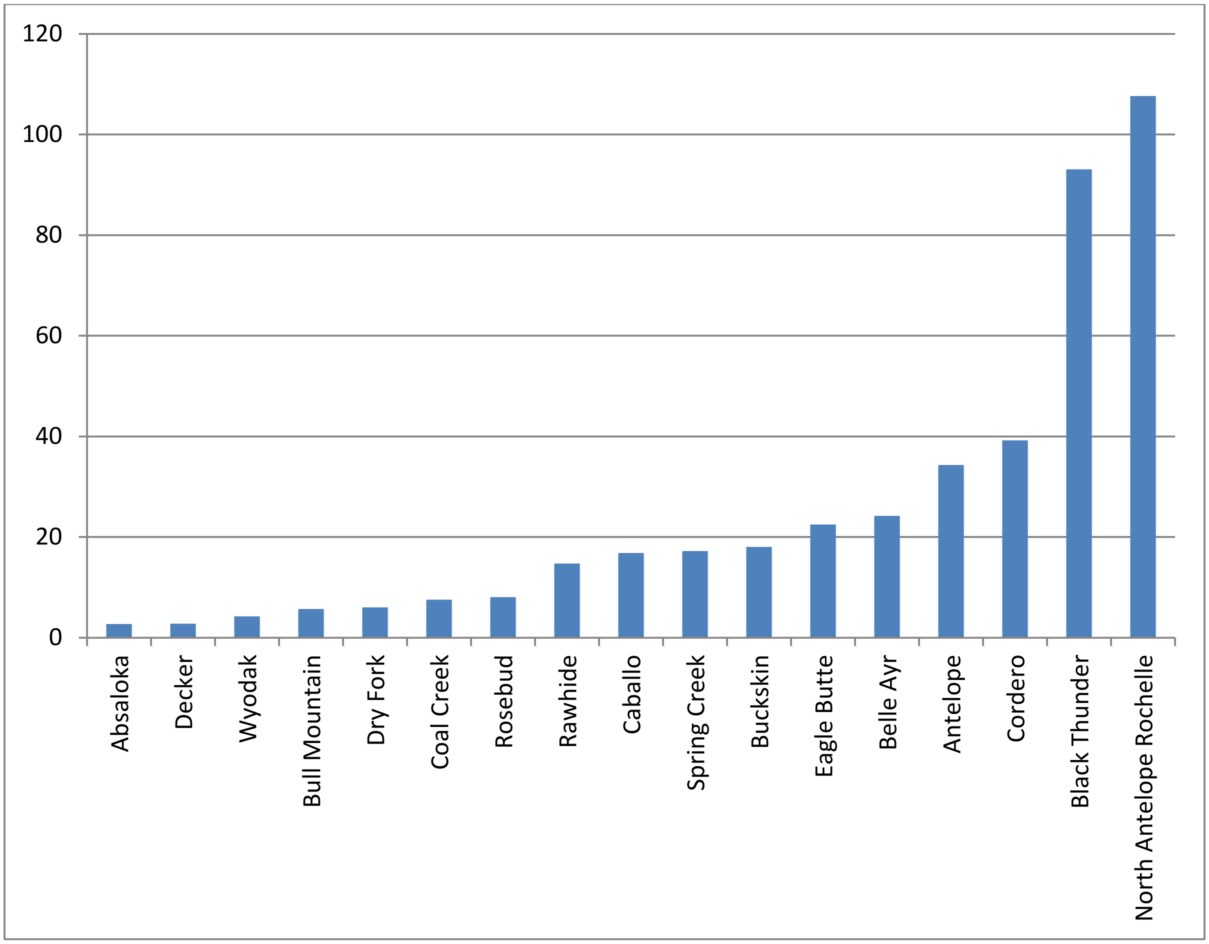
Table 1. Powder River Basin Coal Production by State (million short tons)

State	2008	2009	2010	2011	2012	2013	2014	2008–2014 Average
Montana	44	38	44	41	36	42	44	42
Wyoming	452	414	428	426	388	374	381	410
Total	496	452	473	467	425	416	425	451

Notes:
Source: Mine Safety and Health Administration 2014.

Figure 5 shows that only 17 mines contribute to coal production in the Powder River Basin, and all except one (Bull Mountain) are surface mines. Two mines (Black Thunder and North Antelope Rochelle) dominate production, accounting for approximately half of the region's coal production.

Figure 5. Powder River Basin 2012 Production by Mine (million short tons)



Source: Mine Safety and Health Administration 2014.

Powder River Basin coal mines are large compared to other U.S. coal mines. Most Powder River Basin mines produce at least 10 million tons per year, and two (the Black Thunder and the North Antelope Rochelle Mines in Wyoming) each produce 100 million tons per year. For comparison, mines in the eastern United States produce, on average, less than 1 million tons of coal per year, with very few mines producing over 4 million tons per year.

Mining conditions change over time. Initially coal reserves are mined that are the easiest to access and have the least amount of overburden.[6] However, as a mine ages, more overburden must be removed to access the coal, thus increasing the cost of production. Productivity gains have counteracted some of the increased cost of overburden removal. For example, the size of the shovels and trucks has increased, which allows more material to be moved in the same amount of time. The most significant contributor to the cost of surface mining coal production, however, remains the overburden ratio.[7]

2.3 Uinta Basin

The Uinta Basin coalfield is located in the western portion of Colorado and in Utah (Figure 6). Coal production in the Uinta Basin is from both underground and surface mines; however, over 80% of the coal is from underground mines (Mine Safety and Health Administration 2014). The coal produced from the Uinta Basin is both bituminous and subbituminous coal, with bituminous coal the predominant kind at 85% of annual production. The Uinta Basin bituminous coal has an average heat content of 11,345 Btu/lb and the subbituminous coal has an average heat content of 9,985 Btu/lb.[8]

Between 1983 and 2014, coal production in the Uinta Basin has ranged between 26.9 and 62.1 million short tons, with an average of 46.5 million short tons (Figure 7) (Mine Safety and Health Administration 2014). Uinta Basin coal production peaked in 2005 with 62.1 million short tons (Mine Safety and Health Administration 2014). Since 2005, Uinta Basin coal production steadily declined through 2010, and then picked up slightly in 2011 before declining again. Since 2011, Uinta Basin coal production has decreased from 45.6 million short tons to 38.5 million short tons in 2013.

This analysis considers two sources of Uinta Basin coal: coal produced in Colorado with a heat content of 11,780 Btu/lb, and coal produced in Utah. Two bituminous coal types are modeled in Utah, one with a heat content of 11,500 Btu/lb and low sulfur content and the second with a heat content of 11,950 Btu/lb and medium sulfur content.

[6] Overburden is the layers of soil and rock covering a coal seam. It is removed prior to surface mining and replaced after the coal has been taken from the seam.

[7] The overburden ratio refers to the ratio of the thickness of soil and rock that lies above a coal seam and the thickness of the coal seam itself. In surface mining, which is the predominant mining method in the Powder River Basin, the soil and rock above a coal seam must be removed before the coal can be mined. For example, a coal seam that is 30 feet thick and overlain by 120 feet of rock and soil would have an overburden ratio of 4.0 (=120/30)

[8] EIA 923 data, using a weighted average over 2010 through 2014.

Figure 6. Uinta Basin (Colorado and Utah)

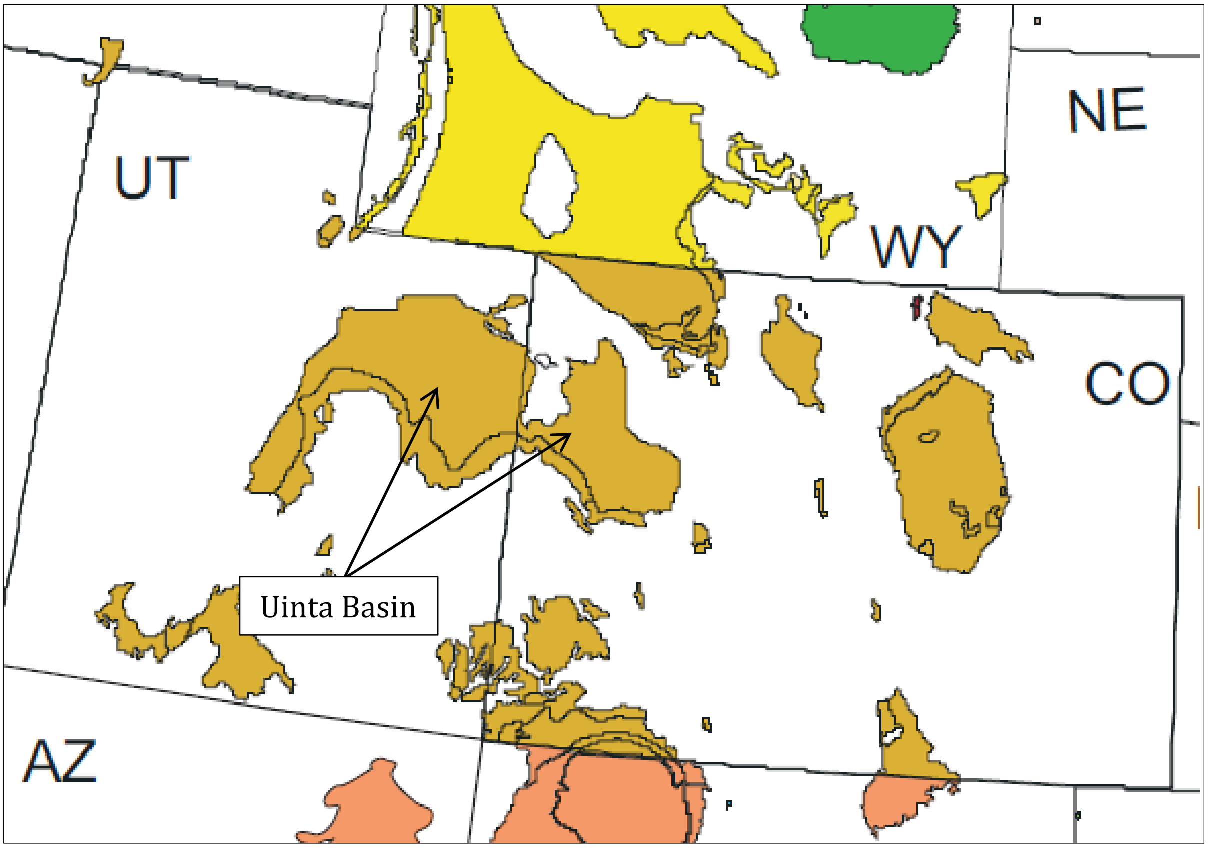
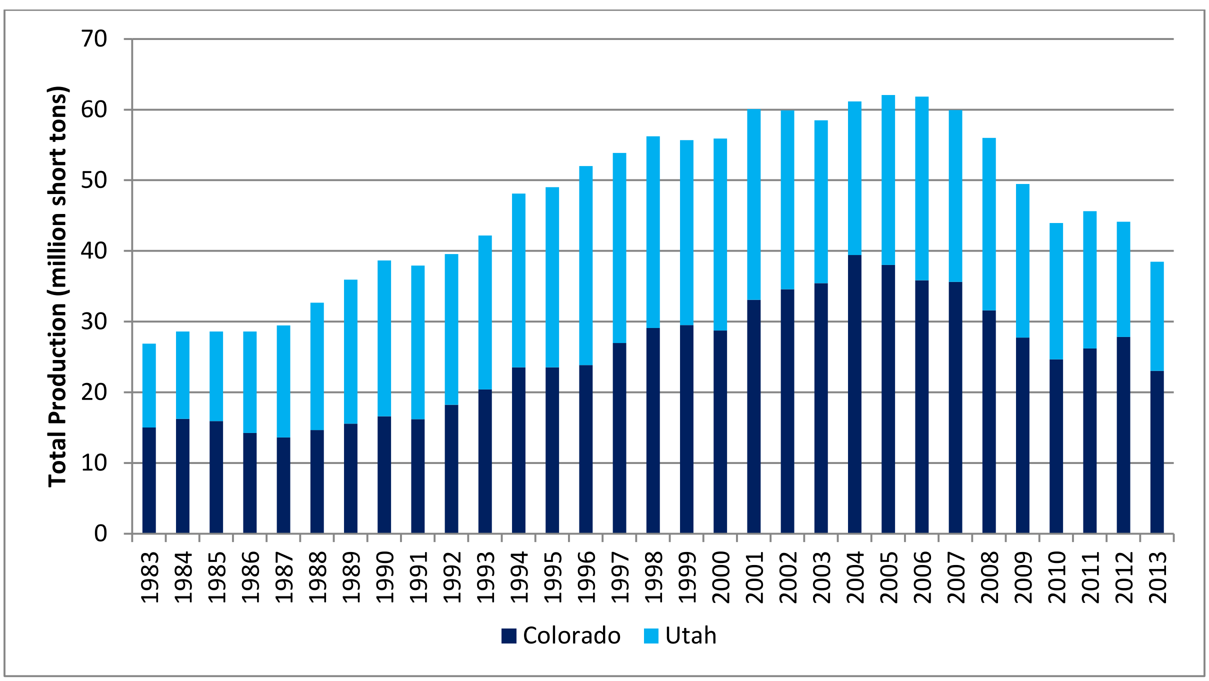


Figure 7. Historical Uinta Basin Coal Production (Colorado and Utah)



Source: Mine Safety and Health Administration 2014 (1983–2013 data).

Since 2008, Colorado coalfields have produced about 58% of Uinta Basin coal, with the remaining 42% produced in Utah (Table 2). The coal from both regions has a similar heat content; however, the Utah coal is closer to the export terminals, and thus, is more likely to be exported.

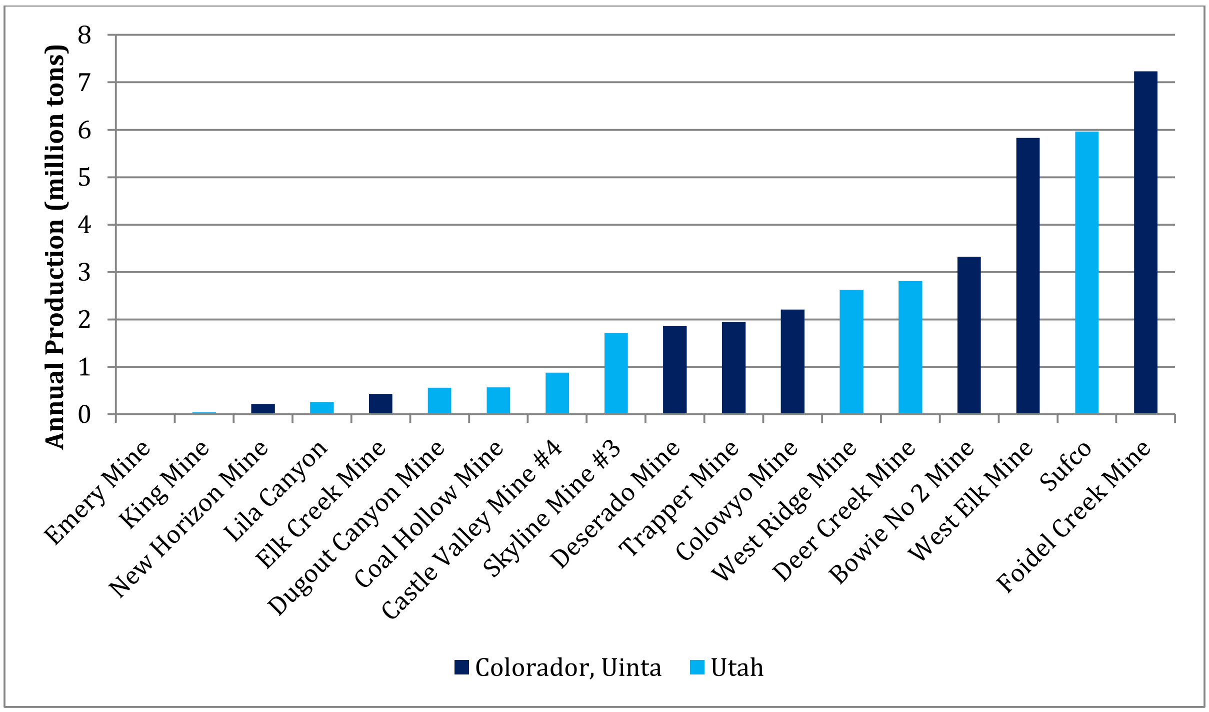
Table 2. Uinta Basin Coal Production by State (million tons)

State	2008	2009	2010	2011	2012	2013	2014	2008–2014 Average
Colorado, Uinta	31.6	27.8	24.6	26.2	27.8	23.5	23.0	26.4
Utah	24.4	21.7	19.3	19.4	16.3	16.4	17.9	19.3
Total	56.0	49.5	43.9	45.6	44.1	39.9	41.0	45.7

Notes:
Source: Mine Safety and Health Administration 2014.

Figure 8 shows that only 18 mines contribute to coal production in the Uinta Basin in 2013. Three mines (West Elk Mine, Sufco, and Foidel Creek Mine) produce over 5 million short tons per year, and account for approximately half of the region's coal production.

Figure 8. Uinta Basin 2013 Production by Mine (million short tons)



Source: Mine Safety and Health Administration 2014

2.4 Coal Distribution

2.4.1 Powder River Basin

Powder River Basin coal is subbituminous and has a lower heat content than the bituminous coal mined in the eastern United States. The lower heat content increases the transportation cost per unit of energy, and has effectively limited the historical distribution of Powder River Basin coal to domestic markets, although in recent years exports of Powder River Basin coal have been increasing.

Historically, 98% of Powder River Basin coal has been distributed to the domestic market. Powder River Basin coal generally reaches large markets in the Midwest, Texas, the southeast, and within the basin itself (U.S. Energy Information Administration 2013b). On average, from 2010 through 2014, Iowa, Illinois, Kansas, Michigan, Missouri, Oklahoma, and Wisconsin, consumed more than 48% (201 million tons per year) of Powder River Basin coal, while Texas consumed 14% (58 million tons per year) (Tables 3 and 4).

Table 3. Average Annual Deliveries of Powder River Basin Coal by Region[a]

Region	Montana Coal (million tons per year)	Wyoming Coal (million tons per year)	Total (million tons per year)	Montana Coal (%)	Wyoming Coal (%)
Central United States	15.1	269.7	284.8	41	68
Mid-Atlantic	0.2	1.0	1.1	0	0
Northeast		1.5	1.5	0	0
Powder River Basin	8.9	15.3	24.1	24	4
Rockies		9.8	9.8	0	2
Southeast		24.3	24.3	0	6
Southwest	0.6	6.1	6.8	2	2
Texas	0.0	58.4	58.4	0	15
West	2.6	4.2	6.8	7	1
Exports	9.4	4.2	13.6	26	1
Total	**36.8**	**394.5**	**431.2**	**100**	**100**

Notes:

[a] Domestic deliveries average 2010-2014 data from U.S. Energy Information Administration 923; International deliveries (exports) average 2009-2011 data from U.S. Energy Information Administration *Annual Coal Distribution Report* as 2012 data is not yet available.

Source: U.S. Energy Information Administration 2013a, 2013c.

Table 4. Historical Powder River Basin Coal Production by Source State and Destination (million tons)[a]

State	Historical Distribution	2009	2010	2011	2012	2013
Montana	Domestic Consumption[b]	36	38	33	25	30
	Exports[c,d]	2	6	8	11	12
	Total Production[e]	38	44	41	36	42
Wyoming	Domestic Consumption[b]	411	423	422	384	370
	Exports[c,d]	3	5	4	4	4
	Total Production[e]	414	428	426	388	374
Total	Domestic Consumption[b]	447	462	455	409	400
	Exports[c,d]	5	11	12	15	16
	Total Production[e]	452	473	467	425	416

Notes:
[a] Estimated exports from Montana have grown six-fold between 2009 and 2013, causing total Powder River Basin exports to more than triple. However, exports of Powder River Basin coal remain less than 4% of total Powder River Basin coal production.
[b] Total production less exports.
[c] U.S. Energy Information Administration 2013b. Export values estimated for 2012 and 2013.
[d] Thapa pers. comm.
[e] Mine Safety and Health Administration 2014.

The following factors have historically limited the economic viability of exporting Powder River Basin coal compared to higher heat content thermal coal.

- Long distances to export terminals
- Abundant international coal supply
- Relatively low international coal prices
- Relatively high shipping costs compared to international coal sources

Powder River Basin coal is exported primarily through the Pacific Northwest to Asia, with a small amount exported to Europe (Table 5).

Table 5. Powder River Basin Coal Exports by Terminal of Departure (2012)

Terminal	Destination	Coal Exports (million tons per year)
Westshore (Vancouver, BC)[a]	Asia	4.5
Ridley (Prince Rupert, BC)[b]	Asia	2.2
New Orleans and Texas Gulf Coast[c,d]	Asia	2.0
Duluth (Superior, WI)[c,d]	Europe	1.5
Total		**10.2**

Notes:
[a] Westshore Terminals Investment Corporation 2012
[b] IHS McCloskey 2013a
[c] U.S. Securities and Exchange Commission 2012a
[d] U.S. Securities and Exchange Commission 2012b

2.4.2 Uinta Basin

The Uinta Basin consists of coal deposits in Utah and northwestern Colorado, and is part of the broader Rocky Mountain coal production area. In total, the basin covers 14,450 square miles. Over the last 20 years, Utah has produced an average of 23.7 million tons of coal, although production in the last 3 years has fallen to between 19.4 and 15.4 million tons. The Colorado portion of the Uinta Basin has had average production over the last 20 years of 29.9 million tons, with production in the last 3 years ranging between 23.1 and 27.8 million tons (Mine Safety and Health Administration 2014).[9] The coal from this region is bituminous and ideal for energy production, and stays primarily within Colorado and Utah. On average between 2010 and 2014, 70% of Uinta basin coal has been consumed in Colorado and Utah. However, Uinta Basin Coal is also consumed in states to the east, including Alabama, Illinois, Kentucky, Mississippi, and Tennessee[10]. Table 6 shows the average annual deliveries of Uinta Basin coal by region.

Table 6. Average Annual Deliveries of Uinta Basin Coal by Region[a]

Region	Colorado Uinta Coal (million tons per year)	Utah Coal (million tons per year)	Total (million tons per year)	Colorado Uinta Coal (%)	Utah Coal (%)
Central United States	5.70	0.21	5.91	32	1
Mid-Atlantic	0.07	0	0.07	0	0
Rockies	9.96	12.37	22.34	56	84
Southeast	1.45	0.13	1.58	8	1
Southwest	0.13	0	0.13	1	0
West	0.41	2.06	2.47	2	14
Total	**17.73**	**14.77**	**32.50**	**100**	**100**

Notes:
[a] Domestic deliveries average 2010–2014 data from U.S. Energy Information Administration 923
Source: U.S. Energy Information Administration 2013a, 2013b.

2.5 Pacific Northwest Export Terminals

The main operating coal export terminals on the west coast are in Vancouver and Prince Rupert (British Columbia, Canada). These terminals have limited capacity for additional overseas export of U.S. coal in spite of recently completed and proposed capacity expansions. Existing coal traffic from Canadian mines already consumes most of the Canadian terminal capacity (Westshore Terminals 2013). Increased coal terminal capacity in the United States or Canada is foreseeable because several companies in addition to Millennium Bulk Terminals—Longview LLC, such as Teck Coal and SSA Marine, have recently proposed several new terminals for construction on the west coast and have begun environmental reviews or permitting processes.

[9] MSHA Part 50 data.
[10] EIA 923 data 2010 through 2014.

2.5.1 Existing Pacific Northwest Terminals

There are three existing terminals and four proposed terminals in the Pacific Northwest through which U.S. coal could be exported. The existing coal export terminals are in British Columbia, Canada, and include Westshore Terminal, Neptune Terminal, and Ridley Terminal. The Westshore and Neptune Terminals are located near Vancouver, while the Ridley Terminal is located at Prince Rupert, which is approximately 1,400 rail miles north of Vancouver.

2.5.1.1 Westshore Terminal

The Westshore Terminal is located at Roberts Bank, British Columbia, less than 1 mile north of the U.S. border. The BNSF Railway Company (BNSF), Canadian Pacific (CP), and Canadian National (CN) railroads serve this terminal. Westshore is one of the largest coal export terminals in North America and serves both Canadian and U.S. coal producers with a capacity of 36.3 million tons per year.

2.5.1.2 Neptune Terminal

The Neptune Terminal is owned by Canadian coal company Teck Coal and is served by the BNSF, CP, and CN railroads. Neptune's export capacity is 13.2 million tons per year. Teck Coal plans to expand the Neptune Terminal capacity by an additional 6.6 million tons per year, with an expected online date of 2015. Historically, Neptune Terminal has only shipped metallurgical coal.

2.5.1.3 Ridley Terminal

The Ridley Terminal, located in Prince Rupert, British Columbia, is served by the CN railroad, and has a capacity of 13.2 million tons per year. Ridley Terminal primarily handles coal from mines in northern British Columbia, although a few million tons of coal from the Powder River Basin have shipped through this terminal in the last 5 years. Several Powder River Basin coal producers, such as Arch Coal and Cloud Peak Energy, signed 5-year contracts to ship coal through Ridley Terminal. The contracts expire in 2015 and the government-owned terminal is expected to handle only Canadian coal from 2015 onward (Arch Coal 2011; de Place and MacRae 2012).[11] It is also significantly more expensive to ship Powder River Basin or other U.S. coal through Ridley Terminal compared to current or proposed terminals in Washington, Oregon, or Vancouver, British Columbia. Despite having 10% shorter shipping distance to the Pacific Basin, Ridley Terminal has a rail distance that is about 100% longer than other terminals.[12] At current rail and shipping costs, the overall transportation cost from the Powder River Basin to Asia is higher through Ridley Terminal than through the Westshore Terminal.

2.5.2 Planned Pacific Northwest Export Terminals

Four new coal export terminals are proposed in Washington, Oregon, and British Columbia that could provide additional capacity for Powder River Basin and other U.S. coal exports. Figure 9 shows the export capacities of these terminals. Three of the proposed terminal projects are in Washington and Oregon.

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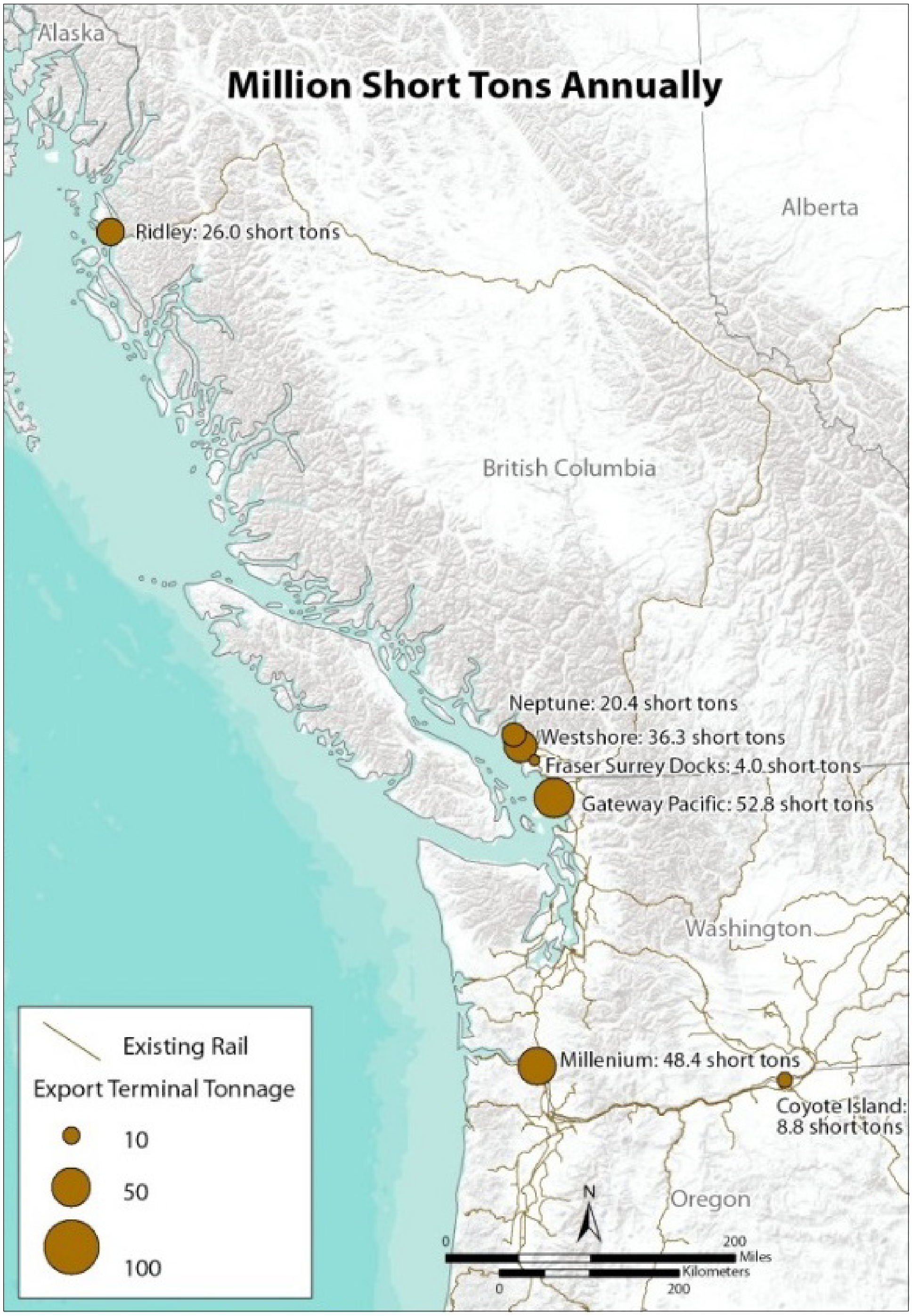
[11] Arch Coal's agreement with Ridley Terminal to export up to 2.5 million metric tons per year through 2015.

[12] Cloud Peak states that the rail distance from their Powder River Basin mines to Ridley is over 2,600 miles and can require up to three different rail carriers (Cloud Peak Energy 2013).

Figure 9. Existing and Planned Coal Export Terminals



2.5.2.1 Gateway Pacific Terminal

The proposed Gateway Pacific Terminal at Cherry Point, Washington, would handle bulk commodities such as coal. The terminal is served by BNSF and has a planned capacity of 52.8 million tons of coal per year. One advantage of this terminal would be that it could load capesize vessels, which provide a cost advantage over smaller Panamax vessels.[13]

2.5.2.2 Millennium Bulk Terminals—Longview

This is the Proposed Action discussed in this technical report. The Millennium Bulk Terminal—Longview operates an existing bulk product terminal on the Columbia River in Cowlitz County. Plans include adding infrastructure to unload coal from trains and move it to storage and then to ships. The terminal is served by the BNSF and UP railroads. The terminal can load up to Panamax size vessels, with no plans to modify the port to handle larger vessels.

2.5.2.3 Coyote Island Terminal

The Coyote Island Terminal at Morrow, Boardman, Oregon, would be located on the Columbia River. This terminal would be served by the BNSF railroad and has a planned capacity of 8.8 million tons per year. Coal coming to this terminal would be barged by the shipper down the Columbia River to the Port Westward Industrial Park in Oregon and transloaded onto Panamax vessels. On August 18, 2014, the Oregon Department of State Lands denied the removal-fill permit for the Coyote Island Terminal at the Port of Morrow in Boardman, Oregon. The applicant, Ambre Energy, has appealed the decision, and a hearing is pending as of March 2015 (Oregon Department of State Lands 2014).

2.5.2.4 Fraser Surrey Docks

Fraser Surrey Docks, at Vancouver, British Columbia, has applied for a permit to construct a coal transfer facility of 4.4 million tons per year of capacity. BNSF would serve this facility. On August 21, 2014, Port Metro Vancouver granted a Project Permit for the terminal's Direct Coal Transfer Project, which is scheduled to begin operations late in 2015 (Port Metro Vancouver 2014).

2.5.3 Export Routing

The coal that would most likely be exported out of the Pacific Northwest terminals is from the Powder River Basin, as most other coal basins are farther away or have other export options, such as terminals on the Atlantic or Gulf coast. The one exception is the Uinta Basin that might be competitive through the proposed coal export terminal. The transportation costs were estimated for coal exports through the terminal and the other existing and planned Pacific Northwest terminals.

Tables 7 and 8 show the details of the cost calculations for transporting coal to Japan from the Powder River Basin through the two most economically viable options, which would be the Proposed Action and the Vancouver, British Columbia, area terminals. This analysis focuses on the Pacific Basin because it is the fastest growing market for steam coals, and Japan is an example of a Pacific Basin movement. Japan was selected for the model to illustrate the total transportation costs, because it has historically imported more coal than any other Pacific Basin country, and is one possible destination for coal exports through the terminal. Powder River Basin coal exports to other countries, such as China, South Korea, or Taiwan, would be similar, except that the shipping distances would be longer by 140 to 1,100 miles.

[13] *Capesize* vessels are cargo ships capable of carrying approximately 150,000 metric tons. *Panamax* vessels are smaller and can carry approximately 75,000 metric tons. The Gateway Pacific Terminal would be able to load the larger, capesize vessels because of its deeper waters.

Table 7. Estimated Powder River Basin Rail and Ship Export Costs—Pacific Northwest Exports

Powder River Basin Export Routes	Rail Distance (miles)	Rail Rate with fuel surcharge ($/ton)	Total Rail Cost (2012$/ton)[a]	Ship Distance (nautical miles)	Ship Rate ($/ton-nautical mile)	Total Ship Cost via Panamax ($/ton)[b]	Port Fee ($/ton)	Total Transportation Cost ($/ton)
Montana to Japan via MBTL	1,231	$0.0249	$30.65	4,402	$0.0027	$11.88	$11.00	$53.53
Montana to Japan via Vancouver	1,357	$0.0249	$33.79	4,328	$0.0027	$11.69	$11.00	$56.48
Wyoming 8800 Btu/lb to Japan via MBTL	1,360	$0.0249	$33.86	4,402	$0.0027	$11.88	$11.00	$56.74
Wyoming 8800 Btu/lb to Japan via Vancouver	1,483	$0.0249	$36.93	4,328	$0.0027	$11.69	$11.00	$59.62

Notes:

[a] Includes fixed rail cost of $1.50/ton.

[b] Includes transfer cost of $1.50/ton.

PNW = Pacific Northwest; Btu/lb = British thermal units per pound

Table 8. Estimated Powder River Basin Delivered Coal Costs—Pacific Northwest Exports

Powder River Basin Export Routes	Total Transportation Cost ($/ton)	Illustrative Minemouth Price ($/ton)[a]	Total Delivered Cost ($/ton)	Heat Content (MMBtu /ton)	Delivered Cost to Japan ($/MMBtu)
Montana to Japan via MBTL	$53.53	$15.00	$68.53	18.6[c]	$3.68
Montana to Japan via Vancouver	$56.48	$15.00	$71.48	18.6[c]	$3.84
Wyoming 8800 Btu/lb to Japan via MBTL	$56.74	$13.00	$69.74	17.6	$3.96
Wyoming 8800 Btu/lb to Japan via Vancouver	$59.62	$13.00	$72.62	17.6	$4.13

Notes:

[a] Actual minemouth prices will differ by year for the various Powder River Basin coals; $15/ton approximates the Montana Powder River Basin 9,300 Btu/lb coal prices expected in 2016, and $13/ton approximates Powder River Basin Wyoming 8,800 Btu/lb coal prices expected in 2016.

[c] Spring Creek heat content is 9,300 Btu/lb; this is taken as the illustrative existing Montana coal's heat content.

MMBtu = million British thermal units; Btu = British thermal units

The existing and proposed Pacific Northwest terminals, not including Ridley Terminal, have the following advantages and characteristics.

- **Shortest export route to Asia.** Shipping distances to Japan from the Pacific Northwest are approximately half the distance from the U.S. Gulf Coast.
- **Lowest-cost export.** There is an ocean freight cost advantage to Asia via the Pacific Northwest as compared to Gulf Coast or California originating exports.
- **Historically used for Powder River Basin shipments**. Historically, Powder River Basin exports have been shipped primarily via Pacific Northwest terminals, supporting the conclusion that this export route is most economical for Powder River Basin coal.

Lastly, as Table 8 shows, the delivered costs to Japan via the existing and proposed Pacific Northwest terminals are similar for all Powder River Basin coals. Relatively small changes in production costs or parts of the transportation cost could affect the export prospects of any of the Powder River Basin coals. It may be more economical to export certain Powder River Basin coals to the Pacific Basin and transport others to domestic locations, as determined by the variables of location, markets, transportation facilities, and heat content of the coal.

Chapter 3
International Coal Markets

3.1 International Coal Demand

As described in Chapter 2, Section 2.3, *Coal Distribution*, only about 2% of Powder River Basin coal is exported to international markets. This chapter discusses this market.

3.1.1 Major Importing and Exporting Countries

The top five global coal-importing countries (Japan, China, South Korea, India, and Taiwan) are located in Asia and together they account for 64% of total coal imports globally. In Europe, while total coal imports have not bounced back to pre-recession levels last seen in 2007, they grew by about 8% from 2009 to 2012. A greater percentage of European coal imports came from the United States over this time period, with U.S. coal exports to Europe approximately doubling in just four years. Table 9 provides the top coal countries for coal imports in 2012.

Some of the top importers rely heavily on coal imports to meet their consumption. For example, Japan, South Korea, and Taiwan import all of their coal, whereas China and India have significant domestic production and could reduce imports if coal prices increase.

Table 9. Top International Coal Importers in Million Short Tons (2012)

Rank	Country	Total Coal Import	Total Coal Consumption	Import (%) of Consumption
1	China	317.9	3,887.3	8
2	Japan	203.5	201.9	101
3	Korea, South	135.7	137.6	99
4	India	97.2	744.5	13
5	Taiwan	73.5	72.1	102
6	Germany	53.4	269.4	20
7	United Kingdom	49.6	69.8	71
8	Russia	34.8	274.2	13
9	Turkey	31.8	108.4	29
10	Italy	26.6	26.1	102
11	Malaysia	24.3	27.2	89
12	Brazil	19.9	27.3	73
13	Thailand	18.6	38.8	48
Total Coal Imports		**1,086.8**		

Notes:
Source: U.S. Energy Information Administration 2013c.

The top coal exporters are Indonesia and Australia, together accounting for nearly 54% of the total coal exports in 2012 (Table 10). In Australia, companies and port owners propose to construct and expand export terminals, which would triple export capacity from 490 to 1,420 million tons per year (Yang and Cui 2012).

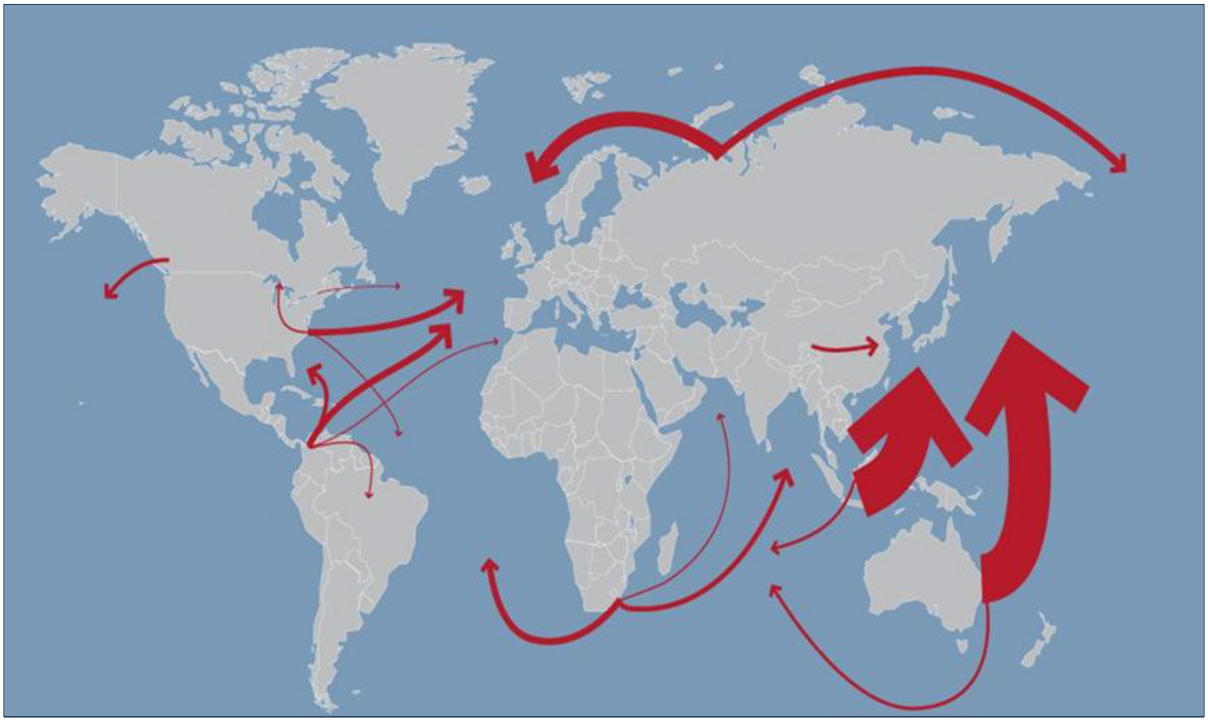
Table 10. Top International Coal Exporters in Million Tons (2012)

Rank	Country	Total Coal Export	Total Coal Production	Export (%) of Production
1	Indonesia	421.8	488.1	86
2	Australia	332.4	463.8	72
3	Russia	150.7	390.2	39
4	United States	126.7	1,016.5	12
5	Colombia	92.2	98.6	94
6	South Africa	82.0	285.8	29
7	Canada	38.8	73.3	53
8	Kazakhstan	35.2	138.9	25
9	Mongolia	24.3	47.0	52
10	Vietnam	21.2	46.4	46
11	Poland	14.9	158.2	9
12	North Korea	13.2	43.2	31
13	China	10.2	4,017.9	0.3
Total Coal Exports		**1,309.5**		

Notes:
Sources: Yang and Cui 2012;, U.S. Energy Information Administration 2010.

In summary, the largest markets in the Pacific Basin are served primarily by the largest exporters in the Pacific Basin, Australia and Indonesia (Figure 10). Recent Pacific Basin coal trade is comparable to the flows presented for 2009. While the Pacific Basin market is expected to grow, so is the competition between a few large suppliers.

Figure 10. Indonesia and Australia Dominate Pacific Basin Coal Markets



Source: Alpha Natural Resources 2010.

While Japan has historically been the largest importer of coal worldwide, the Indian and Chinese economies are projected to grow, adding to the demand for energy resources in the Indo-Pacific region. Coal continues to be the fuel of choice to meet burgeoning demand in these growing countries; however, planned coal additions and construction have slowed significantly since 2012. India and China currently have plans to increase coal capacity by nearly 800 gigawatts, down from 1,100 gigawatts in 2012 (Shearer et al. 2015). This proposed capacity is more than twice the total U.S. installed coal capacity of about 300 gigawatts (as of 2013). Japan, South Korea, and Taiwan lack significant domestic thermal coal reserves and have been key importers in the Pacific Basin steam coal import market. Both India and China will likely continue or increase their consumption of coal going forward. The following sections address market conditions in the top two coal-importing nations, which are expected to remain the top importing countries for the next 10 years: Japan and China. The next three top importers—South Korea, India, and Taiwan—are expected to have flat to increasing imports, with South Korea generally flat and Taiwan increasing slowly, while coal imports to India are expected to grow more rapidly as large amounts of new electrical generating capacity comes online.

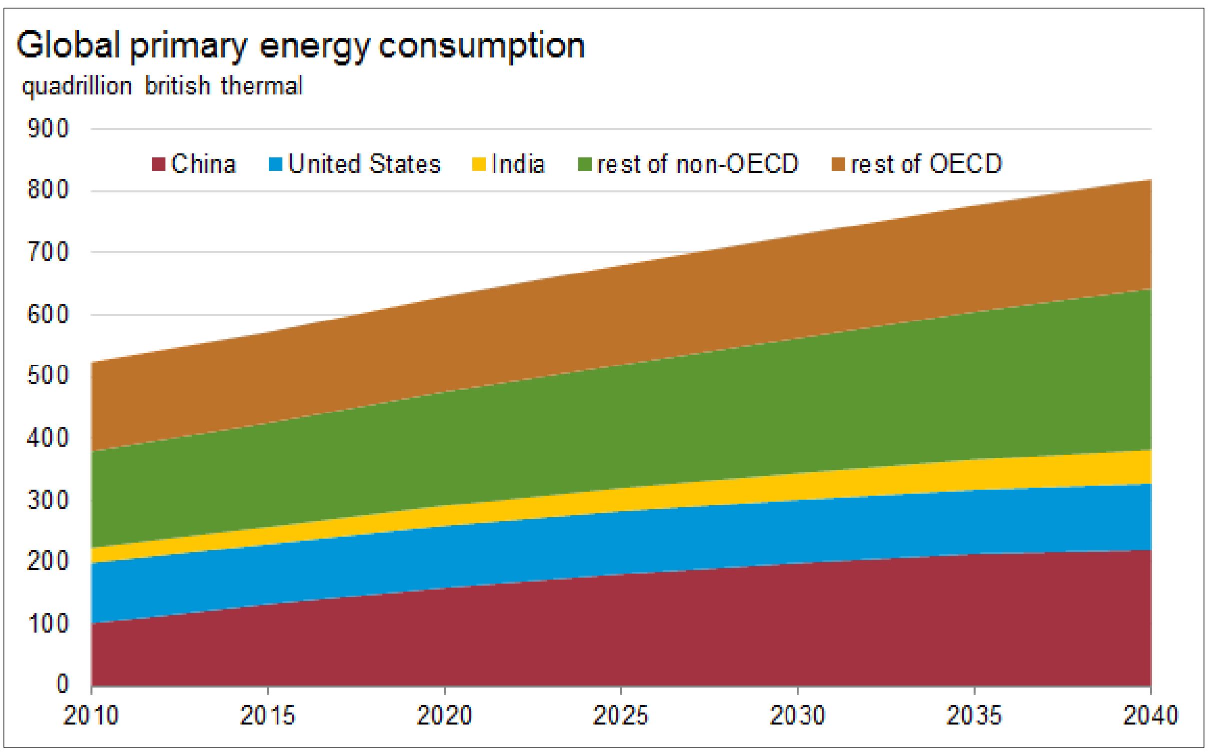
3.1.2 Asian Focus

China, Japan, South Korea, and Taiwan have historically been the world's primary importers of coal. The following provides an overview of their coal consumption and recent import level trends.

3.1.2.1 China

China is the world's largest coal producer and consumer. China's coal demand, driven by power generation and industrial uses, increased by an average of 8.44% annually from 2001 to 2012. For comparison, coal demand outside of China increased at an average of 3.8% per year (U.S. Energy Information Administration 2013b). However, coal consumption in China and across the globe actually slipped in 2012 by about 1.7% and 1.2%, respectively. As of 2012, China's coal consumption accounted for 47% of global coal consumption at about 3.9 billion tons annually—almost as much as the entire rest of the world combined (U.S. Energy Information Administration 2013d). China's demand for coal is expected to grow in the future. Although current policy changes in China will reduce the growth rate of coal consumption, the absolute amount of coal consumed is expected to continue to increase. EPA's projection of China's power generation shows that coal will produce 67% to 75% of the nation's electrical energy from 2012 to 2040 (Figure 11). Coal-fired electric power generation is expected to increase by 87% compared to current 2013 levels (U.S. Energy Information Administration 2013d). To meet growing demand, China is considering proposals for new installed coal capacity of 496 gigawatts (Shearer et al. 2015). For comparison, as of the end of 2014, the total capacity for all coal-fired power plants in the United States was 299 gigawatts, with nearly 18 additional gigawatts of retirements expected by the end of 2016 (SNL Energy 2015). With its vast domestic coal resources, China has historically been a coal exporter. However, China's coal imports exceeded exports for the first time in 2009 (Figure 12). In 2012, China imported 318 million tons of coal, or approximately 8% of total Chinese coal consumption.[14] The increase in imports has been rapid and dramatic, and suggests a strong market in the Pacific Basin.

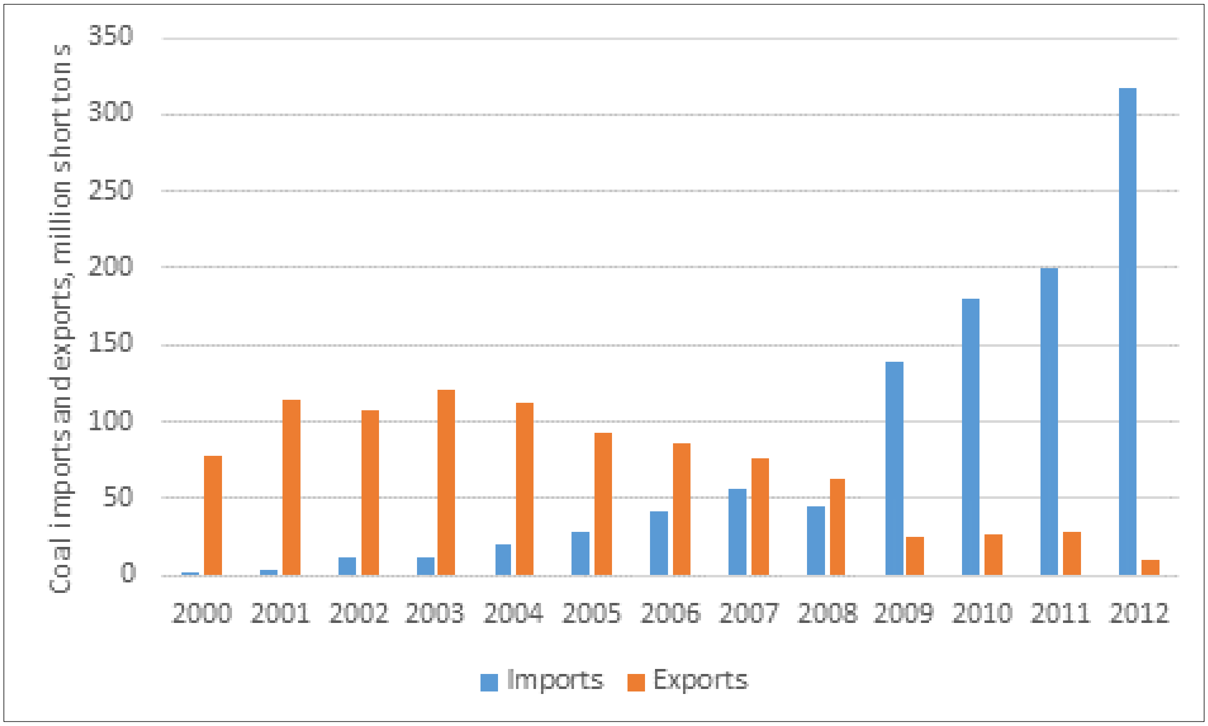
Figure 11. China's Projected Cumulative Power Generation by Type



Source: U.S. Energy Information Administration 2014.

[14] For reference, 200 million tons is about 45% of recent annual coal production from the Powder River Basin, and about 10 times the permitted annual production of 20 million tons from the Otter Creek Mine.

Figure 12. China's Coal Imports and Exports, 2000–2012 (million tons)



Source: U.S. Energy Information Administration 2012.

While analysts expected China's reliance on imports to increase through 2015, Chinese coal imports have actually fallen since peaking in 2013. Weaker economic growth has led to lower coal consumption, while a governmental emphasis on reducing the energy intensity of their economy and lowering air pollution are both compounding factors as well. In response, the government has protected domestic industry and prioritized domestic coal consumption. These measures resulted in a Chinese import tariff of 6% for thermal coal as of October 2014 (The Guardian 2015; Sustainable Enterprise Media 2014).

China has made progress in addressing a number of issues that might have required it to import more coal in the last year and going forwards (Hook 2011).

- **Transportation bottlenecks.** Mining activity in China has shifted farther north and west, away from the south and eastern coastal cities where many coal-fired power plants are located and the demand for electricity is greatest. The coal must be transported from remote northwest locations, where there is limited demand for electricity, to the northeast ports, where it is shipped to the southern ports for domestic consumption. China has made extensive progress in addressing transportation bottlenecks over the last 5 years, which has reduced the reliance on imported coal.

- **Mine safety.** China produces coal primarily from underground coal mines. The methane concentrations in China's underground mines are responsible for a high number of fatalities, relative to fatalities in U.S. underground mines on a per ton basis. In 2012, the overall death rate in China's coal mines was 0.374 deaths per million tons of coal production. In contrast, the death rate in the United States was around 0.035 deaths per million tons of coal production. By increasing coal imports, especially coal produced from surface mines, China expects to lower overall mining fatalities per ton of coal consumed (China Labour Bulletin 2013; Mine Safety and Health Administration 2014).

- **Mine consolidation.** The Chinese government has been consolidating small, private mines into a few large state-owned mines. Initially, consolidation causes coal production to fall dramatically as mines are closed temporarily to retrofit them with additional safety measures (Hook 2011). This consolidation process is well under way and most mines are back to full production.

3.1.2.2 Japan

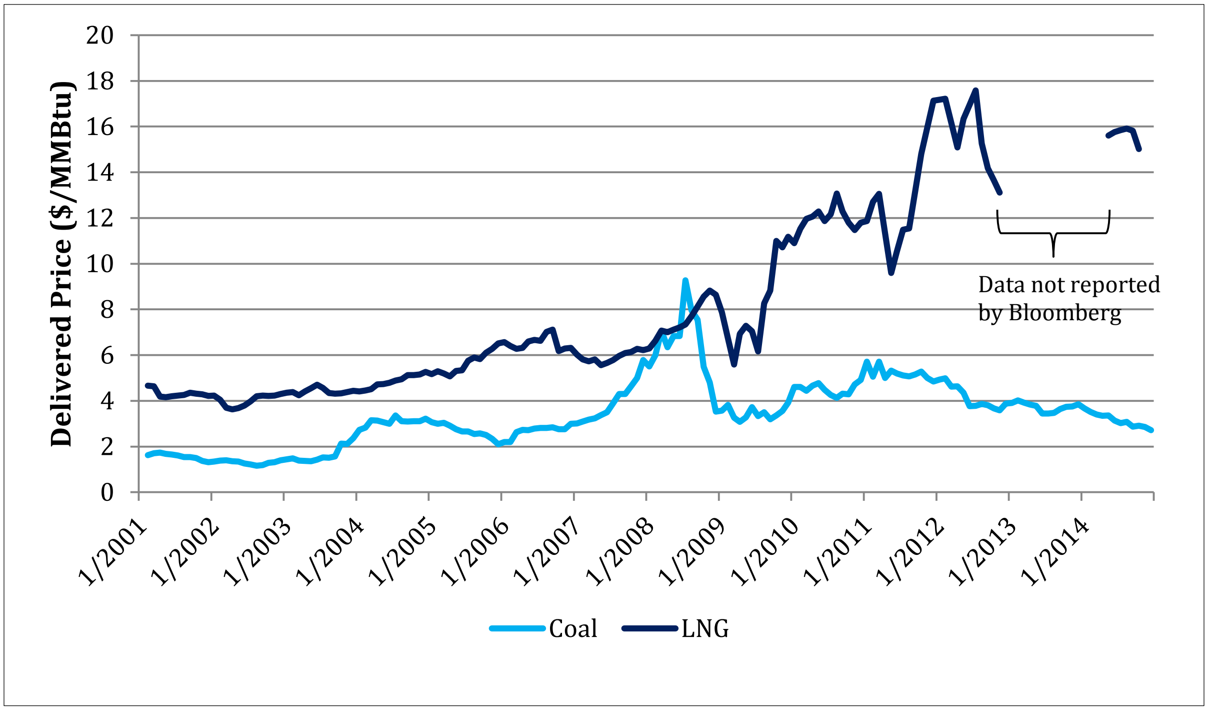
Japan was the world's largest coal importer through 2010; however, after 2010, China became the world's largest coal importer. Japan imported an average of 193.5 million short tons of coal per year between 2000 and 2012 (U.S. Energy Information Administration 2011). Without domestic steam coal resources, Japan relies heavily on imports to satisfy domestic coal demands. Several factors may drive an increase in Japan's coal consumption and imports in the future.

- **Uncertain future for nuclear energy.** The earthquake and tidal wave of March 2011 caused cataclysmic damage at the Fukushima nuclear power plant, precipitating the shutdown of 48 of Japan's 50 nuclear reactors, leaving only two reactors at the Oi nuclear plant in operation (Westlake 2012). Nuclear energy had previously supplied about 30% of the country's electricity needs, a percentage that, prior to the damage, had been expected to increase to 40% by 2017 and 50% by 2030 (World Nuclear Association 2013). The first two idled reactors may reopen in June 2015; however, nuclear reactor operations are still highly uncertain and coal and natural gas consumption are likely to remain higher than consumption prior to 2011.

- **Relative expense of liquefied natural gas.** Coal has historically been significantly cheaper than liquefied natural gas at generally about half price per unit of energy (Figure 13). Much of the recent rush to build U.S. liquefied natural gas export terminals is targeted at exporting gas to Asian countries such as Japan (the world's largest liquefied natural gas importer) to take advantage of the significantly higher natural gas prices in Asia.

- **Renewed government commitment to coal energy.** After withholding approval of all but two proposed coal-fired power plants since 2006, Japan's Ministry of Environment recently lifted a virtual ban on the construction of new coal plants, provided they are equipped with the cleanest and best technologies. This development is motivated by the economic need to diversify energy resources rather than by environmental or safety considerations (Iwata 2013).

Figure 13. Delivered Coal versus Natural Gas Prices to Japan ($/MMBtu)



Source: McCloskey and LNG Japan Corporation data from Bloomberg.

3.1.2.3 South Korea

South Korea is one of the top energy importers in the world, relying on fuel imports for about 97% of its energy demand due to lack of domestic fuel resources. In 2013, the country was the fourth-largest importer of coal. Australia and Indonesia account for the majority of South Korea's coal imports, followed by Russia. Between 2005 and 2012 coal consumption in South Korea increased by 55%. This rise was driven primarily by growing demand from the electric power sector. The electric power sector accounts for 62% of the country's coal consumption, while the industrial sector accounts for most of the remaining amount (U.S Energy Information Administration 2015).

3.1.2.4 Taiwan

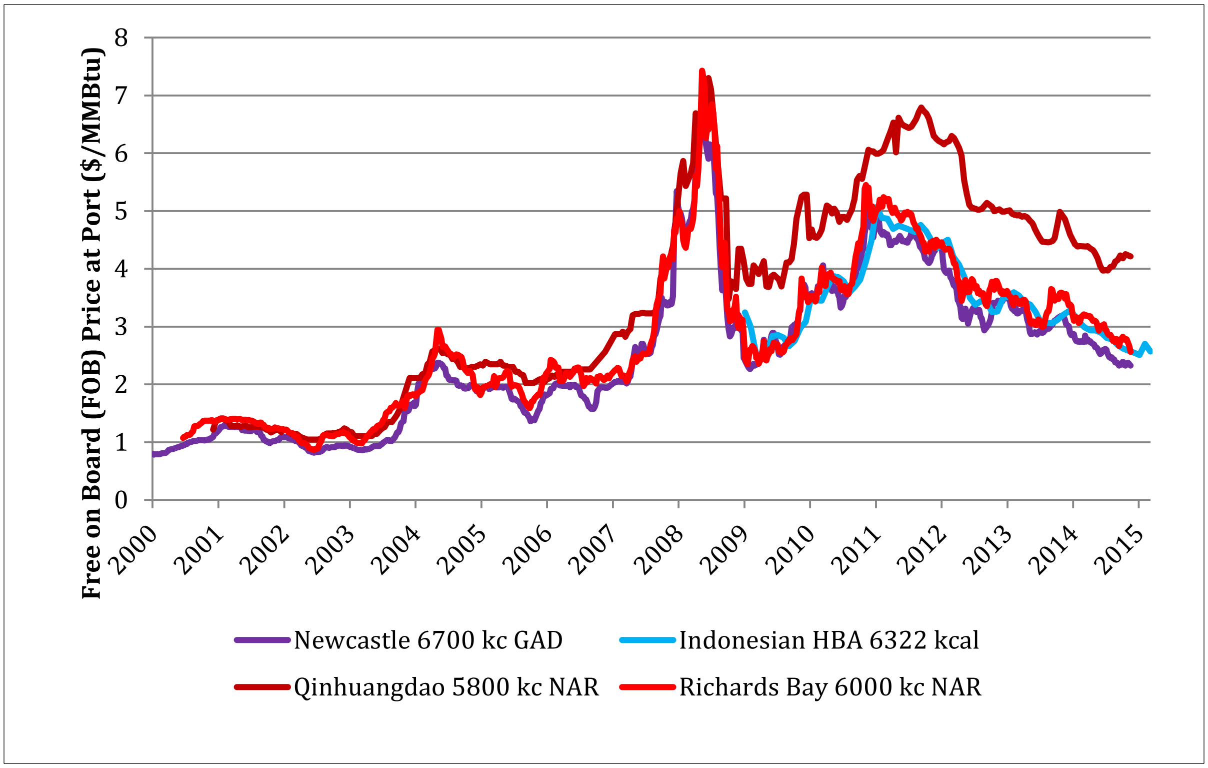
Oil and coal made up 41% and 34% of Taiwan's total primary energy consumption in 2013, respectively, while the remainder was mostly natural gas, nuclear, and smaller amounts of various renewable energy sources. Due to its very limited domestic energy resources, Taiwan imports a large percentage of coal and oil. Taiwan consumed about 72 million tons of coal in 2012, all of which was imported. Coal consumption steadily increased overall since the 1990s and slowed after 2007 as a result of natural gas and renewables substituting some coal supply in the power sector.

3.1.3 Coal Prices

3.1.3.1 Free On Board Prices

Free on board (FOB) terminal prices refer to the aggregate price of the coal, insurance, loading, transportation to the terminal, and documentation costs, typically paid by the seller. Figure 14 shows FOB prices at the supply country's terminal, expressed as price per energy unit ($/MMBtu) to account for coals with different heat content. Key players in the Pacific Basin steam coal export market shown in Figure 15 include Australia (Newcastle), Indonesia (HBA), China (Qinhuangdao), and South Africa (Richards Bay). The coal prices in Figure 15 are not adjusted for the coal moisture content because coals are reported as gross air-dried, gross as received, and net as received.[15]

Figure 14. Historical Pacific Basin Free On Board Steam Coal Prices

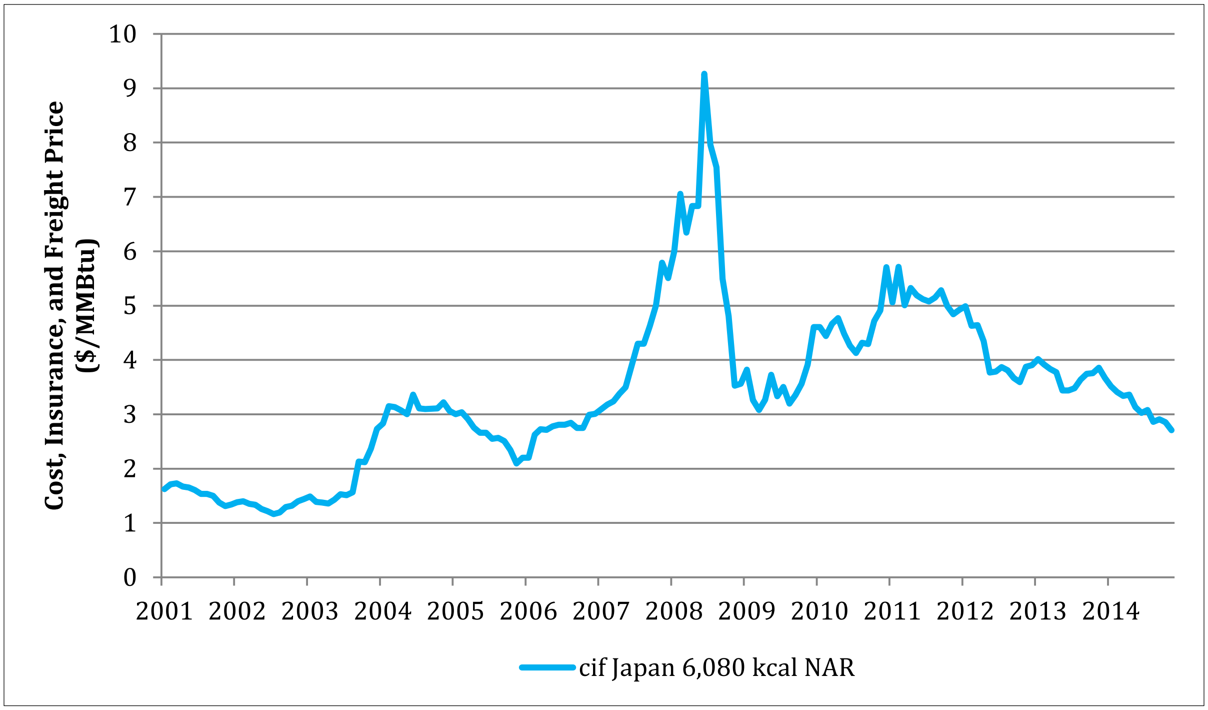


Source: McCloskey, Platts, Indonesia Coal Index, and Newcastle Export Index data from Bloomberg.

Trends in FOB costs are relatively consistent across supply ports, with the exception of China's Qinhuangdao prices, which were noticeably higher from late 2008 to 2014. This gap in prices further illustrates demand for lower-cost coal imports in China, although there are non-market effects impacting Chinese prices as well. The most recent peak in prices was in early 2011 at about $5/MMBtu. Since then international coal prices have dropped by 50% to around $2.5/MMBtu. Powder River Basin coal shipped through Vancouver, British Columbia or other Pacific Northwest ports would have an FOB cost of close to $2.9/MMBtu in 2015, making it somewhat higher than the Pacific Basin 2015 coal prices.

[15] Definitions and conversions can be found at World Coal Association, Coal Conversion Statistics (http://www.worldcoal.org/resources/coal-statistics/coal-conversion-statistics).

Figure 15. Pacific Basin Steam Coal Prices—Japan and Asia



Source: McCloskey data from Bloomberg.

3.1.3.2 Delivered Coal Prices to the Pacific Basin

Delivered coal prices to the Pacific Basin include the costs of coal, freight, and insurance. These prices are summarized using IHS McCloskey's Japan index benchmarks (IHS McCloskey 2013b), which show delivered prices at the terminal of delivery.[16] Prices ranged from $2.7 to $5.7/MMBtu from their peak in early 2011 to 2014 (Figure 15). Delivered prices to Japan in the range of $3.0/MMBtu suggest that Powder River Basin coal would have a difficult time being cost-competitive, if shipped through the Pacific Northwest to Japan or other Pacific Basin countries, until international coal prices increase.

[16] IHS McCloskey is a company that provides benchmark coal prices that can be accessed through Bloomberg.

Chapter 4
Model Framework, Methods, and Key Assumptions

IPM® was used to assess likely coal production, consumption, and distribution patterns resulting from development of the proposed terminal. The impacts of economic and regulatory uncertainties on these outcomes were also examined, through the analysis of three scenarios.

This chapter provides an overview of the IPM® framework, the key assumptions for running the model, and the specific methods used in its analysis.

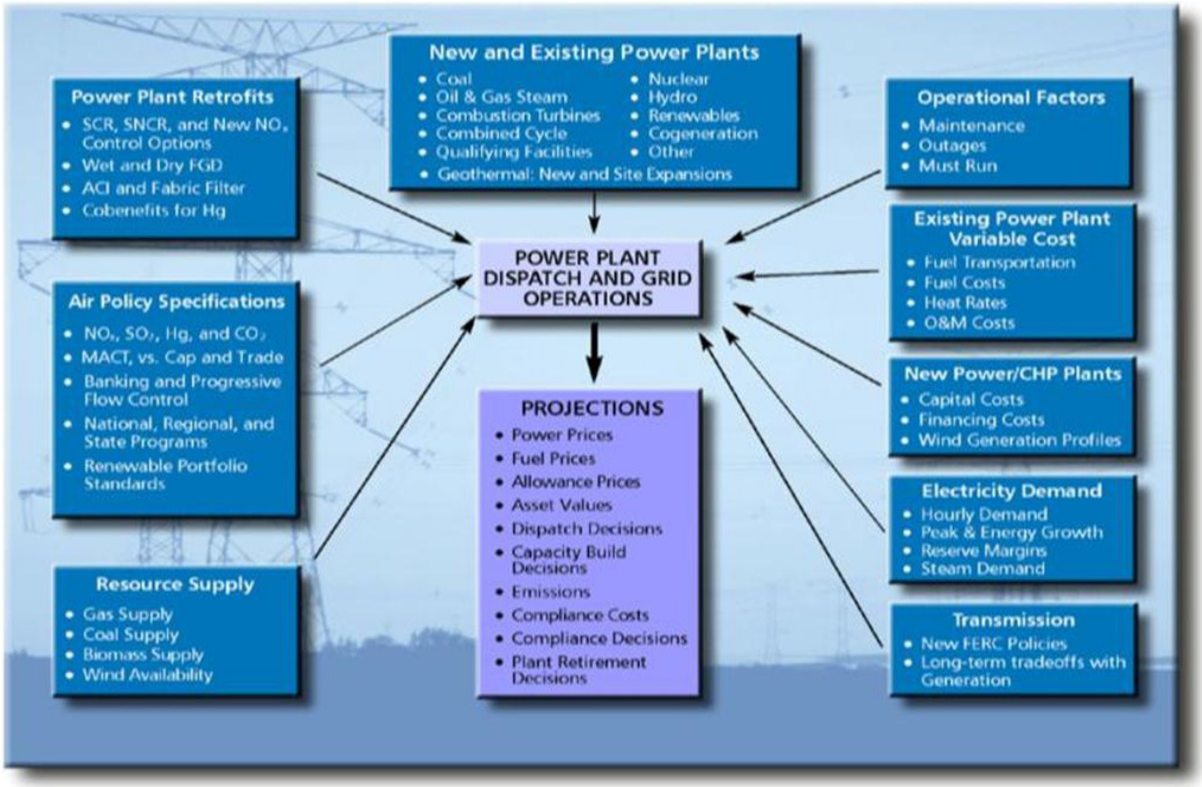
4.1 IPM® Overview and Model Framework

IPM® is an engineering and economic model of the coal and power sectors, supported by an extensive database of coal and power parameters. The model has the ability to add new electricity-generating capacity in response to demand growth and policies, such as renewable portfolio standards. It is widely used to assess domestic and international coal production, transportation, and consumption, and the operations and economics of the U.S. electric power industry. The model also characterizes the U.S. natural gas industry. IPM® is a multiregional model in terms of electricity demand regions, fuel demand regions, and coal supply regions that provides detailed results on a plant, regional, or national level. ICF International has maintained IPM® since the mid-1970s.

IPM® simultaneously analyzes the following energy sectors and the important interactions between them (Figure 16).

- The coal mining industry, including regional coal mine type and coal quality distinctions.
- Coal transportation sectors, such as rail, barge, and ship.
- The electric power generation sector, including regional and power-plant-type distinctions, and very detailed treatment of existing power plants, especially coal-fired units.
- The electricity consumption portion of the business, including hourly and seasonal variations in demand.
- The electricity transmission sectors and the alternatives available to local power production.
- Environmental regulations (national and state) affecting the power sector including CO_2 emissions limitations and renewable portfolio standards. The model also calculates emissions for each individual plant.
- Investment and long-term operational decisions such as coal power plant retirement, power plant mothballing, new power plant construction, existing coal mine operation, and new coal mine additions.
- Domestic and international coal deliveries and consumption.
- Interactions with the natural gas industry.

Figure 16. Integrated Planning Model (IPM®)



IPM® analyzes these markets and calculates competitive market prices based on supply and demand fundamentals. It forecasts the following wide range of parameters.

- Wholesale market power prices for each electricity demand region.
- Power plant dispatch.
- Fuel consumption and both delivered and coal minemouth or gas hub prices.
- Interregional transmission flows.
- Environmental emissions and associated costs.
- Capacity expansion and retirements.
- Retrofits based on an analysis of the engineering economic fundamentals.

The model does not extrapolate from historical conditions. Rather, it provides a least-cost forecast for a given set of current and future conditions that determine how the industry will function. The optimization routine that IPM® uses has dynamic effects—it looks ahead at future years and simultaneously evaluates decisions over an entire specified time horizon, typically 20 to 40 years.

IPM® uses a dynamic linear programming structure to model how electricity demand is met through a mix of generation and transmission in each region, as well as the transmission between regions. The North American version[17] of IPM® is divided into roughly 110 power demand regions, including eight Canadian provinces. The North American version of the model also includes international coal demand and coal supply regions to forecast global coal production and movement.

4.1.1 IPM® Users and Documentation

IPM® is widely used, both in the United States and globally, by private sector companies such as electric utilities, coal power plant owners, coal companies, independent power producers, and financial institutions, and public sector entities, such as environmental groups and state public service commissions (Table 11).

Table 11. Private and Public Sector Entities Using IPM®

Private Sector Entities	Public Sector Entities
PEPCO	U.S. Environmental Protection Agency
Entergy	State public service commissions
Exelon	Environment Canada
Tucson Electric Power	European Union
Florida Power and Light (FPL)	Environmental groups (e.g., Natural Resources Defense Council)
Dominion	
NRG	
Delmarva Power	
Southwestern Electric Power Company	
Calpine	
APS	
Duke Energy	
American Electric Power	
Otter Tail Power Company	
Xcel Energy	
Dogwood Energy	
Peabody Energy	
Dynegy	

IPM® has been used in support of the following types of analyses.

- Coal price forecasts, including forecasts supporting litigation.
- Other coal industry forecasts, including production, transportation, and consumption.
- Air emissions compliance strategies for coal power plants and emissions allowance price forecasting.
- Impact assessments of alternate environmental regulatory standards including coal sector impacts.

[17] ICF International has completed IPM® systems for Europe, Australia, Japan, China, Korea and India, among other nations.

- Assessments of power plant retirement decisions, such as for existing coal power plants.
- Valuation studies for generation and transmission assets, including coal power plant valuations.
- Forecasting of regional forward energy and capacity prices.
- Forecasting of state and regional renewable energy credits.
- Impact assessments of changes in fuel pricing.
- Integrated Resource Planning analyses.
- Economic or electricity demand growth analyses.
- Pricing impacts of demand responsiveness.

EPA uses IPM® to analyze the impact of air emissions policies on the U.S. electric power sector. As part of this analysis, EPA publishes its assumptions and other information regarding its use of IPM® on its website (U.S. Environmental Protection Agency 2012). Although this documentation provides insight into EPA's assumptions, the data and assumptions used by ICF in this analysis are not necessarily the same as used by EPA. However, ICF did use many of the EPA assumptions as described in more detail in Section 4.2.

4.2 Key Assumptions

In this use of IPM®, key assumptions were made regarding fuel; air, waste, and water regulations; renewable energy regulations; reserve margin targets; mothballing and retirement of existing power plants; and transmission. To the extent possible, assumptions from publicly available sources, such as the EIA, IEA, and EPA were used. The majority of assumptions were obtained from EPA's v5.13 IPM Base Case (2013). The following subsections discuss the major assumptions used in this analysis.

4.2.1 Assumptions from Millennium Bulk Terminals—Longview

The following project-specific assumptions were provided by the Applicant.

- The proposed coal export terminal will export 44 million metric tons of coal per year.
- The proposed coal export terminal will start exporting 44 million metric tons of coal in 2025.
- Only Powder River Basin or Uinta Basin coal will be exported through the proposed coal export terminal.

4.2.2 Fuel

Fuel-related assumptions include those concerning coal and natural gas production and demand.

4.2.2.1 Coal Supply Curves

For this analysis, coal supply curves from EPA's v5.13 IPM® case were used. Because EPA only models the United States and does not include international representation beyond coal imports from Colombia and coal production from Canada, coal supply curves were developed for each of the international supply regions used in the model, except for Canada. These international coal supply curves were adjusted over time at the average rate that the EPA domestic supply curves were adjusted. On average, the domestic EPA supply curves increase in cost by 1.5% annually. Thus the international supply curve costs were also increased by 1.5% per year. The coal prices that the EPA coal supply curves produce in the Past Conditions (2014) Scenario are shown in Table 12 for Wyoming, Montana, Colorado, and Utah, which are regions from which coal might be exported through the terminal. Coal prices in 2016 for Wyoming Powder River Basin 17.6 MMBtu/ton coal are expected to be around $10.9/ton (2012$) and rising to $13.0/ton by 2018.[18] Thus, the EPA supply curves for Wyoming Powder River Basin coal result in prices somewhat higher than market expectations as of early 2015. Coal prices in 2016 for Utah coal are expected to be $40.8/ton (2012$) and rising to $41.2 by 2018. EPA's coal supply curves were most likely developed in 2013, at which time the Uinta Basin coal prices were in the $35/ton range. Thus, the EPA supply curves result in Uinta Basin coal prices that are below market expectations for the next few years. Since 2013, coal prices in general have declined by 10% to 20%, although some prices started declining in 2012 and others, such Powder River Basin coal fell 20% to 30% in 2012 and have been gradually increasing. Coal prices have decreased recently due to lower demand because of milder weather and because of being displaced by natural gas, which has been at historically low prices. In the mid- to long term, which is the focus of this analysis, coal prices are expected to increase above the low prices observed in 2015.

However, of equal importance is that a cohesive view of the coal markets and coal prices is used in the analysis. Such a cohesive approach is obtained by using the EPA coal supply curves in their entirety.

Table 12. Coal Prices in the Past Conditions (2014) Scenario—No-Action Alternative (2012$/short ton)

Year	Wyoming Powder River Basin, 17.6 MMBtu/ton	Montana Powder River Basin, 18.2 MMBtu/ton	Colorado Uinta, 23.58 MMBtu/ton	Utah Uinta, 23 MMBtu/ton
2016	12.69	11.99	29.42	27.00
2018	13.37	12.62	30.72	28.05
2020	14.16	13.37	32.61	29.43
2025	16.21	15.30	36.05	32.73
2030	18.70	17.64	40.44	36.95
2040	24.59	23.18	52.03	45.81

4.2.2.2 Natural Gas

This analysis incorporates the natural gas module that EPA used in its IPM® v5.13 Base Case. The assumptions and details of the natural gas module are fully documented in Chapter 10 of EPA's v5.13 documentation, which can be found at:

[18] SNL Coal Price Forecast as of May 18, 2015; SNL Financial; www.SNL.com.

http://www.epa.gov/airmarkets/programs/ipm/psmodel.html. Using the natural gas module allows natural gas prices to adjust to changes in demand. Table 13 shows the natural gas prices at Henry Hub, which is a major natural gas pricing point in Louisiana.

Table 13. Natural Gas Prices in the Past Conditions (2014) Scenario (2012$/MMBtu)

Year	Henry Hub (2012$/MMBtu)
2016	4.73
2018	5.39
2020	4.86
2025	5.34
2030	5.52
2040	6.12

4.2.3 Air, Waste, and Water Regulations

The regulatory assumptions used in this analysis reflect the assumptions used by EPA in its IPM® v5.13 Base Case. The Past Conditions (2014) Scenario for this analysis of the terminal does not include EPA's Clean Power Plan. However, the 2015 Energy Policy Scenario does include the proposed Clean Power Plan as modeled by EPA.

- The provisions of the Clean Air Interstate Rule (CAIR) are used in the analysis for sulfur dioxide (SO_2) and nitrogen oxides (NO_x) regulations. CAIR uses a cap and trade system to reduce SO_2 and NO_x for 27 eastern states and DC. CAIR uses Title IV SO_2 allowances as currency for the SO_2 trading program. The initial bank and allowance totals for CAIR are the same as for the Acid Rain Program established under Title IV of the Clean Air Act Amendments of 1990. For the Annual NO_x trading program, the total Annual NO_x allowances issued for 2016 was 1.2 million and the initial bank for 2016 was projected to be 1.5 million allowances. For the Ozone Season NO_x trading program, the total seasonal NO_x allowances was 0.48 million and the initial bank going into 2016 was projected to be 0.74 million.

- The EPA's Mercury and Air Toxics Standards final rule is used in the analysis and requires that all coal-fired generating units be controlled for air toxics, or be within 1 year of being controlled, by 2016, or the units must be retired (40 Code of Federal Regulations [CFR] Parts 60 and 63).

- EPA included the CO_2 cap in the Regional Greenhouse Gas Initiative for this analysis. The Regional Greenhouse Gas Initiative is a market-based regulatory program to reduce CO_2 emissions by setting a cap on emissions that decreases each year. Nine states in the northeast are part of the initiative (Regional Greenhouse Gas Initiative 2014).

- EPA also included the California Assembly Bill 32 cap-and-trade program in the v5.13 Base Case, which is expected to be more stringent than any likely federal CO_2 standards. The bill affects both in-state generation and power imported into California (Assembly Bill No. 32 Chapter 488).

- Other state SO_2 and NO_X regulations are included where final regulations exist.

4.2.4 Renewable Energy Regulations

- EPA's assumptions and regional structure regarding state specific renewable portfolio standards and solar carve-outs as described in Section 3.9.8 of Chapter 3 of EPA's documentation of its IPM® v5.13 Base Case were used.

4.2.5 Reserve Margin Targets

IPM's reliability-related assumptions reflect planning reserve margin requirements, which are targets for generating capacity that are used to ensure sufficient generating capacity is available at all times, such as when some plants are out of service for maintenance or equipment problems occur during peak demand periods.

- The reserve margin assumptions used in IPM® for this analysis are the planning reserve margins used by EPA in its IPM® v5.13 Base Case, as described in Section 3.6 of Chapter 3 of its v5.13 documentation.

4.2.6 Mothballing and Retirement

ICF's assumptions reflect the ability of electricity generating plants to mothball and return to service at a later date, or to retire. The capability to model plants entering a mothball state or retiring more realistically represents the actual energy market than a model that does not include this capability.

- To capture market exit behavior, IPM® included mothballing and retirement capabilities. Generating units with high fixed operations and maintenance costs become candidates for mothballing and retirement as more efficient generation capacity is constructed.
- The mothballing option is provided for all oil/natural gas steam facilities and is exercised if short-term annual fixed costs exceed annual revenues in a market with excess supply. The decision to mothball takes into consideration fixed costs, reserve requirements, and the costs of mothballing a unit and returning it to service at a later date.
- Retirement options are available to all existing coal, nuclear, and oil/natural gas steam units in IPM®. The modeling assumes that the retirement option would be exercised if projected discounted cash flows do not exceed projected costs (fixed, variable, and capital). Again, this decision takes long-term reserve requirements and revenues into consideration.
- The analysis assesses higher fixed operations and maintenance costs to uncontrolled coal units after 60 years in service to account for life-extension costs, potentially increasing the amount of coal retirements as the model chooses to retire units rather than pay the life-extension costs.

4.2.7 Transmission

IPM's assumptions took into account the capabilities of transmission lines. These assumptions are based on a thorough analysis of the transmission structure and constraints, and represent the most probable outlook at the time of the forecast.

- Joint capacity constraints were included to reflect limitations across groups of transmission links.

- Total transmission capability assumptions from public sources such as the North American Electric Reliability Corporation and regional reliability councils were used, as well as interface limits published by the International Organization for Standardization, where available.
- In regions where data were unavailable, the analysis used estimates derived from industry contacts and proprietary modeling exercises.
- The model assumed that power transported across power pools would incur a cost of $3.09 per megawatt hour (2011 U.S. dollars) to reflect charges assessed by one power pool to another.
- IPM® did not include regional through-and-out rates for any transactions terminating in the combined PJM-MISO footprint. Regional through-and-out rates are transmission rates for transactions where electricity originated in one transmission control area was transmitted to a point outside that control area.
- Transmission losses vary with line loading and line length, but estimating the exact loss factors for each interconnecting transmission path for the entire country would be impracticable. ICF's analysis, therefore, assumed transmission losses between 2% and 3%, based on industry practices. Note that these losses were intended to capture only bulk power transmission losses; distribution losses were not included.

4.2.8 International Coal Demand

International coal demand in the model is represented by a forecast of a region's or country's total thermal coal demand. Two sources were used as starting points for the international demand forecast. First, for the Past Conditions (2014) and Cumulative Scenarios, the most recent EIA forecast available was used, which was EIA's 2013 International Energy Outlook. The EIA data was used because it is a publicly available source and because it provides coal demand forecast data in sufficient detail for the countries of interest. Second, the International Energy Agency's 2014 World Energy Outlook was used. Tables 14 through 16 show the demand forecast for six Pacific Basin countries/regions. The Lower Bound and 2015 Energy Policy Scenarios used international demand forecasts based on IEA's 2014 World Energy Outlook, New Policy Scenario as a starting point. Under the New Policy Scenario major industrial countries are assumed to have policies in place to reduce the emissions of GHGs. These policies reduce the demand for coal. However, because of differences in assumptions, all but China's coal demand forecast uses the IEA New Policy Scenario, since the coal demand for other countries was higher than the EIA forecasts used in the Past Conditions (2014) Scenario. Thus, in the Lower Bound Scenario the EIA demand growth rates for all but China were reduced by 50% instead of using the higher IEA New Policy Scenario forecast for all other Pacific Basin countries. Without this assumption, the Lower Bound coal demand would have been the same as or higher than the Past Conditions (2014) Scenario coal demand, which would defeat the purpose of the Lower Bound Scenario. The IEA Current Policy Scenario was not used for the Past Conditions (2014) Scenario in this analysis as the IEA data is not provided at sufficient detail to populate the international demand regions used in the model.

Table 14. International Coal Demand—Past Conditions (2014) and Cumulative Scenarios (Trillion Btu)

	Country or Region					
Year	**China**	**Hong Kong**	**India**	**Japan**	**South Korea**	**Taiwan**
2016	76,248	336	11,841	3,190	2,013	1,633
2017	79,543	338	12,111	3,190	1,992	1,641
2018	81,449	339	12,325	3,182	1,977	1,650
2019	83,174	341	12,675	3,188	1,961	1,658
2020	84,961	343	13,109	3,190	1,945	1,666
2021	87,254	345	13,482	3,190	1,947	1,675
2022	89,458	346	13,821	3,184	1,939	1,683
2023	91,682	348	14,187	3,173	1,927	1,691
2024	94,198	350	14,592	3,164	1,919	1,700
2025	96,410	351	14,904	3,151	1,899	1,708
2026	97,989	353	15,251	3,142	1,873	1,717
2027	99,672	355	15,641	3,131	1,843	1,725
2028	101,448	357	15,965	3,119	1,814	1,734
2029	103,146	359	16,280	3,105	1,781	1,743
2030	104,764	360	16,591	3,089	1,751	1,751
2031	106,167	362	16,951	3,077	1,754	1,760
2032	107,315	364	17,306	3,063	1,757	1,769
2033	108,297	366	17,659	3,042	1,757	1,778
2034	109,033	368	18,010	3,022	1,760	1,787
2035	109,484	369	18,346	3,001	1,761	1,796
2036	109,703	371	18,670	2,972	1,747	1,805
2037	109,799	373	18,969	2,933	1,732	1,814
2038	109,662	375	19,280	2,902	1,722	1,823
2016–2019 CAGR	2.94%	0.50%	2.29%	-0.02%	-0.87%	0.50%
2020–2029 CAGR	2.18%	0.50%	2.44%	-0.30%	-0.97%	0.50%
2030–2038 CAGR	0.57%	0.50%	1.90%	-0.78%	-0.21%	0.50%
2016–2038 CAGR	1.67%	0.50%	2.24%	-0.43%	-0.71%	0.50%

Table 15. International Coal Demand—Lower Bound Scenario (Trillion Btu)

	Country or Region					
Year	China	Hong Kong	India	Japan	South Korea	Taiwan
2016	68,855	336	11,841	3,190	2,013	1,633
2017	69,742	338	11,977	3,189	1,987	1,637
2018	70,639	339	12,114	3,188	1,961	1,641
2019	71,549	341	12,253	3,187	1,936	1,646
2020	72,470	343	12,402	3,172	1,907	1,650
2021	72,713	345	12,553	3,158	1,880	1,654
2022	72,956	346	12,706	3,144	1,852	1,658
2023	73,200	348	12,861	3,130	1,825	1,662
2024	73,445	350	13,017	3,116	1,799	1,666
2025	73,691	351	13,176	3,102	1,772	1,670
2026	73,887	353	13,336	3,088	1,747	1,675
2027	74,083	355	13,499	3,074	1,721	1,679
2028	74,280	357	13,663	3,060	1,696	1,683
2029	74,477	359	13,830	3,046	1,671	1,687
2030	74,675	360	13,961	3,010	1,666	1,691
2031	74,545	362	14,093	2,975	1,661	1,696
2032	74,416	364	14,227	2,941	1,656	1,700
2033	74,288	366	14,361	2,906	1,651	1,704
2034	74,159	368	14,497	2,872	1,645	1,708
2035	74,031	369	14,635	2,839	1,640	1,713
2036	73,497	371	14,774	2,806	1,635	1,717
2037	72,968	373	14,914	2,773	1,630	1,721
2038	72,442	375	15,055	2,740	1,625	1,726
2039	71,922	375	15,198	2,708	1,620	1,730
2040	71,406	375	15,342	2,677	1,615	1,734

Notes:
Source: IEA World Energy Outlook 2014 for China demand. Due to differences in methodology, the IEA thermal coal demand for the other countries is above the EIA demand forecast. Thus, the demand estimate for the other countries was calculated by reducing the growth rates by 50%.

Table 16. International Coal Demand—Upper Bound Scenario (Trillion Btu)

	Country or Region					
Year	**China**	**Hong Kong**	**India**	**Japan**	**South Korea**	**Taiwan**
2016	76,248	336	11,841	3,190	2,013	1,633
2017	79,611	339	12,248	3,190	2,004	1,646
2018	83,122	341	12,670	3,190	1,996	1,658
2019	86,788	344	13,106	3,189	1,987	1,670
2020	89,624	346	13,585	3,184	1,977	1,683
2021	92,553	349	14,081	3,180	1,968	1,695
2022	95,577	351	14,595	3,175	1,958	1,708
2023	98,700	354	15,129	3,170	1,949	1,721
2024	101,925	357	15,681	3,165	1,939	1,734
2025	105,256	359	16,254	3,161	1,930	1,747
2026	108,695	362	16,848	3,156	1,921	1,760
2027	112,247	365	17,464	3,151	1,911	1,773
2028	115,915	368	18,102	3,146	1,902	1,786
2029	119,703	370	18,763	3,142	1,893	1,800
2030	120,731	373	19,296	3,129	1,891	1,813
2031	121,769	376	19,845	3,117	1,889	1,827
2032	122,815	379	20,409	3,105	1,887	1,841
2033	123,870	382	20,990	3,093	1,885	1,854
2034	124,934	384	21,586	3,081	1,883	1,868
2035	126,008	387	22,200	3,069	1,881	1,882
2036	127,090	390	22,831	3,057	1,879	1,897
2037	128,182	393	23,480	3,045	1,877	1,911
2038	129,283	396	24,148	3,033	1,875	1,925
2039	130,394	399	24,835	3,021	1,873	1,940
2040	131,514	402	25,541	3,010	1,871	1,954

Notes:
The EIA thermal coal demand estimate was calculated by increasing each country's growth rate by 50%.

4.2.9 Coal Demand Elasticity

Because the international coal demand is a forecast that is an input to the model, coal demand elasticity was used to adjust the demand based on the change in delivered coal prices. The demand elasticity is a measure of how much coal demand will change with a given change in the delivered coal price. As delivered coal prices change, the demand for coal changes in the opposite direction. ICF conducted a literature search to identify an energy-specific demand elasticity for this analysis. A total of eight sources were reviewed that provided demand elasticity for electricity, natural gas, and coal. The demand elasticity found in the sources ranged from a minimum of 0.11% to a maximum of 1.2%. Thus, for a 1.0% decrease in delivered coal prices there would be an increase in demand of between 0.11% and 1.2%. For the Past Conditions (2014) Scenario, the average of the eight sources, 0.4%, was used for the coal demand elasticity. The Lower and Upper Bound Scenarios used the minimum and maximum demand elasticity values from the literature search.

4.2.10 CO_2 Emissions from Coal Combustion

To estimate the CO_2 emissions from coal combustion, two main inputs are required. These inputs are (1) the amount of coal consumed in trillion Btu (TBtu) and (2) the carbon content, in pounds per million Btu, of the coal being consumed. The carbon content varies by coal rank (i.e., bituminous, subbituminous, and lignite) and by the source region of the coal; however, the data by region is incomplete. Since IPM® includes all U.S. coal plants, the model calculates the CO_2 emissions in the United States. However, IPM® does not calculate the CO_2 emissions for international coal consumption. The model solution does determine the amount of coal consumed and the type of coal consumed, which covers the two inputs required for calculating CO_2 emissions from international coal demand regions. IPM assumes that no coal plants have carbon capture and sequestration technology installed and that it will not be installed on new or existing plants during the timeframe of this analysis. Table 17 shows the CO_2 content of the three coal ranks.

Table 17. CO_2 Content in Coal by Type and Source Region

Source	Coal Type	CO_2 (lb/MMBtu)
Powder River Basin – WY	Subbituminous	214.3
Powder River Basin – MT	Subbituminous	215.5
Uinta – CO	Bituminous	209.6
Uinta – UT	Bituminous	209.6
Australia	Bituminous	205.3
Indonesia	Bituminous	205.3
Indonesia	Subbituminous	212.7
China	Bituminous	205.3
China	Lignite	215.4

Notes:
Source: Hong and Slatick 1994

4.2.11 Coal Distribution Limitations

Coal plants are typically designed to burn a specific type of coal and have limited ability to switch to a different type of coal. For example, coal plants designed to burn bituminous coal have boilers that are too small to burn 100% subbituminous coal. However, bituminous coal plants are typically able to mix some subbituminous coal along with the bituminous coal they consume. Coal plants in Japan, South Korea, Taiwan, and Hong Kong, consume higher heat content bituminous coal and thus would be limited in the amount of subbituminous coal that they could consume without needing costly plant retrofits. To ensure that the model does not send more subbituminous coal to these countries than they can use, constraints were added to limit the amount of subbituminous coal to no more than 30% of the country's total coal demand in TBtu.

4.2.12 Coal Reserves

Coal reserves both domestically and internationally are an important companion input to annual coal production capacity in the coal supply curves. Over time as the reserves on a step on the coal supply curve are exhausted the solved equilibrium price must solve higher on the coal supply curve, thus generally pushing prices higher over time, all else equal.

The domestic coal reserve estimates used in this analysis are included in the EPA coal supply curves adopted from EPA's v5.13 IPM documentation. International reserve data is generally of lower quality and can be inconsistent between sources. If multiple sources of reserve estimates were available, the analysis used the higher estimates, as technological improvements tend to make resources available that might have been un-economic previously.

4.3 Methods

This section provides an overview of the methods used in the analysis.

4.3.1 Model Run Years

Table 18 presents a map of calendar years and run years. Run years aggregate calendar years to limit model complexity. In other words, a run year is a calendar year chosen to represent a single year or a group of years in which prevailing electricity and fuel market conditions and environmental policies are expected to be most similar. The number of IPM® run years must be limited to decrease model complexity. The analysis period of 2016 to 2038 reflects the 23-year period of reasonably foreseeable coal export by the proposed terminal.

Table 18. Mapping of Calendar Years and Model Run Years

Calendar Year	Run Year
2016	2016
2017	
2018	2018
2019	2020
2020	
2021	
2022	
2023	2025
2024	
2025	
2026	
2027	
2028	2030
2029	
2030	
2031	
2032	
2033	
2034	2040
2035	
2036	
2037	
2038	

Calendar Year	Run Year
2039	
2040	
2041	
2042	
2043	
2044	
2045	

4.3.2 Coal

4.3.2.1 Modeling U.S. Coal Production

IPM® optimizes coal production, transportation, and consumption. For this purpose, the model uses coal supply curves developed for EPA, which provide supply curves for 34 different domestic coal supply basins. The international coal supply curves for 25 international supply basins were developed by ICF and added to the domestic supply curves to allow for global coal modeling. Coal supply curves are developed for 15 coal types distinguished by rank and sulfur content. There are multiple coal supply curves for each supply basin corresponding to the major coal quality types in that region. The supply curves consist of a series of supply "steps" that consist of a production cost, annual production capacity, and a coal resource limit. These supply curves are then incorporated into IPM®. Each coal power plant in IPM® is assigned to its own coal demand region in the model.

Coal varies by heat content, SO_2 content, hydrogen chloride content, and mercury content among other characteristics. To capture differences in the sulfur and heat content of coal, a two letter "coal grade" nomenclature is used. The first letter indicates the "coal rank" (bituminous, subbituminous, or lignite) with their associated heat content ranges (as shown in Table 19). The second letter indicates their "sulfur grade," i.e., the SO_2 ranges associated with a given type of coal. (The sulfur grades and associated SO_2 ranges are shown in Table 20).

Table 19. Coal Rank Heat Content Ranges

Coal Type	Heat Content (Btu/lb)	Classification
Bituminous	>10,260–13,000	B
Subbituminous	>7,500–10,260	S
Lignite	Less than 7,500	L

Notes:
Btu/lb = British thermal units per pound

Table 20. Coal Grade SO_2 Content Ranges

SO_2 Grade	SO_2 Content Range (lbs/MMBtu)
A	0.00–0.80
B	0.81–1.20
D	1.21–1.66
E	1.67–3.34
G	3.35–5.00
H	> 5.00

Notes:
SO_2 = sulfur dioxide; lbs/MMBtu = pounds per million metric British thermal unit

IPM® includes integrated U.S. and international coal market modeling. Figures 17 and 18 show the domestic and international coal supply regions. The modeling platform captures terminal capacity limits, international shipping costs, steam coal supply, and demand from both electricity and non-electricity sectors.

Figure 17. Domestic Coal Supply Regions

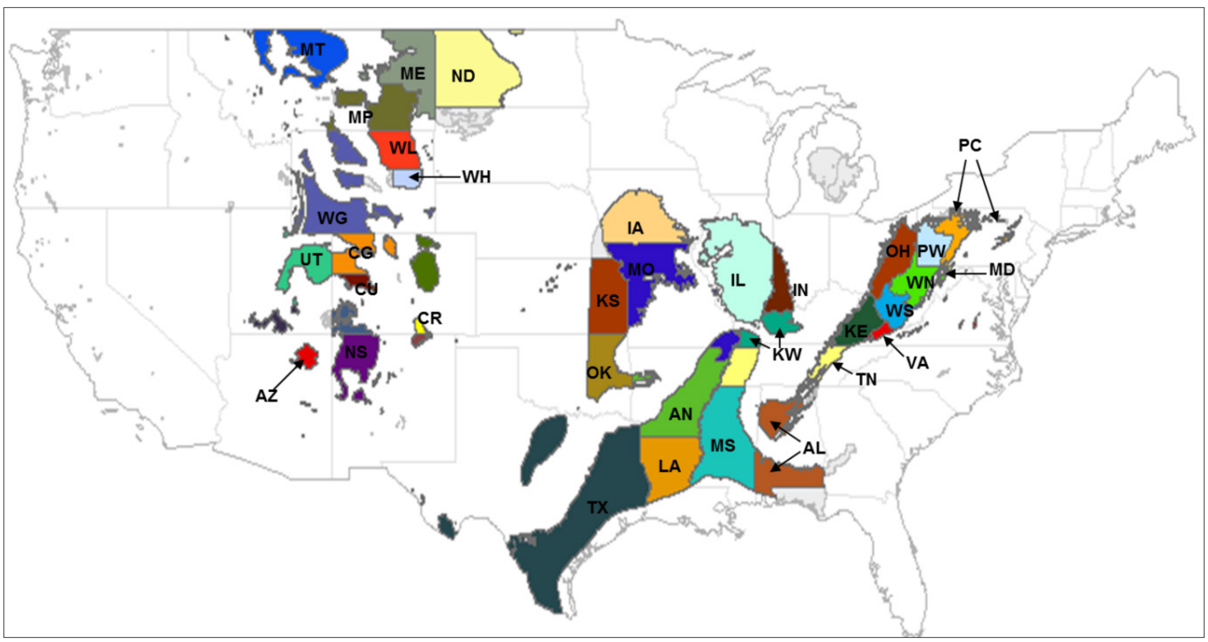
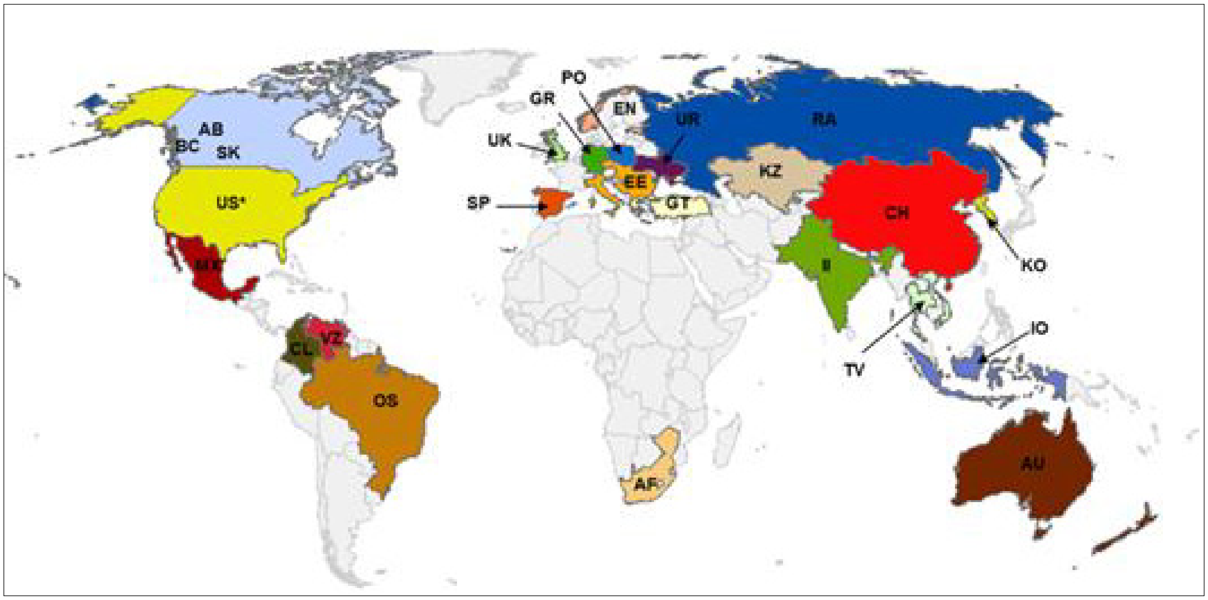


Figure 18. International Coal Supply Regions



4.3.2.2 Coal Demand

Using IPM®, coal demand is determined in the United States and Canada by the operation of existing coal-fired power plants, and elsewhere by projections of coal demand by country. Within a model run, IPM® calculates thermal coal consumption for each coal-fired electricity generation plant in the United States and Canada. Thermal coal consumption and coal prices are determined by the supply and demand economics of meeting the electricity demand. The plant specific coal consumption and coal supply region price projections result in an integrated and consistent analysis in IPM® of the electricity demand; natural gas supply and prices; air emissions regulations for NO_X, SO_2, hydrogen chloride, and mercury; CO_2 policy alternatives, and renewable portfolio standards and explicit modeling of renewable generation options.

If the future electricity demand cannot be met by existing power plants, IPM® will determine the type and amount of new generating capacity required to meet the electricity demand on a least cost basis. The different types of capacity that can be added consist of combustion turbines, combined cycles, nuclear units, wind plants, coal-fired units, solar PV and thermal, geothermal, biomass, landfill gas, and hydro. Thus, if IPM® determines that new coal plants in the United States and Canada are necessary, it will increase coal demand. IPM® can also determine that it is most economical to retire existing coal plants, which would decrease coal demand. This is only applicable in the United States and Canada, as coal plants are modeled explicitly in only these countries. Using this structure, IPM® is able to model explicitly the shifts in coal demand related to environmental mandates, natural gas prices, and coal production and transportation costs. For example, if natural gas prices are low, more electricity will be generated by natural gas-fired combined cycles, and coal consumption will be lower than in a case with higher natural gas prices. Outside of the United States and Canada, coal demand is estimated using historical coal consumption data, expected coal plant construction, and economic and population trends.

Table 21 shows the coal demand forecast for China, the rest of the Pacific Basin, and the United States. As the forecast shows, China is expected to continue to be the largest thermal coal consumer through 2038.

Table 21. Global Thermal Coal Demand (million tons)

Year	China[a]	Hong Kong[a]	India[a]	Japan[a]	South Korea[a]	Taiwan[a]	United States[b]
2018	4,548	14.6	712	136	83.8	66.6	907
2025	5,383	15.1	820	135	80.5	69.0	863
2030	5,849	15.5	958	132	74.2	70.7	852
2038	6,123	16.1	1,096	124	73.0	73.6	865

Notes:

[a] International total coal demand obtained from EIA International Energy Outlook 2013. Metallurgical coal demand was subtracted to obtain the thermal coal demand.

[b] The U.S. demand is from the Past Conditions (2014) Scenario of this analysis.

In terms of non-electricity sector demand for thermal coal, IPM® includes domestic and international forecasts that serve as the demand for this coal. IPM® has an international coal supply and demand representation that enables it to project coal exports out of and imports into the United States and other countries. Table 22 summarizes the overall U.S. electricity demand forecast.

Table 22. U.S. Energy Demand Forecast

Year	Energy Demand (TWh)
2016	4,048.7
2018	4,134.6
2025	4,390.0
2030	4,535.1
2040	4,887

Notes:

Source: EPA IPM V5.13 documentation

TWh = terawatt hours

4.3.2.3 Coal Transportation

The model also connects the 34 U.S. coal supply regions and the 25 international supply regions with the plant specific coal demand regions in the United States and Canada, and 26 international coal demand regions. The transportation costs between supply and demand regions are based on the transportation mode, such as rail, barge, and truck, and the mileage between each region by mode. Each coal demand region has on average 9 supply regions connected to it, using one or more transportation modes. For international shipments, shipping rates are estimated based on published shipping cost data and are adjusted going forward based on projections of the global shipping index, the Baltic Dry Index.

During each run, IPM® determines the least cost means to meet power sector demand for coal as part of an integrated optimal solution for power, fuel, and emissions markets. Thus, IPM® is able to determine the optimal sourcing of coal for each power plant based on the estimated coal prices and transportation costs. Additional information on the coal transportation inputs and methodology used can be found in Chapter 9 of EPA's documentation on the IPM v5.13 Base Case.

4.3.3 Environmental Compliance

4.3.3.1 Plant-by-Plant Compliance Overview

For explicitly modeled coal plant in the United States and Canada, IPM® incorporates constraints on emissions of NO_X, SO_2, hydrogen chloride, mercury, CO_2, and potentially other pollutants into its optimization process. Since coal demand in other countries is done through a forecast and not explicitly modeling coal plants, this is only applicable to U.S. and Canadian coal plants. Constraints are specified on the basis of target emissions rates, cap-and-trade policies, dollars per ton emitted tariffs, or command-and-control policies, and applied to individual generating units or groups of units. Power-generating units subject to environmental regulations have the following compliance options, with any combination or individual use of the first four options as a viable compliance mechanism.

- **Reduce running regime**. To comply with non-command-and-control policies, such as target emissions rates or an emissions cap, a unit can reduce the number of hours in a year it operates and shift when it operates to hours that are more lucrative, which would be during peak demand periods of a day or year. For example, a plant might run only during the peak hours of 6:00 a.m. and 10:00 p.m., or only during the peak summer season.
- **Fuel switch**. Coal-fired units can choose from a variety of coals of different sulfur and mercury contents to minimize emissions and allowance cost impacts. The demand for these lower content coals results in premiums for those coals, over coals with higher pollutant contents. This premium may shrink if, for example, control becomes the dominant compliance option and higher pollutant content coals can be burned by controlled units. Oil units are generally offered fuels with different sulfur contents as well. The system may also fuel switch, from new coal builds to new natural gas builds, for example, to address CO_2 emissions requirements.
- **Retrofit**. For the four pollutants NO_X, SO_2, hydrogen chloride, and mercury, a variety of retrofit technologies is available to reduce emissions. In the case of CO_2, IPM® includes potential carbon capture-and-sequestration technology retrofits that can be applied to both new and existing units.
- **Purchase allowances**. By calculating an allowance price, IPM® is implicitly assuming that some units are sellers of allowances and others are buyers.
- **Retire.** A unit can be forced to retire or be given the economic option to retire if it cannot cover its operating costs going forward.

4.3.3.2 CO_2 Emissions

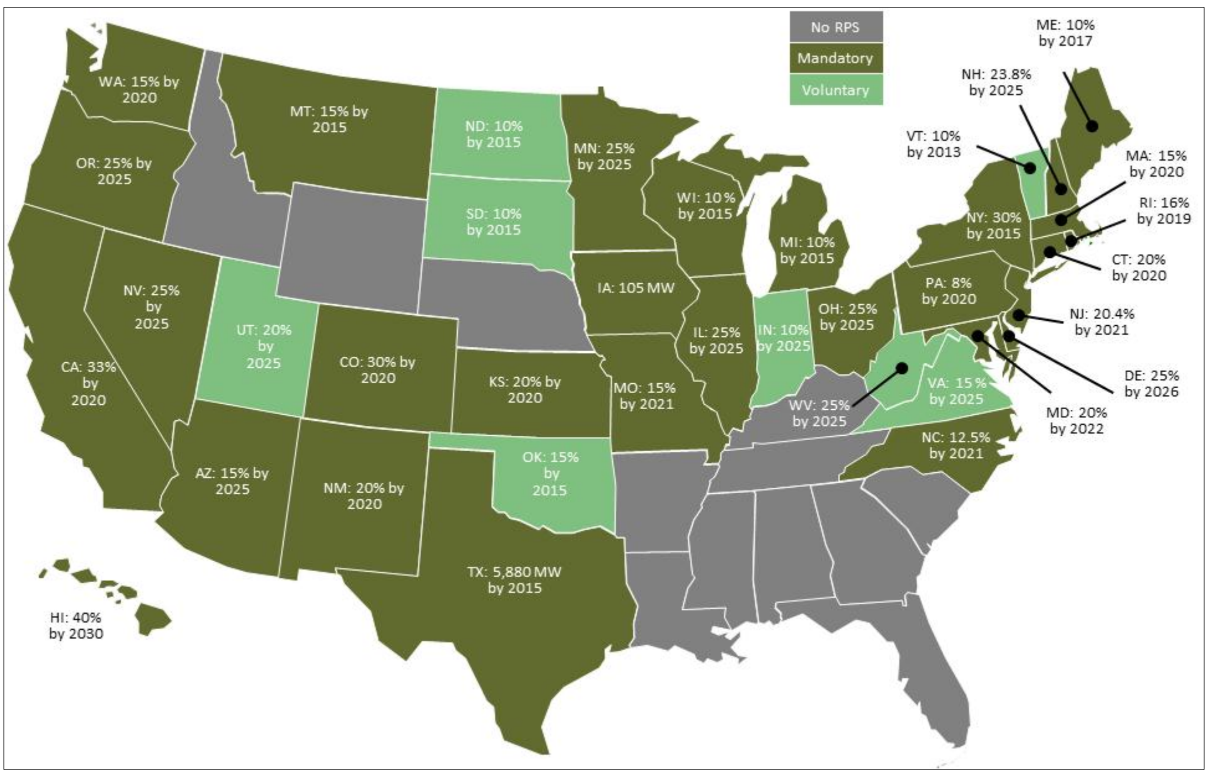
IPM® has the capability to model carbon policies as a cap-and-trade program or as a strict limit on CO_2 emissions from the power sector or the economy as a whole. In the 2015 Energy Policy Scenario, which is the scenario that includes a CO_2 policy, IPM models EPA's proposed Clean Power Plan through state level emissions constraints in the same way that EPA modeled the Clean Power Plan. The modeled CO_2 program reflects the proposed regulations that covers CO_2 emissions only from the power sector. As of mid-2015, a policy that goes beyond the power sector seems unlikely, based on public and Congressional sentiment. The New Source Performance Standards for CO_2 for new and modified sources are reflected in the model by requirements that any new coal units, other than those named by EPA as exceptions, would have to be constructed with carbon capture and sequestration.

4.3.3.3 Renewable Portfolio Standards

IPM® treats renewable portfolio standards as follows.

- Twenty-nine states and the District of Columbia have passed mandatory renewable energy requirements; eight more have enacted voluntary standards or goals (Figure 19).
- The design of each renewable portfolio standard varies by target and timing, the types of renewable generation allowed, the geographic scope within which a generator might be eligible to meet the standard, and the types of enforcement mechanisms and escape clauses included.

Figure 19. Renewable Portfolio Standards



Renewable generation capacity tends to have a higher-levelized cost than fossil-fuel generation. To encourage the development of renewable capacity, many states allow generators to commoditize the green attributes of renewable power in renewable energy credits.[19] The sale of such credits can provide supplemental revenue.

4.3.3.4 Other State and Regional Requirements

The modeling also addresses the following state and regional programs.

[19] Alternative terms used for such instruments include *green tags* and *renewable energy certificates*.

- IPM® included the CO_2 cap currently specified in the Regional Greenhouse Gas Initiative.
- IPM® includes California Assembly Bill 32 cap-and-trade program, which affects both in-state generation, as well as power imported into California.
- IPM® includes other state SO_2 and NO_X regulations where final regulations exist.

4.3.4 Natural Gas

This analysis uses the natural gas mode from EPA's IPM v5.13 Base Case. A thorough description of the natural gas modeling and assumption is contained in Chapter 10 of EPA's documentation for v5.13, and thus, is not duplicated here.

Chapter 5
Scenarios

Four main scenarios and a cumulative scenario were modeled using IPM®. The four main scenarios are the Past Conditions (2014) Scenario, Lower Bound Scenario, Upper Bound Scenario, and 2015 Energy Policy Scenario. The Cumulative Scenario takes into account the addition of other reasonably foreseeable planned export terminals in the Pacific Northwest. The Lower and Upper Bound Scenarios are designed to provide reasonable bounds on GHG emissions from the implementing the Proposed Action. The four main scenarios differ regarding the following six parameters.

- International coal prices
- International thermal coal demand growth rate
- Coal demand elasticity
- Powder River Basin and Uinta Basin coal prices
- U.S. rail transportation prices
- U.S. and International Climate Policy

5.1 Scenarios Analyzed

A No-Action Alternative and a Proposed Action case were created for each scenario analyzed, except for the Cumulative Scenario, where the Proposed Action is compared to the Past Conditions (2014) Scenario No-Action Alternative. This was done to isolate the Proposed Action as the only change between the No-Action Alternative and Proposed Action in each scenario. Table 23 summarizes the Past Conditions (2014), Lower Bound, Upper Bound, and 2015 Energy Policy Scenarios and the following sections provide additional details on the differences between each scenario.

Table 23. Scenario Definitions

Parameter	Scenario: Past Conditions (2014) No-Action and Proposed Action	Lower Bound No-Action and Proposed Action	Upper Bound No-Action and Proposed Action	2015 Energy Policy No-Action and Proposed Action
International Coal prices	$60 to 70/ton	Decrease by 10%	Increase by 50%	No change from Past Conditions (2014)
International thermal coal demand growth rate	2016 to 2038 CAGR China: 1.7% India: 2.2% Korea: -0.7% Japan: -0.4% Taiwan: 0.5%	Use IEA World Energy Outlook demand forecast from the New Policy Scenario, unless the IEA demand is greater than the EIA demand. In these cases the EIA demand growth rates were reduced by 50%.	Increase coal demand growth rates by 50%. For countries with negative growth rates, the growth rate would be set to zero.	Use IEA World Energy Outlook demand forecast from the New Policy Scenario unless the IEA demand is greater than the EIA demand. In these cases the EIA demand growth rates were reduced by 50%.
Coal demand elasticity	1.0% change in delivered coal cost results in 0.4% change in demand in opposite direction	1.0% change in delivered coal cost results in 0.11% change in demand in opposite direction	1.0% change in delivered coal cost results in 1.2% change in demand in opposite direction	No change from Past Conditions (2014)
Powder River Basin and Uinta Basin coal prices	Powder River Basin 8800 Btu/lb: $12/ton Uinta Basin 11,700 Btu/lb: $40/ton	Increase Powder River Basin by 25% and Uinta Basin by 10%	Decrease by 10%	No change from Past Conditions (2014)
U.S. Rail transportation costs	Between $30 to 36/ton	Increase by 20%	Decrease by 20%	No change from Past Conditions (2014)
U.S. Climate Policy	No National Climate Policy	No National Climate Policy	No National Climate Policy	Clean Power Plan as proposed

Notes:
CAGR = compound annual growth rate; IEA = International Energy Agency; EIA = Energy Information Administration; Btu/lb = British thermal units; lb = pound; MMBtu = million metric British thermal units

5.1.1 Past Conditions (2014) Scenario

The Past Conditions (2014) Scenario is defined by a set of assumptions that are intended to represent the state of the energy markets as of mid-2015 when the model was run. The assumptions that are presented in Chapter 4, *Model Framework, Methods, and Key Assumptions*, are the Past Conditions (2014) Scenario assumptions. For the six parameters that are changed to define the four main scenarios, the Past Conditions (2014) Scenario is defined as described in the following bullets.

- International coal prices would be between $60 to $70 per short ton.
- The international thermal coal demand growth rate would vary by country, with China operating at the highest rate at 1.7%, and South Korea with a negative growth rate of -0.7%.
- Coal demand elasticity would be moderate, with every 1.0% change in delivered coal cost resulting in 0.4% change in demand in the opposite direction.
- Powder River Basin coal prices would be $12/ton for Powder River Basin 8800 Btu/lb coal, and Uinta Basin prices would be $40/ton for 11,700 Btu/lb coal.
- Rail transportation costs would be $30 to $36 per ton for coal transported from the Powder River Basin and Uinta Basin to the proposed coal export terminal.
- Coal would emit 205 to 215 pounds of CO_2 per MMBtu when combusted, with the lower value for bituminous coal and the upper value for lignite.
- This scenario operates under an assumption of no national climate policy.

5.1.2 Lower Bound Scenario

The Lower Bound Scenario is designed to result in a reasonable lower bound estimate of global CO_2 emissions from the power sector and to evaluate the likelihood of a smaller CO_2 emissions impact with the construction and operation of the proposed coal export terminal. This scenario is designed to be a plausible and reasonable lower bound, and does not attempt to model an absolute lowest bound of CO_2 emissions or CO_2 emissions due to the Proposed Action. The energy market under the Lower Bound Scenario could be described as a high renewable energy penetration scenario. If renewable energy penetration is higher than expected, international coal consumption and prices would both decline. For the seven parameters that are changed to define the four main scenarios, the Lower Bound Scenario for both the No-Action Alternative and Proposed Action is defined as described in the following bullets.

- International coal prices were decreased from the Past Conditions (2014) Scenario by 10%. This change would cause a smaller amount of induced demand because it would reduce the differential in prices between international coal and the coal exported through the terminal. Thus, there would be lower CO_2 emissions than the Past Conditions (2014) Scenario, because the export of coal from the terminal would cause a smaller reduction, or no reduction, in international delivered coal prices, and thus, would induce less new coal demand than the Past Conditions (2014) Scenario.
- Powder River Basin and Uinta Basin coal prices would increase by 25% and 10%, respectively.
- Transportation costs would increase by 20% for Powder River Basin and Uinta Basin coal movements to the terminal.
- Coal demand would be less elastic than the Past Conditions (2014) Scenario. In the Lower Bound Scenario a 1.0% change in delivered coal cost would result in a 0.11% change in coal demand in the opposite direction. To the extent that there would be a decrease in delivered coal costs, this assumption would cause the amount of induced demand to be less than it would be under the Past Conditions (2014) Scenario.

- International thermal coal demand in the Lower Bound Scenario was obtained from the International Energy Agency (IEA) World Energy Outlook demand forecast for its New Policy Scenario, except if the IEA demand was greater than the EIA demand forecast used for the Past Conditions (2014) Scenario, then the EIA demand growth rates were reduced by 50% and the resulting demand forecast used in the analysis.

- The Lower Bound Scenario does not include a national or international climate policy.

5.1.3 Upper Bound Scenario

The Upper Bound Scenario is designed to result in a reasonable upper bound estimate of global CO_2 emissions and to evaluate the likelihood of greater CO_2 emissions impact with the construction and operation of the terminal. This scenario is designed to be a plausible and reasonable upper bound, and does not attempt to model an absolute highest bound of global CO_2 emissions or CO_2 emissions due to the Proposed Action. The world energy outlook under the Upper Bound Scenario could be described as a high coal demand scenario, where coal plant construction, and thus, coal demand, is higher than expected in the Past Conditions (2014) Scenario. Thus, both international coal consumption and prices would increase. The coal prices would increase because the higher demand would drive the prices higher. For the seven parameters that change to define the four main scenarios, the Upper Bound Scenario for both the No-Action Alternative and Proposed Action is described in the following bullets.

- International coal prices were increased from the Past Conditions (2014) Scenario by 50%. This change would cause a larger amount of induced demand because it would increase the differential between the international coal prices and the coal exported though the terminal. Thus, there would be higher CO_2 emissions than the Past Conditions (2014) Scenario, because the export of coal from the terminal would cause a larger reduction in international delivered coal prices, and thus, would induce more new coal demand than the Past Conditions (2014) Scenario.

- Powder River Basin and Uinta Basin coal prices would decrease by 10%.

- Transportation costs were decreased by 20% for Powder River Basin and Uinta Basin coal movements to the terminal.

- Coal demand would be more elastic than the Past Conditions (2014) Scenario. In the Upper Bound Scenario, a 1.0% change in delivered coal cost would result in a 1.2% change in coal demand in the opposite direction. To the extent that there would be a change in delivered coal costs, this assumption would cause the amount of induced demand to be greater than it would be under the Past Conditions (2014) Scenario.

- International thermal coal demand in the Upper Bound Scenario was obtained by increasing the Past Conditions (2014) Scenario coal demand growth rates by 50%, unless the country had a negative growth rate. In this case, the negative growth rate was set to zero, to obtain a flat demand.

- The Upper Bound Scenario does not include a national or international climate policy.

5.1.4 2015 Energy Policy Scenario

The 2015 Energy Policy Scenario was created to evaluate how recent international climate negotiations and perspectives on future climate policies might affect GHG emissions under the Proposed Action. In particular, this scenario evaluates the November 2014 U.S.-China announcement on climate change action goals and implementation of the proposed U.S. EPA Clean Power Plan. This scenario represents the energy market as of late 2014 and is the most probable of the four scenarios.

The 2015 Energy Policy Scenario is the same as the Past Conditions (2014) Scenario except for two parameter changes. First, the international thermal coal demand was taken from the IEA World Energy Outlook, New Policy Scenario demand forecast. The New Policies Scenario takes into account the policies and implementing measures affecting energy markets that have been adopted as of mid-2014, together with relevant policy proposals, even if specific measures needed to put them into effect have yet to be fully developed. The New Policies Scenario assumed only cautious implementation of these proposed commitments and plans.

Second, this scenario includes the Clean Power Plan as proposed by EPA, which is intended to reduce CO_2 emissions in the United States that are a start to achieving the November 2014 commitments. The Clean Power Plan would also likely reduce the amount of coal consumed in the United States. This analysis uses the proposed Clean Power Plan in the modeling because the final Clean Power Plan was not released until August, 2015, which was after the modeling was completed. See the side bar below for the key differences between the proposed and final Clean Power Plan.

Differences between the proposed and final Clean Power Plan:

CPP Component	Proposed Rule	Final Rule
Implementation	2020	2022
Interim standards	1 step 2020-2029	3 steps, 2022-2024, 2025-2027, 2028-2029
Best System of Emission Reduction (BSER) application	State-specific	Interconnection, to develop national technology specific standards
BSER Building Blocks	Four	Three (removed nuclear and existing RE from BB3 and all of BB4-EE)
State Standard derivation	BSER applied to 2012 baseline	National technology-specific rates applied to 2012 adjusted baseline
Standard types	Rate-based	Rate- and mass-based
Potential for trading	Allowed with joint plan	Allowed with joint plan or trading-ready option

5.1.5 Cumulative Scenario

The Cumulative Scenario include the addition of other planned export terminals in the Pacific Northwest in both the United States and Canada. The export terminals, and their capacities included in this scenario are shown in Table 24. Each terminal is assumed to operate at full capacity, for a total export tonnage of 183 million metric tons, which would include both thermal and metallurgical coal. Because the Canadian export terminals primarily export Canadian coal and are expected to continue this practice, only a portion of these terminals are available to export U.S. coal, as shown in the last column of Table 24. All other assumptions are the same as in the Past Conditions (2014) Scenario.

Table 24. Planned and Existing Pacific Northwest Export Terminals

Terminal	State/Province	Online Year	Capacity (MMTons/year)	Capacity Available for U.S. Coal (MMTons/year)
Planned				
Millennium Bulk Terminal—Longview	Washington	2025	44	44
Gateway Pacific Terminal	Washington	2030	48	48
Coyote Island/Morrow	Oregon	2030	8	8
Fraser Surrey Docks	British Columbia	2018	4	4
Westshore Expansion	British Columbia	2017	3	3
Ridley Expansion	British Columbia	2016	13	9
Neptune Expansion	British Columbia	2018	6	0
Total Planned			126	116
Existing				
Westshore	British Columbia	N/A	33	8
Neptune (metallurgical coal only)	British Columbia	N/A	12	0
Ridley	British Columbia	N/A	12	5
Total Existing			57	13
Total Planned and Existing			**183**	**129**

Notes:
MMTons/year = million metric tons per year

Chapter 6
Modeling Results

6.1 Overview of Results

This chapter presents the coal production, consumption, distribution, and emissions modeling results. Coal production results are presented for both U.S. and non-U.S. production, with a focus on Powder River Basin and Uinta Basin coal production. Emissions of CO_2 are presented for the consumption of coal only in the Pacific Basin, and for coal and natural gas in the United States. Emissions from other sources, such as the transportation of coal, are presented in the air quality and greenhouse gas sections of the EIS. Emissions of CO_2 from natural gas are included in this chapter, because natural gas generation is a replacement for coal-fired electric generation that will have CO_2 emissions. Results are presented for the full modeling time horizon of 2016 through 2040 to provide additional context for the changes that would occur under the Proposed Action. However, the averages presented in the tables are only for the period 2025 to 2040, to focus the changes in results on the period when the proposed coal export terminal is operational in the model. Construction of the coal export terminal is expected to begin in 2018 and continue through 2024, when full operation of the coal export terminal begins.

The proposed coal export terminal may cause changes in coal production at the following scales of production.

- Powder River Basin or Uinta Basin coal production
- U.S. coal production
- Non-U.S. coal production, such as in Indonesia or Australia

This section provides an overview of the Past Conditions (2014) Scenario, No-Action Alternative and Proposed Action results, as well as results from the four scenarios analyzed.

- Lower Bound Scenario
- Upper Bound Scenario
- 2015 Energy Policy Scenario

    The Cumulative Scenario is discussed in section 6.6, *Cumulative Scenario*.

All coal production and consumption results in this analysis are presented in million metric tons.

6.1.1 Past Conditions (2014) Scenario Results

Under the Past Conditions (2014) Scenario total U.S. coal production for the No-Action Alternative would have an average of 791 million metric tons per year over 2025 to 2040. U.S. coal production would remain relatively flat over this period. Total non-U.S. coal production in this period would have an average of 8,634 million metric tons per year and increases during the period analyzed to meet the expected growth in coal demand, which is primarily in China and India. For the Proposed

Action, the U.S. average coal production over 2025 to 2040 would be 819 million metric tons, which would be an increase of 28 million metric tons per year. The non-U.S. average coal production would decrease by 26.8 million metric tons per year. The reason that the U.S. coal production would only increase by 28 million metric tons per year is primarily because exported Powder River Basin coal under the No-Action Alternative would shift from the Canadian export terminals to the new terminal under the Proposed Action. Specifically, 13.6 million metric tons of Powder River Basin coal that is exported through the Canadian terminals in 2025 in the No-Action Alternative is no longer exported through the Canadian terminals in the Proposed Action Alternative. Instead this coal from the Powder River Basin is exported through the terminal in the Proposed Action because it is expected that due to lower transportation costs, the coal will shift to the coal export terminal. Therefore there would be a smaller change in total Powder River Basin exports, and thus, total U.S. production, than if the exports through the Canadian terminals continued under the Proposed Action Alternative. Non-U.S. coal production would decrease in response to the increase in exports, and would be less than the change in U.S. production because the lower heat content Powder River Basin coal would be displacing a smaller amount of higher-heat content coal from Asia.

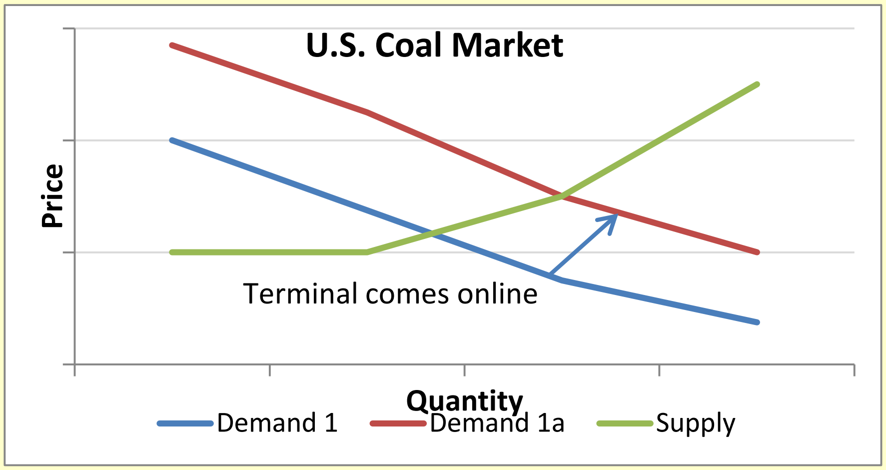
The total average U.S. thermal coal consumption for 2025 to 2040 under the No-Action Alternative would be 785 million metric tons per year, while Pacific Basin average thermal coal consumption would be 7,068 million metric tons per year. Average annual Pacific Basin coal consumption for the period 2025 to 2040 under the Proposed Action would be within 6.5 million metric tons of consumption under the No-Action Alternative. The change would be due to a small amount of induced demand (about 1 million metric tons), which is due to lower delivered coal prices in the Pacific Basin, and due to the greater consumption of lower heat content coal that replaces some higher heat content coal.

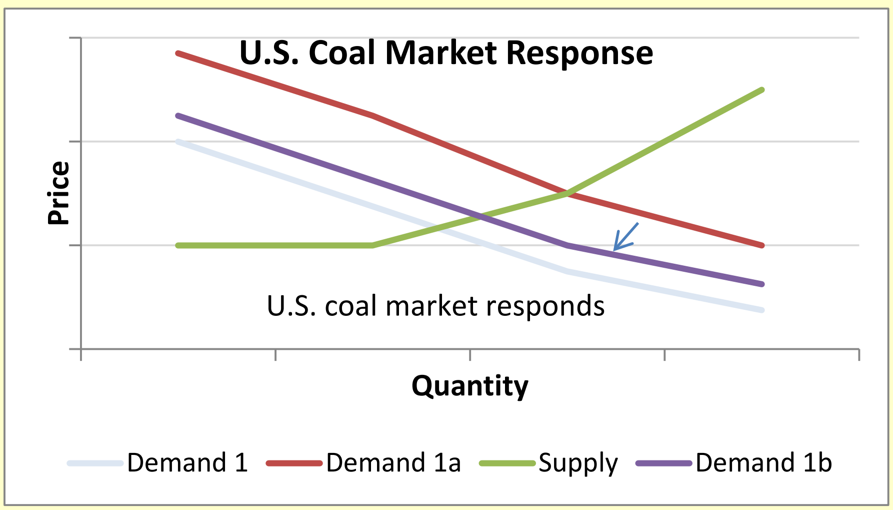
Seaborne thermal coal distribution in the Pacific Basin would average 902 million metric tons per year during 2025 to 2040 under the No-Action Alternative, and would only change by 0.7 million metric tons under the Proposed Action because the exported coal would replace coal produced in Asia. Under the Proposed Action, coal from the Montana portion of the Powder River Basin and from Utah would be exported to Japan. While the total tons of coal transported by ship in the Pacific Basin would only increases by 0.7 million metric tons per year on average, the distance that the coal travels would be greater under the Proposed Action than under the No-Action Alternative. Under the Proposed Action, the change in the distance coal would be transported would average 42,322 nautical miles more than under the No-Action Alternative.

CO_2 emissions in the United States under the No-Action Alternative from the combustion of coal would average 1,505 million metric tons per year over 2025 to 2040, while emissions from natural gas consumption would average 470 million metric tons per year. In the Pacific Basin, CO_2 emissions under the No-Action Alternative from the combustion of coal would average 13,407 million metric tons per year over 2025 to 2040. Under the Proposed Action, CO_2 emissions would increase by 2.6 million metric tons per year in the Pacific Basin, and decrease by 6.9 million metric tons per year in the United States. Since natural gas emissions in the United States would also increase, the total net change in CO_2 emissions under the Proposed Action would be a decrease of 2.55 million metric tons per year on average over 2025 to 2040.

Operation of the Proposed Action would further integrate the U.S. and Asian coal markets. However, to the extent that Asian coal prices would be higher than U.S. prices, operation of the Proposed Action would cause Asian coal prices to decline, while U.S. prices would increase. These changes in prices would cause Asian coal demand to increase and U.S. demand to decrease. The reason U.S. coal prices would increase is because the Applicant would act as a "buyer" of coal, and thus, would shift the demand curve to the right, setting a new, higher equilibrium coal price. In response, utilities would choose to use less coal and more natural gas, so the coal demand curve shifts back to the left, but still to the right of the original curve.

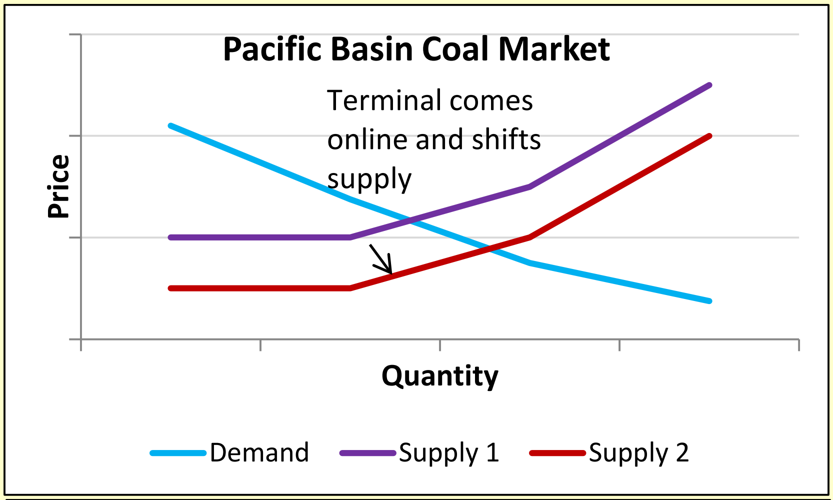
Impact of Proposed Action Alternative on Domestic Coal Supply and Demand at Full Capacity

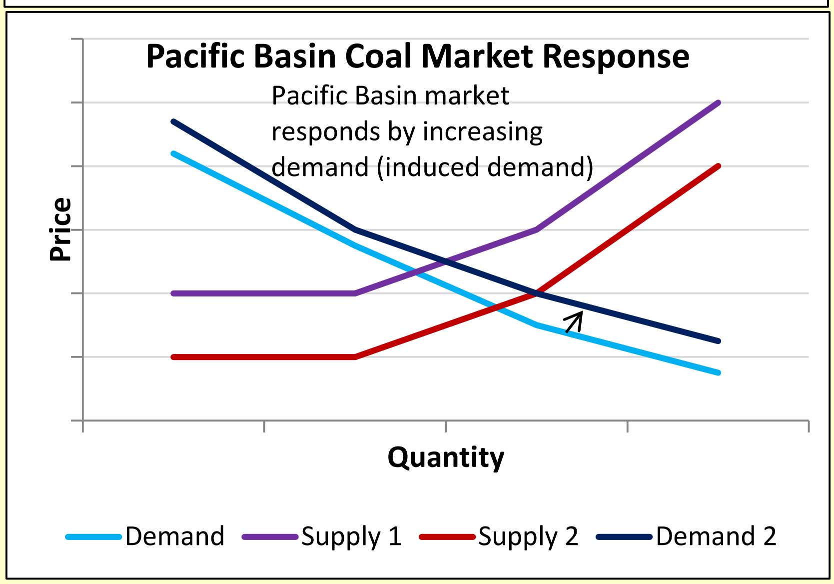




The Proposed Action would cause Asian coal demand to increase because the proposed coal export terminal would act as a new source of coal, and thus, would shift the supply curve to the right, setting a new, lower equilibrium coal price. In response, Asian countries would choose to use more coal, so the coal demand curve would shift to the right.

Impact of Proposed Action on International Coal Supply and Demand at Full Capacity

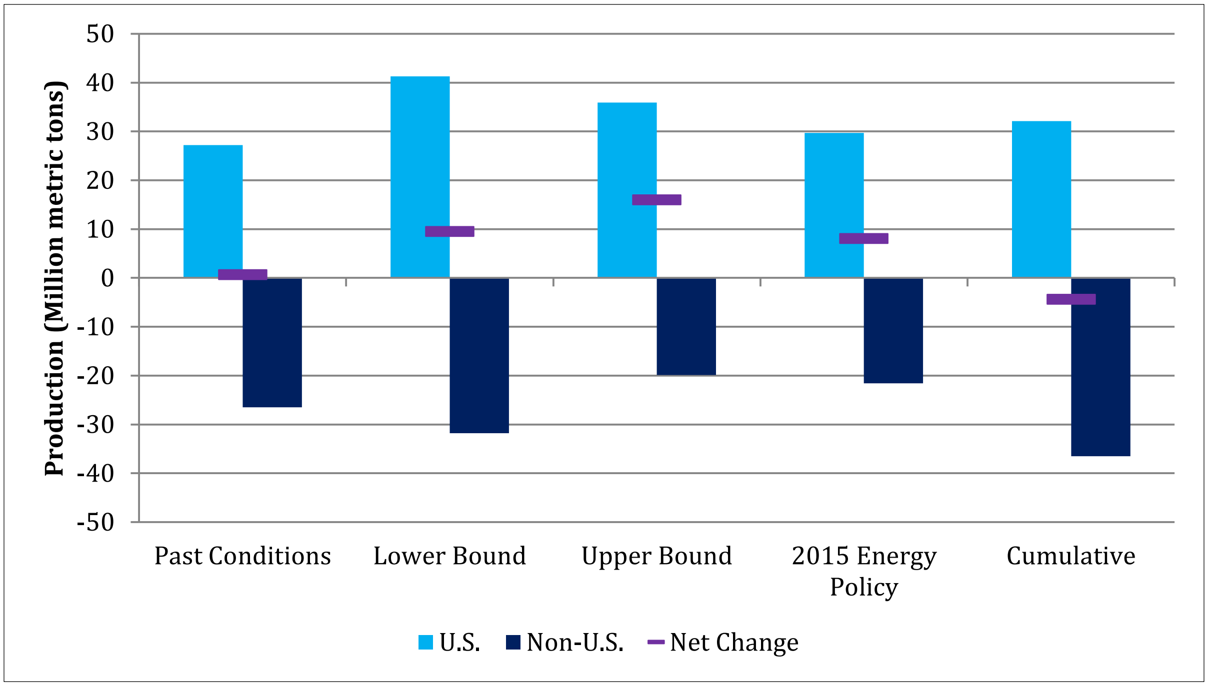




6.1.2 Scenario Results

The four scenarios that were analyzed in addition to the Past Conditions (2014) Scenario are used to explore how CO_2 emissions from the Proposed Action would change under different sets of assumptions. Figure 20 shows the change in production under each scenario for 2025, where the change is calculated by subtracting the No-Action Alternative production from the Proposed Action Alternative production. The change in the 2025 U.S. thermal coal production in the Past Conditions (2014) and the 2015 Energy Policy Scenarios would be less than the other scenarios because in these scenarios coal that is exported through Canadian export terminals under the No-Action Alternative would move to be exported through the proposed coal export terminal. Specifically, 13.6 million metric tons of Powder River Basin coal that is exported through the Canadian terminals in 2025 in the No-Action Alternative is no longer exported through the Canadian terminals in the Proposed Action Alternative. Instead this coal from the Powder River Basin is exported through the terminal in the Proposed Action. Therefore there would be a smaller change in total Powder River Basin exports, and thus, total U.S. production, than if the exports through the Canadian terminals continued under the Proposed Action Alternative.

Figure 20. Change in Production for 2025—Proposed Action minus No-Action Alternative (million metric tons)



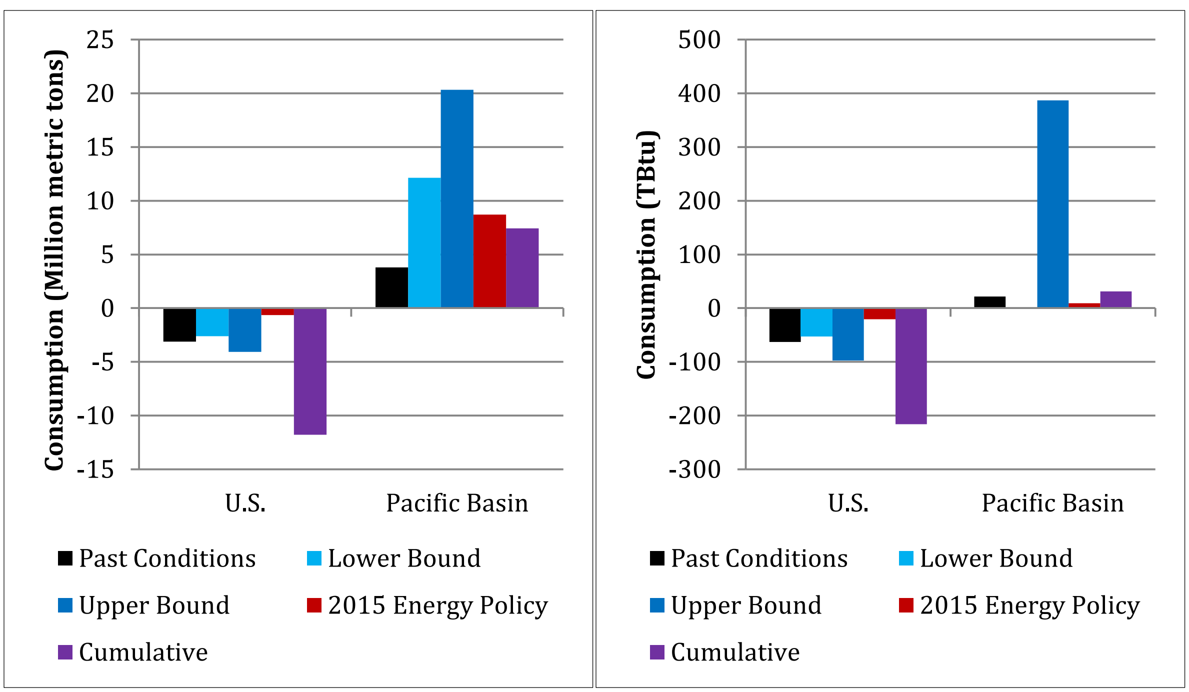
In the Lower Bound Scenario, U.S. coal production increases nearly the full 44 million metric tons of the terminal capacity because under the Proposed Action, nearly the full amount of coal exported is incremental production. Unlike the Past Conditions (2014) Scenario, in the Lower Bound Scenario there are no exports of Powder River Basin coal out of Canadian export terminals in the No-Action Alternative. The change in U.S. coal production in the Lower Bound Scenario Proposed Action Alternative is not equal to the full 44 million metric ton capacity of the terminal because there is some reduction in U.S. coal demand due to higher U.S. coal prices.

In the Upper Bound Scenario, U.S. coal production increases under the Proposed Action because all of the coal exported out of the terminal is incremental, since global coal demand is higher in this scenario. However, the increase in U.S. production is less than the terminal capacity because coal production in the Appalachias declines as exports from this region would decline. Finally, in the Cumulative Scenario, the U.S. production increase is less than the Lower and Upper Bound Scenarios because there is a decrease in U.S. Powder River Basin coal demand due to higher coal prices driven by the large amounts of Powder River Basin exports under this scenario.

Non-U.S. coal production declines in each scenario in proportion to the increase in U.S. production, as there is some induced demand in all but the Lower Bound scenario. Also, the exported Powder River Basin coal would have a lower heat content than some of the coal that it would displace, thus, less total tons would be displaced than exported, while the same amount of total heating value would be replaced. For example, if 10 million metric tons of a 9,000 Btu/lb coal is exported and displaces a 12,000 Btu/lb coal, then the total heat content exported would be 198 TBtu (*=10,000,000 metric tons x 1.1 short tons/metric ton x 2,000 lbs/ short ton x 9,000 Btu/lb x 1 TBtu/10^12 Btu*). The equivalent tons of the 12,000 Btu/lb coal is then 7.5 million metric tons (*=198 TBtu x 10^12 Btu/1 TBtu x 1/12,000 Btu/lb x 1/2000 lb/short ton x 1/1.1 short ton/metric ton x 1 million metric ton/10^6 metric tons*). Thus, for every 10 million metric tons of 9,000 Btu/lb coal exported, only 7.5 million metric tons of 12,000 Btu/lb coal would be displaced.

Coal consumption in the United States would be lower under the Proposed Action because higher Powder River Basin coal prices, due to the export of Powder River Basin coal through the proposed coal export terminal, would depress the U.S. demand for Powder River Basin coal (Figure 21). The depressive effect on U.S. coal consumption would be the largest in the Cumulative Scenario at 11.8 million metric tons, because 100 million metric tons of coal would be exported through all of the proposed terminals, causing a relatively larger increase in coal prices and an attendant depressive effect on coal demand. The EPA IPM v5.13 coal supply curves for the Powder River Basin used in this analysis have a relatively steep right hand section that results in higher coal prices when the demand curve shifts to the right. This is particularly evident in the Cumulative Scenario, which has the largest increase in demand for Powder River Basin coal, due to the model exporting 100 million metric tons of Powder River Basin coal. In this scenario Powder River Basin coal prices would increase by 16.6% in the Proposed Action Alternative compared to the No-Action Alternative.

Figure 21. Change in Consumption for 2025—Proposed Action minus No-Action Alternative (million metric tons and trillion Btu (TBtu))



Coal consumption in the Pacific Basin would be higher under the Proposed Action for two reasons. First, in all but the Lower Bound Scenario, some new demand would be induced due to lower delivered coal prices in the Pacific Basin due to the export of lower cost Powder River Basin coal through the terminal. Second, lower heat content coal would be displacing higher heat content coal.

Therefore, to maintain the same level of electric generation, more tons of the lower heat content coal must be consumed than the amount of the higher heat content coal that was displaced. The change in coal consumption due to the mix of coals is evident by comparing the two charts in Figure 21. The left hand chart shows the change in tons of coal consumed, while the right hand chart shows the change in total heating value of the coal consumed. For example, in the Lower Bound Scenario there is no change in the heating value of the coal consumed in the Pacific Basin; however, there is an increase of 12.1 million metric tons due to switching to consuming more coal that has a lower heat content.

The change in the amount of coal imported in the Pacific Basin in 2025 would be positive in all scenarios and would be highest in the Upper Bound Scenario (Figure 22). This scenario has the highest amount of induced demand, and the change in imports reflects that increase in demand. Also, the exported coal would be displacing the delivery of coal from other countries, and since the coal exported through the terminal would be displacing higher heat content coal there would be a net increase in the tons of coal imported and consumed.

Since CO_2 emissions from the transportation of coal depend on how far the coal is shipped, Figure 23 shows the change in the tons of coal multiplied by the distance the coal is shipped for 2025. Including the distance the coal is shipped shows that the Upper Bound Scenario would have the largest change and the 2015 Energy Policy Scenario would have the smallest change in the ton-miles that the coal is shipped. The Upper Bound Scenario would have the largest change in coal imports because of the larger amount of induced demand compared to the other scenarios. The Lower Bound Scenario would have a larger change in imports than the Past Conditions (2014) Scenario when the source of the coal is included because the shift among sources of the coal in the Past Conditions (2014) Scenario would be between coal supply regions with more similar distances, whereas in the Lower Bound Scenario the change would be due primarily to the export of coal through the terminal.

Figure 22. Change in Imports of Coal in the Pacific Basin via Ship for 2025—Proposed Action minus No-Action Alternative (million metric tons)

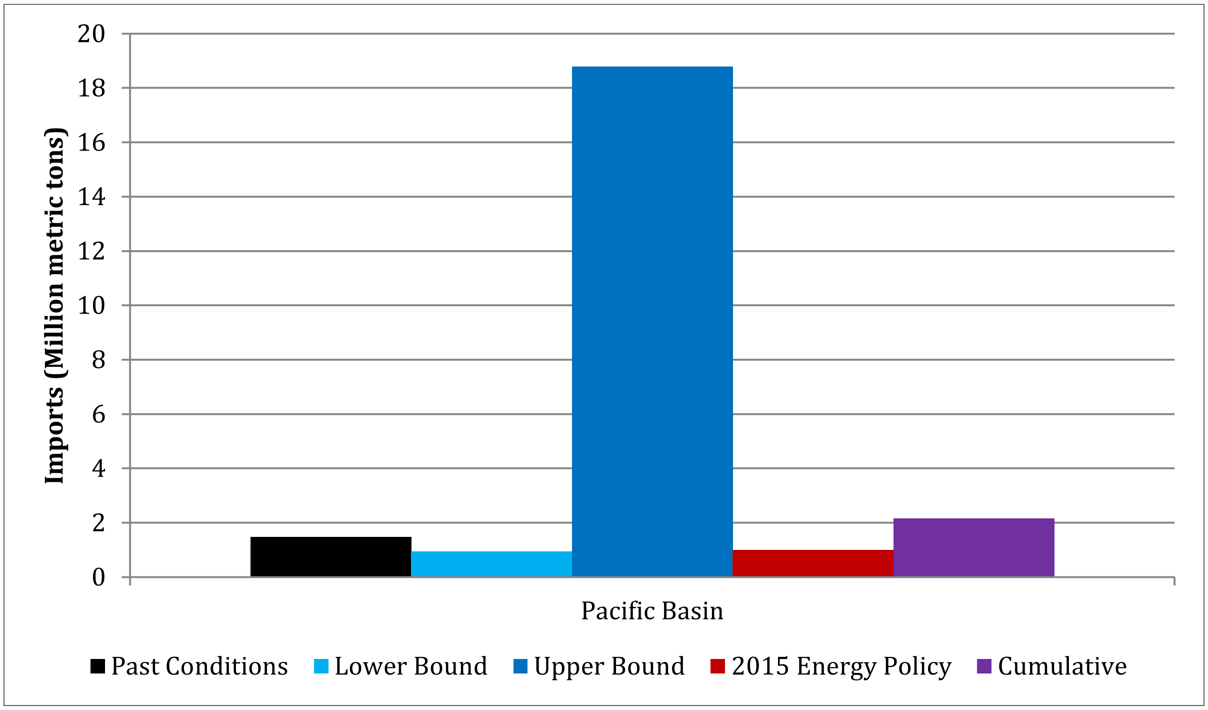
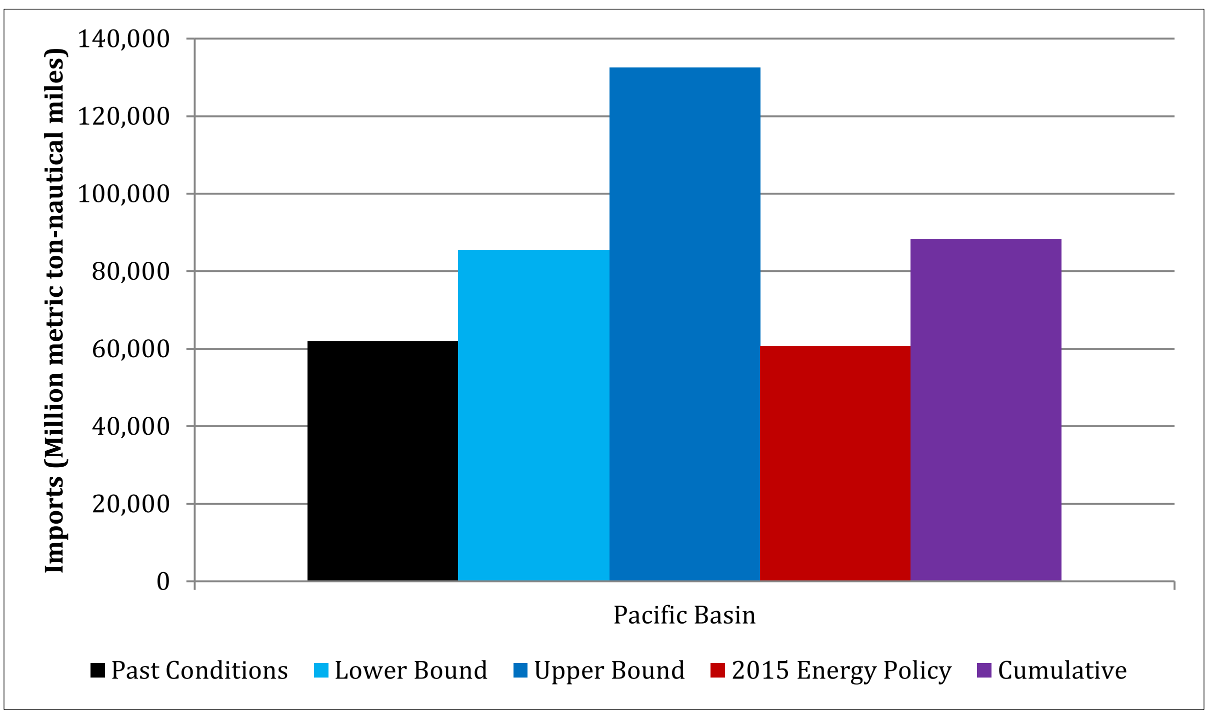
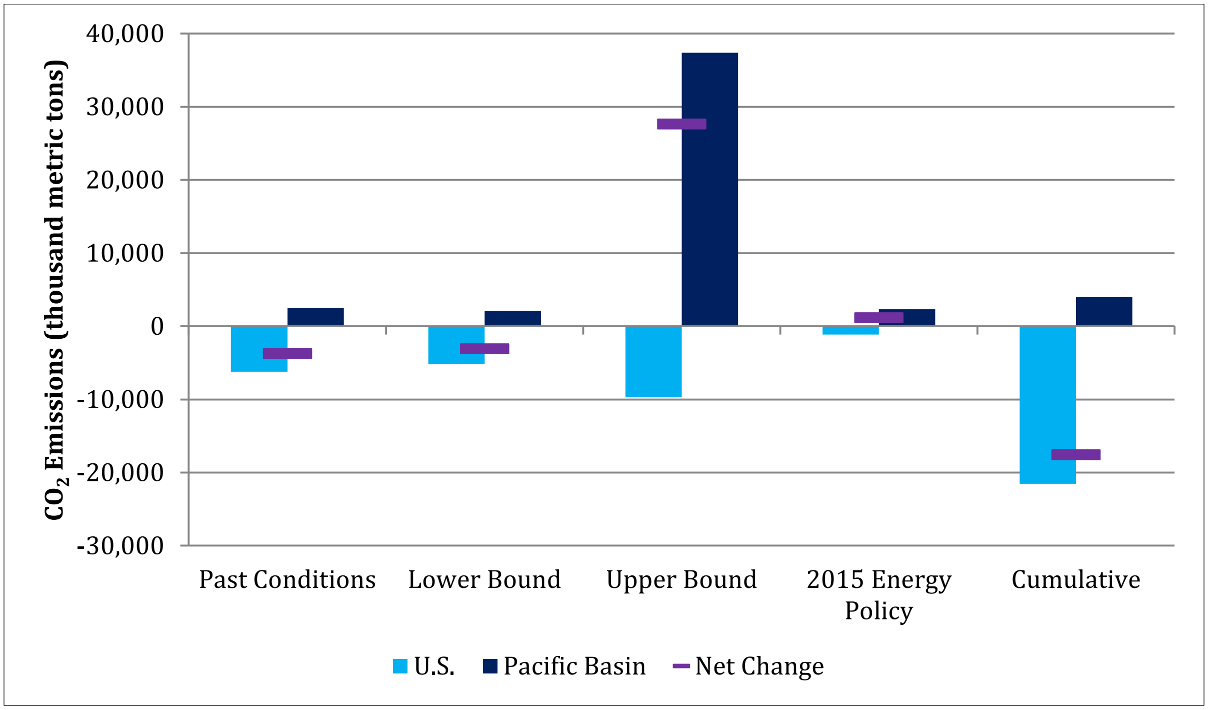


Figure 23. Change in Imports of Coal in the Pacific Basin via Ship for 2025—Proposed Action minus No-Action Alternative (million metric tons – nautical miles)



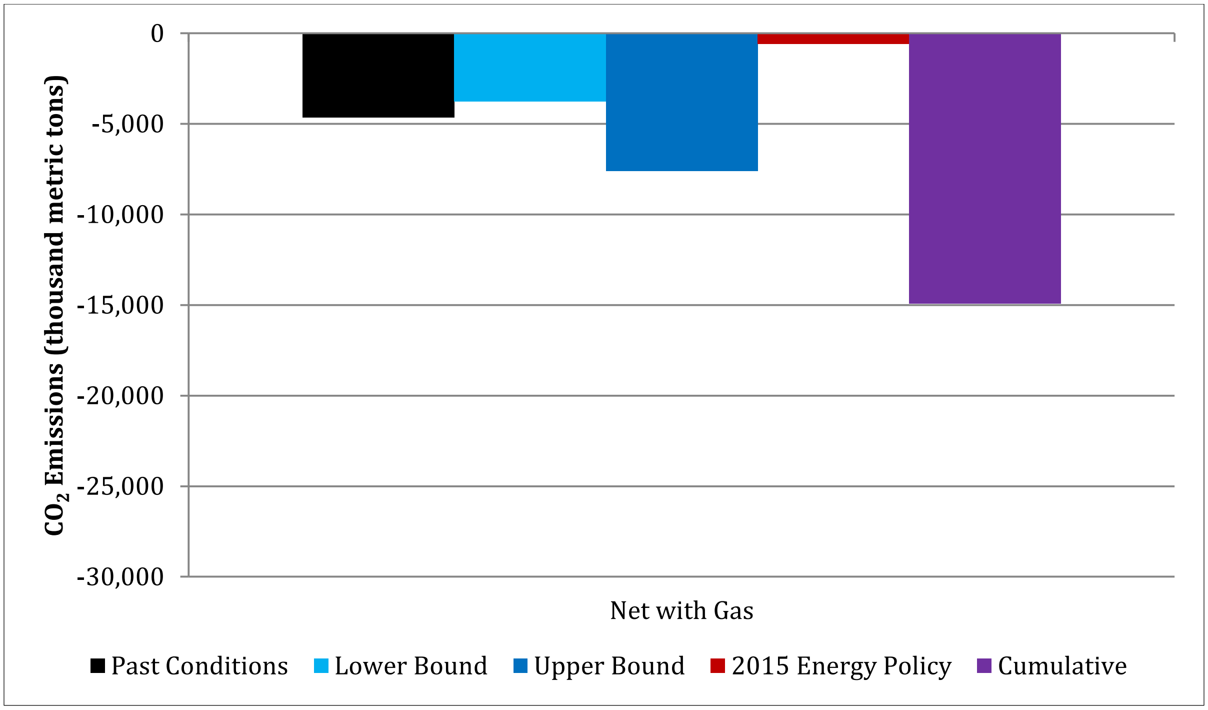
CO_2 emissions from the combustion of coal in the United States and Pacific Basin are estimated for all five scenarios. Figure 24 shows the change in CO_2 emissions from the combustion of coal for the year 2025, when the proposed coal export terminal is modeled to come online. The CO_2 emissions reflect the changes in consumption with U.S. emissions declining while Pacific Basin emissions are increasing. Due to the mix of coals consumed and their respective CO_2 emissions rates, the emissions do not exactly reflect the change in consumption seen in Figure 21.

Figure 24. Change in CO_2 Emissions from the Consumption of Coal for 2025—Proposed Action minus No-Action Alternative (thousand metric tons CO_2)



When the change in CO_2 emissions from the combustion of natural gas are included with the change from the combustion of coal, the net CO_2 emissions in 2025 in the U.S. move closer to zero, but are still a net decrease (Figure 25).

Figure 25. Change in CO_2 Emissions from the Consumption of Coal and the Consumption of Natural Gas in the United States for 2025—Proposed Action minus No-Action Alternative (thousand metric tons CO_2)



6.2 Past Conditions (2014) Scenario

The Past Conditions (2014) Scenario uses the assumptions presented in Chapter 4, *Model Framework, Methods, and Key Assumptions*, and represents the expected energy market outcome. This section presents the modeling results for the Past Conditions (2014) Scenario No-Action Alternative and Proposed Action for coal production, consumption, distribution, and CO_2 emissions.

6.2.1 Coal Production

Under the No-Action Alternative, U.S. thermal coal production would average 791 million metric tons per year for the 2025 to 2040 period. U.S. coal production would be fairly flat between 2020 and 2040 as electric demand growth is primarily met with natural gas and renewable generation. Over the 2016 to 2040 period, non-U.S. coal production grows at an average annual rate of 1.6% per year from 6.4 to 9.4 billion metric tons. Powder River Basin coal production under the No-Action Alternative would average 337 million metric tons per year over 2025 to 2040. Uinta Basin coal production under the No-Action Alternative would average 15.6 million metric tons per year, with production gradually declining over the 2025 to 2040 period. Table 25 shows the No-Action Alternative coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 25. Past Conditions (2014) Scenario Coal Production—No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,448	6,786	7,048	7,805	8,463	9,373	8,634
Total U.S. Thermal Coal	799	838	785	797	788	789	791
Powder River Basin Coal	334	366	329	336	331	344	337
Uinta Basin Coal	18.8	18.4	17.1	16.5	16.3	14.3	15.6

Under the Proposed Action U.S. thermal coal production would average 819 million metric tons per year for the 2025 to 2040 period. As with the No-Action Alternative, U.S. coal production would be relatively flat, although it would be somewhat higher under the Proposed Action after 2025, which is when the terminal is online in the model. Non-U.S. coal production follows the same growth rate under the Proposed Action as the No-Action Alternative, except non-U.S. production declines by 26 to 28 million metric tons per year once the terminal comes online. The non-U.S. production declines because the coal exported through the terminal displaces some of the coal produced in other countries.

Powder River Basin coal production under the Proposed Action would average 359 million metric tons per year with production fluctuating around this average with no clear upward or downward trend. Uinta Basin coal production would average 19.2 million metric tons per year for 2025 to 2040, with production declining until 2040, when additional Uinta Basin coal is exported and production increases. Table 26 shows the Proposed Action coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 26. Past Conditions (2014) Scenario Coal Production—Proposed Action (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,449	6,786	7,048	7,779	8,437	9,346	8,608
Total U.S. Thermal Coal	796	835	782	825	818	815	819
Powder River Basin Coal	332	362	325	363	361	353	359
Uinta Basin Coal	18.5	18.1	16.7	16.2	16.0	24.0	19.2

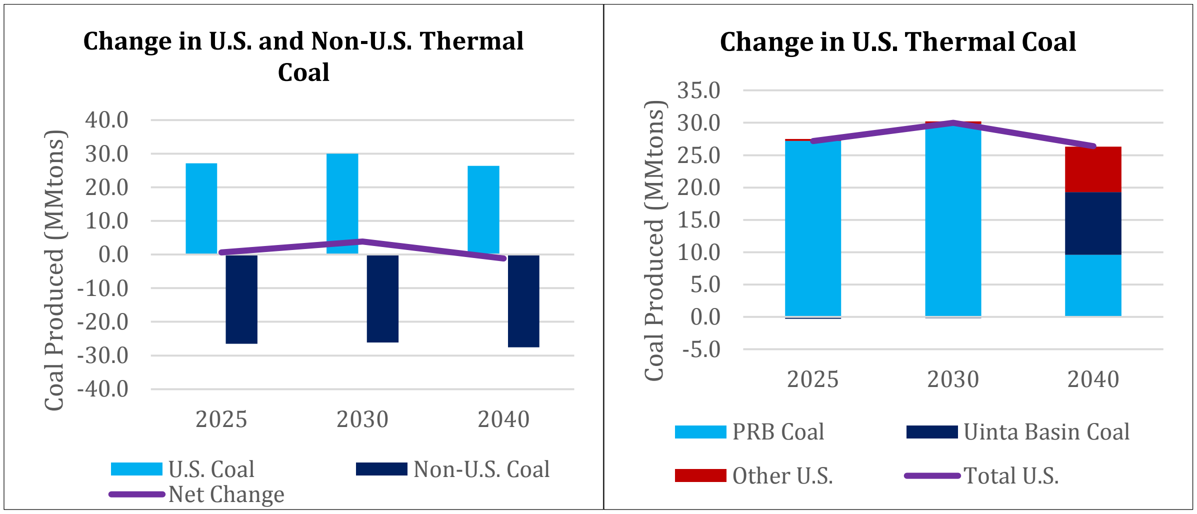
Table 27 shows the estimated change in coal production between the Proposed Action and the No-Action Alternative by model run year to be close to zero in the years before 2025 when the terminal was assumed to come online. Once the terminal is online and exporting coal, total modeled U.S. coal production would be higher under the Proposed Action, primarily due to increases in Powder River Basin and Uinta Basin coal production, and coal production in Colorado that is outside the Uinta Basin. There are small changes in coal production prior to the terminal coming online because the IPM model is forward-looking and makes adjustments in the near term to optimize the whole time period being analyzed. The IPM® model calculates that the terminal comes online in 2025 and that coal prices will change, and thus it makes adjustments throughout the analytical period to minimize overall costs. The decrease in non-U.S. coal production is due to coal shipped through the proposed coal export terminal displacing coal from other countries.

Table 27. Past Conditions (2014) Scenario Change in Coal Production—Proposed Action minus No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	0.1	0	0	-26.5	-26.1	-27.6	-26.8
Total U.S. Thermal Coal	-2.3	-3.2	-2.8	27.2	30.0	26.4	27.8
Powder River Basin Coal	-2.4	-3.9	-3.5	27.2	29.8	9.6	21.2
Uinta Basin Coal	-0.3	-0.3	-0.3	-0.3	-0.2	9.7	3.6

Figure 26 shows that total non-U.S. thermal coal production would decrease in similar amounts to the increase in U.S. coal production under the Proposed Action. This indicates that U.S. thermal coal exports would mostly replace internationally produced coal, instead of the full exported amount adding to overall global coal demand. In 2025 and 2030 the increase in U.S. thermal coal production is due entirely to the increase in Powder River Basin coal production. However, in 2040 the Powder River Basin and Uinta Basin production is only a portion of the total U.S. coal production increase. For example, in 2040 total U.S. thermal coal production increases by 26.4 million metric tons, while Powder River Basin coal production increases by 9.6 million metric tons and Uinta Basin production increases by 9.7 million metric tons. Most of the remaining difference of 7.0 million metric tons is due to a production increase (5.6 million metric tons) in the Colorado Green River area, which is outside of the Uinta Basin in the northwest corner of Colorado. Most of the coal produced in Colorado and Utah is consumed locally. Some of the 9.7 million metric tons of Uinta Basin coal was being consumed locally under the No-Action Alternative and thus is being replaced with other coal from the Rocky Mountain region.

Figure 26. Past Conditions (2014) Scenario Change in Coal Production—Proposed Action minus No-Action Alternative



6.2.2 Coal Consumption

Under the No-Action Alternative U.S. thermal coal consumption averages 785 million metric tons per year for the 2025 to 2040 period. U.S. coal consumption is fairly flat between 2020 and 2040 as electric demand growth is primarily met with natural gas and renewable generation. Over the 2016 to 2040 period, Pacific Basin coal consumption grows at an average rate of 1.9% per year from 4.9 to 7.8 billion metric tons. The growth in consumption is driven by increasing coal consumption in China and India. Table 28 shows the No-Action Alternative coal consumption values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

China is responsible for the largest share of global thermal coal consumption, burning 3,550 million metric tons of coal in 2016. This amount is projected to grow under the No-Action Alternative to 5,431 million metric tons by 2040 and average 5,047 million metric tons over the 2025 to 2040 period. Total U.S. coal consumption remains relatively stable across the projection, fluctuating around 785 million metric tons.

Table 28. Past Conditions (2014) Scenario Coal Consumption—No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	104	119	165	133
Australia	158	168	176	193	212	253	223
China	3,550	3,802	3,975	4,548	5,013	5,431	5,047
Hong Kong	14	14	14	15	15	17	16
India	691	732	783	900	1,010	1,249	1,072
Indonesia	165	181	195	228	264	357	290
Japan	139	133	132	131	128	128	129
South Korea	90	88	87	83	74	82	80
Taiwan	68	72	69	71	81	85	79
Total Pacific Basin Coal Consumption	4,950	5,272	5,526	6,273	6,916	7,767	7,068
Total U.S. Coal Consumption	792	826	772	787	777	790	785

Coal consumption under the Proposed Action follows similar patterns as the No-Action Alternative, with U.S. thermal coal consumption averaging 781 million metric tons per year for the 2025 to 2040 period. As it would be under the No-Action Alternative, U.S. coal consumption would be fairly flat between 2020 and 2040 as electric demand growth is primarily met with natural gas and renewable generation.

Over the 2016 to 2040 period, Pacific Basin coal consumption follows the same pattern as it would be under the No-Action Alternative as it grows from 4.95 to 7.76 billion metric tons. However, under the Proposed Action there is a 0.1%, or about 1 million metric ton total increase in demand in four regions that is induced due to lower delivered coal prices to the Pacific Basin. Demand is induced in Hong Kong, Japan, South Korea, and Taiwan.

Table 29 shows the Proposed Action coal consumption values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 29. Past Conditions (2014) Scenario Coal Consumption—Proposed Action (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	104	119	165	133
Australia	158	168	176	193	212	253	223
China	3,550	3,802	3,975	4,550	5,018	5,431	5,049
Hong Kong	14	14	14	15	15	17	16
India	691	732	783	900	1,010	1,248	1,072
Indonesia	165	181	195	228	264	357	290
Japan	139	133	132	132	129	126	129
South Korea	90	88	87	83	74	82	80
Taiwan	68	72	69	71	81	85	80
Total Pacific Basin Coal Consumption	4,950	5,272	5,526	6,276	6,922	7,764	7,070
Total U.S. Coal Consumption	790	823	769	784	775	785	781

Table 30 shows the estimated change in coal consumption between the Proposed Action and the No-Action Alternative by model run year to be close to zero in the years before 2025 when the terminal was assumed to come online. Once the terminal is online and exporting coal, total U.S. coal consumption is lower by an average of 3.4 million metric tons per year under the Proposed Action for 2025 to 2040. Thermal U.S. coal consumption at electric power plants is lower because once the terminal comes online and is exporting coal the U.S. coal prices increase slightly, which causes a downward shift in U.S. coal demand.

Table 30. Past Conditions (2014) Scenario Change in Coal Consumption—Proposed Action minus No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	2.3	4.5	0	2.1
Hong Kong	0	0	0	0	0	0	0
India	0	0	0	0	0	-1.3	-0.5
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	1.0	1.5	-1.5	0.2
South Korea	0	0	0	0.2	0.2	0.2	0.2
Taiwan	0	0	0	0.2	0.2	0.2	0.2
Total Pacific Basin Coal Consumption	0	0	0	3.8	6.5	-2.4	2.3
Total U.S. Coal Consumption	-2.3	-3.2	-2.8	-3.1	-2.6	-4.2	-3.4

In the Pacific Basin, coal consumption is higher on average by 2.3 million metric tons per year for 2025 to 2040, which is 0.03% higher than the average Pacific Basin coal consumption shown in Table 28. The reason that the Pacific Basin coal consumption increase is higher than the increase in induced demand due to lower coal prices is because a larger quantity of lower heat content subbituminous coal is being consumed, while the total change in the heating value of coal demand is equal to the amount of induced demand. For example, in China under the Proposed Action, coal consumption increases by 2.3 million metric tons in 2025 over the No-Action Alternative; however, the total heat content of the coal consumed remains the same, as does the amount of coal imported (350 million metric tons). This is possible because Indonesia shifts the type of coal exported to China to include 10 million metric tons more subbituminous coal, which has a lower heat content, and 10 million metric tons less bituminous coal, which has a higher heat content under the Proposed Action compared to the No-Action Alternative. Thus, Indonesia is exporting a lower amount of total coal energy to China while still exporting the same total tons of coal (350 million metric tons). China is compensating for the lower delivered heat content by consuming more domestic coal.

6.2.3 Coal Distribution

Coal from the Powder River Basin and the Uinta Basin are distributed primarily in the United States. These distribution patterns are expected to remain largely unchanged under the Proposed Action. Thus, this section focuses on the distribution of coal in the Pacific Basin and how that distribution would be expected to change with the construction of the terminal. Under the No-Action Alternative, no coal would be exported through the terminal; however, 615 million metric tons of coal would be distributed in the Pacific Basin by ship in the seaborne coal market in 2016. Table 31 shows the tons of coal that are imported by each country in the Pacific Basin under the No-Action Alternative. By 2040, a total of 1,194 million metric tons of coal are expected to be distributed in the Pacific Basin seaborne coal market.

Table 31. Past Conditions (2014) Scenario Seaborne Coal Imports in Pacific Basin—No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	104	119	165	133
Australia	0	0	0	0	0	0	0
China	227	227	227	318	318	726	476
Hong Kong	14	14	14	15	15	17	16
India	44	24	12	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	139	133	132	131	128	128	129
South Korea	49	46	43	66	67	74	69
Taiwan	68	72	69	71	81	85	79
Total Pacific Basin Coal sent via ship	615	598	591	704	726	1,194	902

To understand how coal distribution is changing in more detail than the tons of coal imported by each country, the tons of coal shipped to each country were multiplied by the distance in nautical miles that the coal is shipped. This is important because the change in tons imported might not change significantly; however, where the coal is sourced might change, which might have a significant impact on the emissions associated with shipping. Table 32 shows the result of multiplying the tons of coal by the nautical miles that the coal was shipped for coal shipped to each country for the No-Action Alternative. Thus the values in Table 32 are in units of million metric ton-nautical miles.

Table 32. Past Conditions (2014) Scenario Distance Weighted Seaborne Coal Imports in Pacific Basin—No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	4,798	32,290	106,870	123,074	176,042	532,288	299,869
Australia	0	0	0	0	0	0	0
China	386,461	386,461	386,461	541,045	541,045	1,236,674	811,567
Hong Kong	27,007	27,278	27,552	28,247	28,961	65,231	42,868
India	135,789	73,478	38,193	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	535,267	378,469	355,049	352,952	345,299	568,913	434,385
South Korea	128,027	120,235	112,984	173,889	123,473	371,891	234,084
Taiwan	267,987	234,316	103,192	105,797	342,100	359,595	283,264
Total Pacific Basin Coal sent via ship	**1,485,335**	**1,252,527**	**1,130,299**	**1,325,005**	**1,556,918**	**3,134,591**	**2,106,037**

Under the Proposed Action coal would be exported through the terminal to destinations in the Pacific Basin. Table 33 shows how the coal exported from the terminal is distributed by the model. All of the coal would be going to Japan, which would be the closest destination and thus would allow for the greatest reduction in system costs when the model calculates a solution.

Table 33. Past Conditions (2014) Scenario Distribution of Coal Exported—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040
China	0	0	0	0	0	0
Hong Kong	0	0	0	0	0	0
Japan	0	0	0	44.0	44.0	44.0
South Korea	0	0	0	0	0	0
Taiwan	0	0	0	0	0	0
Total Pacific Basin Coal sent via ship through MBTL	**0**	**0**	**0**	**44.0**	**44.0**	**44.0**

Under the Proposed Action, a similar number of tons is distributed in the Pacific Basin seaborne coal market as the No-Action Alternative, as can be seen in Table 34. Meanwhile, Table 35 shows the ton-mile values for coal distributed in the Pacific Basin seaborne coal market under the Proposed Action.

Table 34. Past Conditions (2014) Scenario Seaborne Coal Imports in Pacific Basin—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	75	82	94	104	119	165	133
Australia	0	0	0	0	0	0	0
China	227	227	227	318	318	726	476
Hong Kong	14	14	14	15	15	17	16
India	44	24	12	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	139	133	132	132	129	126	129
South Korea	49	46	43	67	67	74	70
Taiwan	68	72	69	71	81	85	80
Total Pacific Basin Coal sent via ship	615	598	591	706	728	1,193	903

Table 35. Past Conditions (2014) Scenario Distance Weighted Seaborne Coal Imports in Pacific Basin—Proposed Action (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	4,798	32,290	106,870	123,074	176,042	532,288	299,869
Australia	0	0	0	0	0	0	0
China	386,461	386,461	386,461	541,045	541,045	1,236,674	811,567
Hong Kong	27,007	27,278	27,552	28,329	29,042	65,416	42,989
India	135,789	73,478	38,193	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	535,267	378,469	355,049	413,869	411,800	573,343	475,197
South Korea	128,027	120,235	112,984	174,470	124,053	373,049	234,889
Taiwan	267,987	234,316	103,192	106,097	342,552	360,494	283,847
Total Pacific Basin Coal sent via ship	1,485,335	1,252,527	1,130,299	1,386,883	1,624,533	3,141,264	2,148,359

As can be seen in Table 36, which shows the estimated change in tons of coal imported by each of the regions, the largest change in coal imports between the No-Action Alternative and the Proposed Action is in coal exported to Japan in 2030 with an increase of 1.5 million metric tons.

Table 36. Past Conditions (2014) Scenario Change in Seaborne Coal Imports in Pacific Basin—Proposed Action minus No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia – Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0
Hong Kong	0	0	0	0	0	0	0
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	1.0	1.5	-1.5	0.2
South Korea	0	0	0	0.2	0.2	0.2	0.2
Taiwan	0	0	0	0.2	0.2	0.2	0.2
Total Pacific Basin Coal sent via ship	0	0	0	1.5	2.0	-1.0	0.7

Despite the small changes in the total tons of coal imported to each region, there are some relatively large changes in the ton-mile values, as shown in Table 37. For example, in Japan in 2030 coal imports increase by 1.2% while the ton-miles increased by 19%. This change is due to Japan importing Powder River Basin coal through the proposed coal export terminal, which is farther than either Indonesia or Australia.

Table 37. Past Conditions (2014) Scenario Change in Distance Weighted Seaborne Coal Distribution in Pacific Basin—Proposed Action minus No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	Annual Average
Asia - Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0
Hong Kong	0	0	0	81	81	185	122
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	60,917	66,501	4,430	40,811
South Korea	0	0	0	580	580	1,158	805
Taiwan	0	0	0	300	452	899	584
Total Pacific Basin Coal sent via ship	0	0	0	61,879	67,615	6,672	42,322

6.2.4 CO_2 Emissions

This section presents the CO_2 estimated emissions from coal combusted in the United States and the Pacific Basin under the Past Conditions (2014) Scenario No-Action Alternative and Proposed Action. In addition, CO_2 emissions from natural gas consumption in the United States are included because decreases in coal consumption may be offset by increases in natural gas consumption. No other emissions are included in this section.

Table 38 presents the CO_2 emissions under the No-Action Alternative. Total U.S. CO_2 emissions remain fairly flat at an average of 1,505 million metric tons for 2025 to 2040, which reflects the flat coal consumption in the U.S. Pacific Basin CO_2 emissions from coal average 13,407 million metric tons per year between 2025 and 2040, which is 8.9 times the total coal CO_2 emissions from the United States.

Table 39 presents the CO_2 emissions under the Proposed Action. Total CO_2 emissions from coal under the Proposed Action average 0.5% lower than the coal CO_2 emissions under the No-Action Alternative.

Table 38. Past Conditions (2014) Scenario CO_2 Emissions—No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	196,125	220,325	269,361	232,672
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	7,260,862	7,757,297	8,092,857	9,192,572	10,001,116	10,625,911	10,019,496
Hong Kong	32,192	32,514	32,840	33,670	34,520	36,086	34,893
India	1,136,069	1,182,859	1,257,877	1,430,059	1,592,500	1,923,614	1,676,144
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	305,620	304,862	305,584	301,809	294,803	273,014	288,276
South Korea	193,262	189,802	186,751	182,342	167,305	163,906	170,160
Taiwan	155,582	158,027	159,611	163,642	166,852	175,385	169,279
Pacific Basin - Coal	9,752,941	10,352,077	10,813,357	12,182,110	13,245,137	14,420,611	13,406,980
U.S. - Coal	1,538,695	1,606,196	1,490,678	1,515,506	1,495,512	1,506,365	1,505,286
U.S. - Natural Gas	449,418	417,456	421,240	392,499	400,710	585,198	470,174

Table 39. Past Conditions (2014) Scenario CO_2 Emissions—Proposed Action (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	196,125	220,325	269,361	232,672
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	7,260,862	7,757,297	8,092,857	9,193,009	10,001,969	10,625,911	10,019,902
Hong Kong	32,192	32,514	32,840	33,774	34,624	36,190	34,997
India	1,136,069	1,182,859	1,257,877	1,430,059	1,592,500	1,923,521	1,676,108
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	305,620	304,862	305,584	302,717	296,857	273,261	289,308
South Korea	193,262	189,802	186,751	182,892	167,855	164,456	170,710
Taiwan	155,582	158,027	159,611	164,140	167,350	175,883	169,777
Pacific Basin - Coal	9,752,941	10,352,077	10,813,357	12,184,607	13,249,196	14,421,916	13,409,535
U.S. - Coal	1,535,939	1,602,368	1,487,223	1,509,276	1,490,688	1,497,083	1,498,339
U.S.- Natural Gas	449,998	418,357	421,870	394,094	401,689	587,959	472,017

Table 40 shows the estimated change in CO_2 emissions for each region, as well as the total net change across all regions. Total Pacific Basin CO_2 emissions from coal consumption would increase between 1,305 and 4,059 thousand metric tons starting in 2025 due to induced demand from the reduction in delivered coal prices under the Proposed Action. The change in CO_2 emissions from individual countries would be between a decrease of 93 thousand metric tons to an increase of 2,054 thousand metric tons.

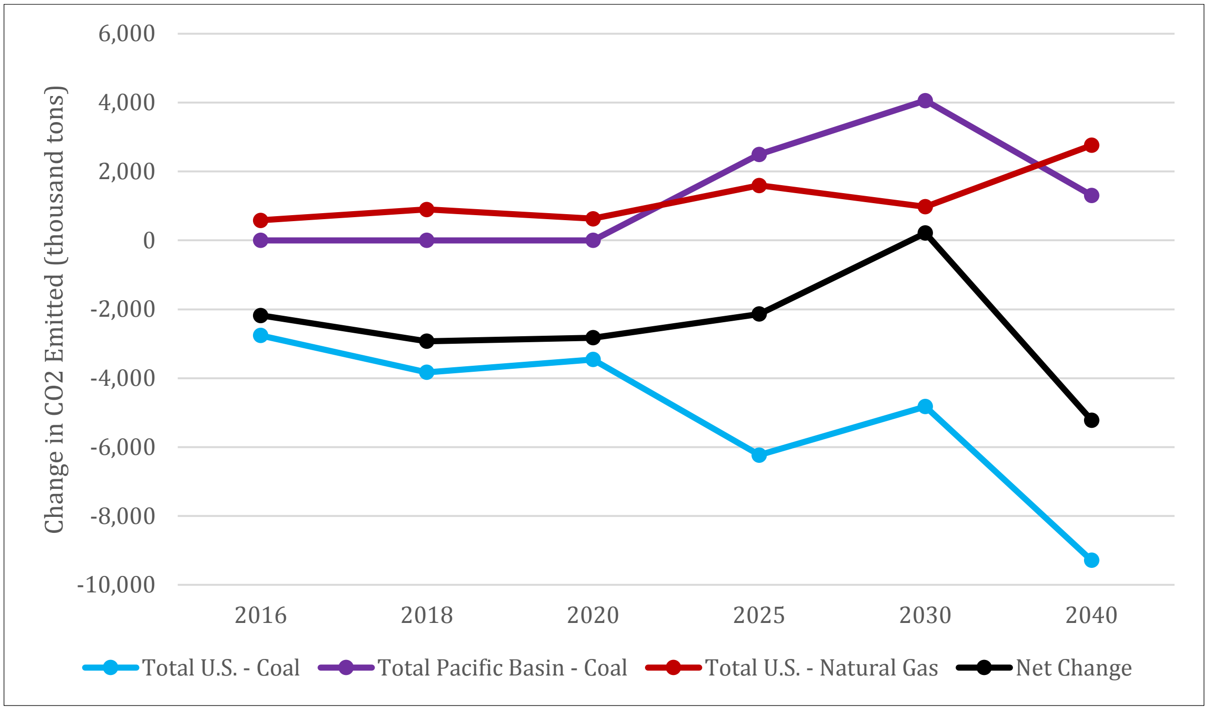
Table 40. Past Conditions (2014) Scenario Change in CO_2 Emissions—Proposed Action minus No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	438	853	0	406
Hong Kong	0	0	0	104	104	104	104
India	0	0	0	0	0	-93	-36
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	907	2,054	247	1,033
South Korea	0	0	0	550	550	550	550
Taiwan	0	0	0	498	498	498	498
Pacific Basin - Coal	0	0	0	2,497	4,059	1,305	2,554
U.S. - Coal	-2,757	-3,828	-3,454	-6,229	-4,823	-9,282	-6,948
U.S. - Natural Gas	580	900	630	1,595	979	2,761	1,843
Total Change	-2,177	-2,928	-2,824	-2,137	215	-5,216	-2,551

In contrast, U.S. coal CO_2 emissions would decrease in every year due to slightly higher coal prices that would depress coal demand under the Proposed Action. The slightly higher coal prices would result from the fact that an additional 44 million metric tons of coal is mined and exported under the Proposed Action, which would shift the demand curve up and yield higher coal prices in the United States. The decrease in coal consumption would be offset by an increase in natural gas consumption, as is seen by the increase in CO_2 emissions from natural gas, which would average 1,843 thousand metric tons per year. The total net change in CO_2 emissions, including both coal and natural gas emissions, would decrease by an average of 2,551 thousand metric tons per year for 2025 to 2040.

U.S. CO_2 emissions from natural gas are expected to increase as electric generation from natural gas-fired plants increases to meet increasing demand and as generation from coal-fired plants decreases. Figure 27 shows the net change in CO_2 emissions between the No-Action Alternative and Proposed Action. The decrease in U.S.coal emissions would drive the net change to be a net decrease in CO_2 emissions, under the Proposed Action.

Figure 27. Past Conditions (2014) Scenario Change in CO_2 Emissions—Proposed Action minus No-Action Alternative[a,b,c]



[a] Total U.S. CO_2 emissions from the combustion of coal would decrease because the terminal would be a new demand sink for U.S. coal, and thus, would cause coal prices to rise, and thus, U.S. coal consumption would decrease in response to the higher prices.

[b] Pacific Basin CO_2 emissions from the combustion of coal would increase due to new demand induced by lower coal prices and because more tons of lower heat content coal would be consumed.

[c] Total U.S. natural gas combustion CO_2 emissions would increase because when coal consumption for electric generation declines, natural gas usage for electric generation would increase to fill the gap.

6.3 Lower Bound Scenario

The Lower Bound Scenario uses the assumptions presented in Chapter 5, *Scenarios*, and represents the lower bound of global GHG emissions that could be reasonably expected if the assumptions are realized. This scenario is designed to model the lowest potential GHG emissions under the Proposed Action, and to provide a low GHG emissions world into which the terminal is constructed and operated. This section presents the modeling results for the Lower Bound Scenario No-Action Alternative and Proposed Action for coal production, consumption, distribution, and CO_2 emissions.

6.3.1 Coal Production

The Lower Bound Scenario is designed to reduce coal consumption, and thus, coal production. Therefore, coal production in the Lower Bound Scenario would be less than the Past Conditions (2014) Scenario. Under the No-Action Alternative U.S. thermal coal production would average 703 million metric tons per year for the 2025 to 2040 period, and would decline by 56 million metric tons between 2016 and 2040 because the higher Powder River Basin coal prices assumed in this scenario would dampen coal demand. Over the 2016 to 2040 period, non-U.S. coal production would grow at an average annual rate of 0.8% per year from 6.1 to 7.4 billion metric tons. Powder River

Basin coal production under the No-Action Alternative would average 258 million metric tons per year over 2025 to 2040, with production declining by less than 1%. Uinta Basin coal production under the No-Action Alternative would average 13.1 million metric tons per year over 2025 to 2040, with production gradually declining over the 2016 to 2040 period. Table 41 shows the No-Action Alternative coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 41. Lower Bound Scenario Coal Production—No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,135	6,297	6,451	6,695	6,958	7,359	7,041
Total U.S. Thermal Coal	748	768	713	716	704	692	703
Powder River Basin Coal	275	295	259	261	253	259	258
Uinta Basin Coal	18.7	18.0	16.0	12.5	14.2	12.6	13.1

Under the Proposed Action, U.S. thermal coal production would average 745 million metric tons per year for the 2025 to 2040 period. When the terminal comes online in 2025, total U.S. coal production would increase by 46 million metric tons over 2020 production, before gradually declining. The decline in production between 2025 and 2030 would be due to declining domestic coal demand. The decline in coal production between 2030 and 2040 is due to an increase in imports of coal into the United States, and thus, less domestic coal is required to meet demand.

Non-U.S. coal production would follow the same growth rate under the Proposed Action as it would under the No-Action Alternative, except production would decline by 32 to 43 million metric tons per year, once the terminal comes online in 2025 in the model. Thus, the coal exported from the terminal would displace coal production in other countries. Powder River Basin coal production under the Proposed Action would average 295 million metric tons per year for 2025 to 2040, with production gradually declining. Uinta Basin coal production would average 15.3 million metric tons per year for 2025 to 2040, with production following the same downward decline as it would under the No-Action Alternative, except in 2040 when production would jump to 20.2 million metric tons due to the export of Uinta Basin coal to Japan.

Table 42 shows the Proposed Action coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 42. Lower Bound Scenario Coal Production—Proposed Action (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,135	6,297	6,451	6,664	6,917	7,317	7,002
Total U.S. Thermal Coal	746	767	711	757	746	734	745
Powder River Basin Coal	273	292	256	302	295	290	295
Uinta Basin Coal	18.5	17.8	14.6	12.9	11.6	20.2	15.3

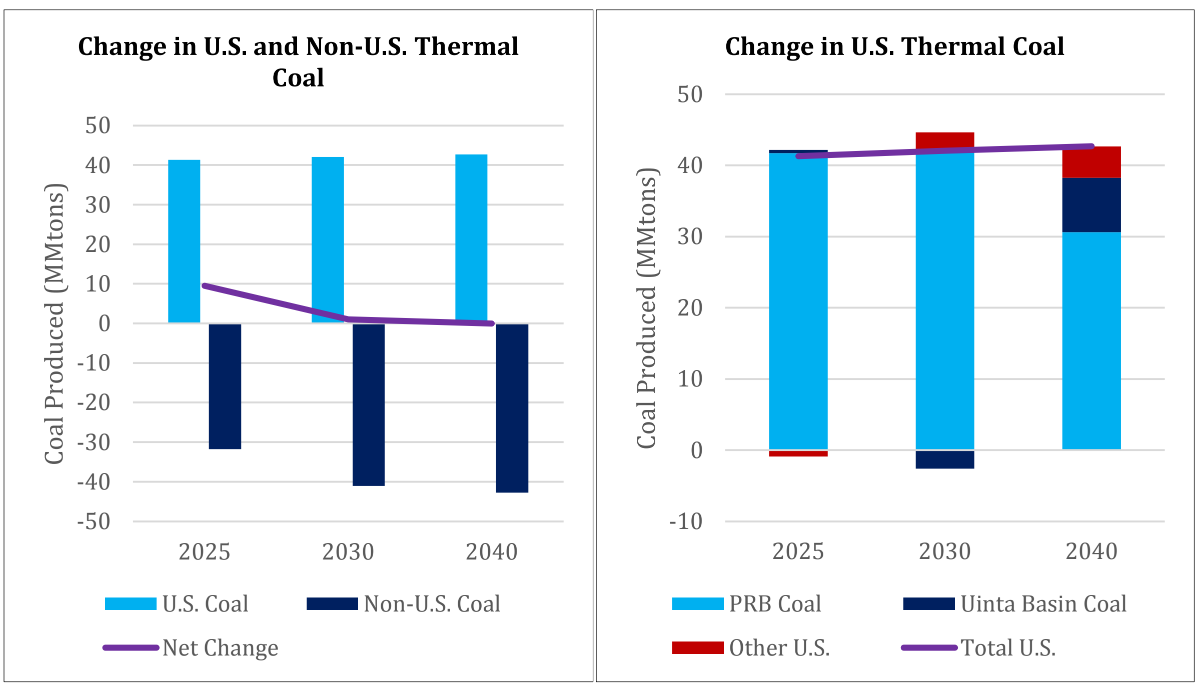
For the United States, Table 43 shows the estimated change in coal production between the Proposed Action and the No-Action Alternative by model run year to be a decrease of 2.0 million metric tons or less in the years before 2025 when the terminal would come online. Once the terminal is online and exporting coal, total modeled U.S. coal production would be higher by an average of 42.1 million metric tons under the Proposed Action, primarily due to increases in Powder River Basin and Uinta Basin production.

Table 43. Lower Bound Senario Change in Coal Production—Proposed Action minus No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	0	0	0	-31.8	-41.0	-42.7	-39.1
Total U.S. Thermal Coal	-1.8	-1.1	-2.0	41.3	42.1	42.7	42.1
Powder River Basin Coal	-2.2	-3.1	-3.2	41.7	41.8	30.6	37.4
Uinta Basin Coal	-0.2	-0.2	-1.4	0.5	-2.6	7.6	2.2

The left-hand chart in Figure 28 shows that total non-U.S. thermal coal production would decrease in similar amounts to the increase in U.S. coal production when comparing the Proposed Action to the No-Action Alternative. This would indicate that U.S. thermal coal exports would take the place of some internationally produced coal, instead of adding to overall global coal demand. The right-hand chart in Figure 28 shows that the changes in Powder River Basin coal production would make up most of the changes in overall U.S. coal production.

Figure 28. Lower Bound Scenario Change in Coal Production—Proposed Action minus No-Action Alternative



In the Lower Bound Scenario, the average increase in U.S. coal production (42.1 million metric tons) under the Proposed Action would be close to the 44 million metric tons of coal being exported through the terminal, while the Past Conditions (2014) Scenario increase would only average 27.8 million metric tons. The difference would be due primarily to changes in coal exports through

Canadian export terminals. In the Past Conditions (2014) Scenario, 13.6 million metric tons of Powder River Basin coal would be exported through Canadian export terminals under the No-Action Alternative. Under the Past Conditions (2014) Scenario Proposed Action, all of the coal being exported through the Canadian terminals would be exported through the terminal . For the Lower Bound Scenario Powder River Basin coal would not be exported through the Canadian export terminals under the No-Action Alternative. Thus, when the terminal comes online, the full amount of exports would be new incremental production, and explains most of the difference in the change in production (42.1 million metric tons – 13.6 million metric tons = 28.5 million metric tons).

6.3.2 Coal Consumption

Under the No-Action Alternative U.S. thermal coal consumption would average 715 million metric tons per year for the 2025 to 2040 period. U.S. coal consumption would be fairly flat between 2020 and 2040, as electric demand growth would be primarily met with natural gas and renewable generation. Over the 2016 to 2040 period, Pacific Basin coal consumption would grow at an average rate of 0.9% per year from 4.6 to 5.6 billion metric tons. The growth in consumption would be driven by increasing coal consumption in China and India. Table 44 shows the No-Action Alternative coal consumption values for each model run year.

China is responsible for the largest share of global thermal coal consumption, burning 3,260 million metric tons of coal in 2016. This amount is projected to grow in the Lower Bound Scenario under the No-Action Alternative to 3,602 million metric tons by 2040. Total U.S. coal consumption would remain relatively stable, hovering in the low 700 million metric ton range. In the Lower Bound Scenario the growth in coal demand in Asia would be only 0.9% and, with the lower international coal prices, would be a challenging market environment for coal transported through the terminal.

Table 44. Lower Bound Scenario Coal Consumption—No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	114	134	165	140
Australia	158	168	176	193	212	253	223
China	3,260	3,337	3,397	3,515	3,625	3,602	3,586
Hong Kong	14	14	14	15	16	17	16
India	686	719	745	801	859	982	891
Indonesia	165	181	195	228	264	357	290
Japan	122	122	131	129	125	121	124
South Korea	83	81	86	78	74	78	77
Taiwan	63	63	68	74	75	80	77
Total Pacific Basin Coal Consumption	4,626	4,768	4,906	5,146	5,384	5,654	5,423
Total U.S. Coal Consumption	749	769	713	719	707	718	715

Coal consumption under the Proposed Action would follow similar patterns as the No-Action Alternative, with U.S. thermal coal consumption averaging 713 million metric tons per year for the 2025 to 2040 period. As with the No-Action Alternative, U.S. coal consumption would be fairly flat between 2020 and 2040 as electric demand growth would be met primarily with natural gas and renewable generation.

Over the 2016 to 2040 period, Pacific Basin coal consumption would follow the same pattern as it grows from 4.6 to 5.6 billion metric tons. Table 45 shows the Proposed Action coal consumption values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 45. Lower Bound Scenario Coal Consumption—Proposed Action (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	114	134	165	140
Australia	158	168	176	193	212	253	223
China	3,260	3,337	3,397	3,526	3,625	3,602	3,589
Hong Kong	14	14	14	15	15	17	16
India	686	719	745	801	859	982	891
Indonesia	165	181	195	228	264	357	290
Japan	122	122	131	130	126	117	123
South Korea	83	81	86	78	73	75	75
Taiwan	63	63	68	74	75	80	77
Total Pacific Basin Coal Consumption	4,626	4,768	4,906	5,158	5,384	5,647	5,423
Total U.S. Coal Consumption	747	768	711	716	705	717	713

Table 46 shows the estimated change in coal consumption between the Proposed Action and the No-Action Alternative by model run year to be zero in the Pacific Basin before 2025 when the terminal was assumed to come online. Once the terminal is online and exporting coal, total Pacific Basin coal consumption would increase by an average of 0.4 million metric tons between 2025 and 2040, with Pacific Basin consumption increasing in 2025 and then decreasing in subsequent years. The increase in consumption in 2025 would be due to the consumption of a greater quantity of lower heat content coal. U.S. coal consumption would be slightly lower at an average of 1.8 million metric tons per year over the 2025 to 2040 period under the Proposed Action due primarily to a decrease in the demand for Powder River Basin coal. Powder River Basin coal demand in the United States would decrease slightly due to higher coal prices caused by higher production when the Powder River Basin coal is exported through the terminal.

In the Pacific Basin, coal consumption would be lower on average by 0.4 million metric tons per year between 2025 and 2040, with only China, Japan, and South Korea having changes above 2 million metric tons. The changes in consumption would be due to changes in the mix of coal consumed and the differences in heat content of the coal being consumed. Under the Proposed Action, a larger quantity of lower heat content coal would be consumed than under the No-Action Alternative in 2025. This makes it appear that total coal consumption is increasing. In 2030, Japan, and in 2040, Japan and South Korea, would be importing a greater quantity of higher heat content coal from Australia, Indonesia, and Utah, so the overall tons of coal consumed falls in these years.

Table 46. Lower Bound Scenario Change in Coal Consumption—Proposed Action minus No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia – Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	11.2	0	0	3.1
Hong Kong	0	0	0	0	-0.4	0	-0.1
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	0.9	0.9	-4.1	-1.0
South Korea	0	0	0	0	-1.4	-2.9	-1.6
Taiwan	0	0	0	0	0	0	0
Total Pacific Basin Coal Consumption	0	0	0	12.1	-0.8	-7.0	0.4
Total U.S. Coal Consumption	-1.8	-1.1	-2.0	-2.6	-1.9	-1.2	-1.8

6.3.3 Coal Distribution

Similar to the Past Conditions (2014) Scenario, the Lower Bound Scenario distribution patterns for Powder River Basin and Uinta Basin coal are expected to remain largely unchanged under the Proposed Action. Thus, this section focuses on the distribution of coal in the Pacific Basin and how that distribution would be expected to change with the construction of the terminal. Under the No-Action Alternative, there is no coal exported through the terminal; however, there would be 454 million metric tons of coal distributed in the Pacific Basin by ship in the seaborne coal market in 2016. Table 47 shows the tons of coal that would be imported by each country in the Pacific Basin under the No-Action Alternative. By 2040, a total of 1,178 million metric tons of coal are expected to be imported in the seaborne coal market in the Pacific Basin.

Table 47. Lower Bound Scenario Seaborne Coal Imports in Pacific Basin—No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	114	134	165	140
Australia	0	0	0	0	0	0	0
China	99	195	227	318	318	726	476
Hong Kong	14	14	14	15	16	17	16
India	38	11	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	122	122	131	129	125	121	124
South Korea	42	39	42	61	67	70	66
Taiwan	63	63	68	74	75	80	77
Total Pacific Basin Coal sent via ship	454	526	576	710	734	1,178	900

To understand how coal distribution is changing in more detail than the tons of coal imported by each country, the tons of coal shipped to each country were multiplied by the distance in nautical miles that the coal would be shipped. The change in tons imported might not change significantly; however, where the coal is sourced might change, which might have a significant impact on the emissions associated with shipping. Table 48 shows the ton-nautical miles for coal shipped to each country under the No-Action Alternative.

Table 48. Lower Bound Scenario Distance Weighted Seaborne Coal Imports in Pacific Basin—No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	4,798	32,290	106,870	272,493	418,998	532,288	422,360
Australia	0	0	0	0	0	0	0
China	169,404	331,634	386,461	541,045	541,045	1,236,674	811,567
Hong Kong	27,007	27,278	27,552	28,247	44,581	46,582	40,822
India	117,868	32,724	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	306,401	306,172	329,879	322,761	313,527	526,326	398,847
South Korea	111,406	102,324	109,207	161,205	200,656	341,389	244,427
Taiwan	94,325	93,933	102,246	194,663	198,365	341,257	252,906
Total Pacific Basin Coal sent via ship	831,211	926,354	1,062,215	1,520,415	1,717,172	3,024,517	2,170,929

Under the Proposed Action coal would be exported through the terminal to destinations in the Pacific Basin. Table 49 shows that the coal exported from the terminal would be distributed by the model to Japan, because this would be the closest destination, thus, it allows for the greatest reduction in system costs when the model calculates a solution. The distribution of coal shipped through the terminal in the Lower Bound Scenario would be the same as the Past Conditions (2014) Scenario.

Table 49. Lower Bound Scenario Distribution of Coal Exported through the Proposed Coal Export Terminal—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040
China	0	0	0	0	0	0
Hong Kong	0	0	0	0	0	0
Japan	0	0	0	44.0	44.0	44.0
South Korea	0	0	0	0	0	0
Taiwan	0	0	0	0	0	0
Total Pacific Basin Coal sent via ship through Terminal	0	0	0	44.0	44.0	44.0

Under the Proposed Action, a similar number of tons would be distributed in the seaborne coal market as for the No-Action Alternative, as can be seen in Table 50. The distance weighted coal distribution in the Pacific Basin is presented in Table 51 for the Proposed Action.

Table 50. Lower Bound Scenario Seaborne Coal Imports in Pacific Basin—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	75	82	94	114	134	165	140
Australia	0	0	0	0	0	0	0
China	99	195	227	318	318	726	476
Hong Kong	14	14	14	15	15	17	16
India	38	11	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	122	122	131	130	126	117	123
South Korea	42	39	42	61	65	67	65
Taiwan	63	63	68	74	75	80	77
Total Pacific Basin Coal sent via ship	454	526	576	710	733	1,171	897

Table 51. Lower Bound Scenario Distance Weighted Seaborne Coal Imports in Pacific Basin—Proposed Action (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	4,798	32,290	106,870	272,493	418,998	532,288	422,360
Australia	0	0	0	0	0	0	0
China	169,404	331,634	386,461	541,045	541,045	1,236,674	811,567
Hong Kong	27,007	27,278	27,552	28,247	38,457	46,582	38,781
India	117,868	32,724	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	306,401	306,172	329,879	408,243	399,008	494,484	438,703
South Korea	111,406	102,324	109,207	161,205	171,009	262,896	204,019
Taiwan	94,325	93,933	102,246	194,663	198,365	341,257	252,906
Total Pacific Basin Coal sent via ship	831,211	926,354	1,062,215	1,605,896	1,766,883	2,914,181	2,168,336

As can be seen in Table 52, which shows the estimated change in tons of coal imported by each of the regions, the changes in coal imports between the No-Action Alternative and the Proposed Action mirror the changes in consumption, except for China because the total amount of coal imported does not change. As mentioned in the previous section, the changes in consumption are due to changes in the mix of coal being consumed and not a change in overall coal demand.

Table 52. Lower Bound Scenario Change in Seaborne Coal Distribution in Pacific Basin—Proposed Action minus No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia – Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0
Hong Kong	0	0	0	0	-0.4	0	-0.1
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	0.9	0.9	-4.1	-1.0
South Korea	0	0	0	0	-1.4	-2.9	-1.6
Taiwan	0	0	0	0	0	0	0
Total Pacific Basin Coal sent via ship	0	0	0	0.9	-0.8	-7.0	-2.8

The changes in the total tons of coal imported to each region would be magnified or diminished depending on how the sources of the coal shifted. There would be some relatively large changes in the ton-mile values, as shown in Table 53. For example, in Japan in 2025 coal imports would increase by less than 1%, while the ton-miles would increase by over 26%.

Table 53. Lower Bound Scenario Change in Distance Weighted Seaborne Coal Distribution in Pacific Basin—Proposed Action minus No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	Annual Average
Asia - Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0
Hong Kong	0	0	0	0	-6,124	0	-2,041
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	85,482	85,482	-31,843	39,856
South Korea	0	0	0	0	-29,647	-78,493	-40,407
Taiwan	0	0	0	0	0	0	0
Total Pacific Basin Coal sent via ship	0	0	0	85,482	49,711	-110,336	-2,593

6.3.4 CO_2 Emissions

This section presents the estimated CO_2 emissions from coal combusted in the United States and the Pacific Basin in the Lower Bound Scenario. In addition, CO_2 emissions from natural gas consumption in the United States are included because decreases in coal consumption may be offset by increases in natural gas consumption. Table 54 presents the CO_2 emissions under the No-Action Alternative. Total U.S. CO_2 emissions from coal would gradually decline and average 1,372 million metric tons between 2025 and 2040, which reflects the gradually declining coal consumption in the U.S. Pacific Basin CO_2 emissions would average 10,061 million metric tons per year between 2025 and 2040, which is 7.3 times the total CO_2 emissions from the U.S. coal combustion emissions. Natural gas CO_2 emissions would average 514 million metric tons per year between 2025 and 2040, which is 44 million metric tons higher than the Past Conditions (2014) Scenario. The higher natural gas emissions under the Lower Bound Scenario would be due to the higher assumed coal prices in this scenario, which would cause a shift away from coal and toward natural gas consumption. Between 2030 and 2040, CO_2 emissions from natural gas would increase by 180 million metric tons. This increase would be due to nuclear units retiring in this period and natural gas-fired generation replacing the retired nuclear generation.

Table 55 presents the CO_2 emissions under the Proposed Action. Total CO_2 emissions under the Proposed Action would follow the same trends as under the No-Action Alternative.

Table 54. Lower Bound Scenario CO_2 Emissions—No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	194,165	217,138	269,361	231,066
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	6,562,859	6,735,018	6,905,308	7,036,113	7,141,291	6,869,080	7,006,215
Hong Kong	32,192	32,514	32,840	33,670	34,330	35,728	34,690
India	1,134,742	1,161,652	1,189,727	1,264,655	1,340,727	1,475,993	1,372,199
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	303,319	303,092	303,914	297,147	288,440	255,726	278,137
South Korea	191,810	186,871	183,174	170,327	159,831	154,367	160,622
Taiwan	155,413	156,058	158,041	159,143	161,146	165,230	162,178
Pacific Basin - Coal	9,049,688	9,301,922	9,550,840	9,837,111	10,110,619	10,178,818	10,061,166
U.S. - Coal	1,460,162	1,500,110	1,377,345	1,386,257	1,358,466	1,373,259	1,371,938
U.S. - Natural Gas	477,173	455,573	463,820	436,317	446,673	626,705	513,809

Table 55. Lower Bound Scenario CO_2 Emissions—Proposed Action (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	194,165	217,138	269,361	231,066
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	6,562,859	6,735,018	6,905,308	7,038,230	7,141,291	6,869,080	7,006,803
Hong Kong	32,192	32,514	32,840	33,670	34,405	35,728	34,715
India	1,134,742	1,161,652	1,189,727	1,264,655	1,340,727	1,475,993	1,372,199
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	303,319	303,092	303,914	297,147	288,440	256,071	278,271
South Korea	191,810	186,871	183,174	170,327	160,131	154,690	160,847
Taiwan	155,413	156,058	158,041	159,143	161,146	165,230	162,178
Pacific Basin - Coal	9,049,688	9,301,922	9,550,840	9,839,229	10,110,994	10,179,485	10,062,139
U.S. - Coal	1,458,006	1,498,426	1,373,883	1,381,092	1,354,117	1,370,285	1,367,897
U.S.- Natural Gas	477,969	456,026	465,155	437,730	447,149	627,368	514,618

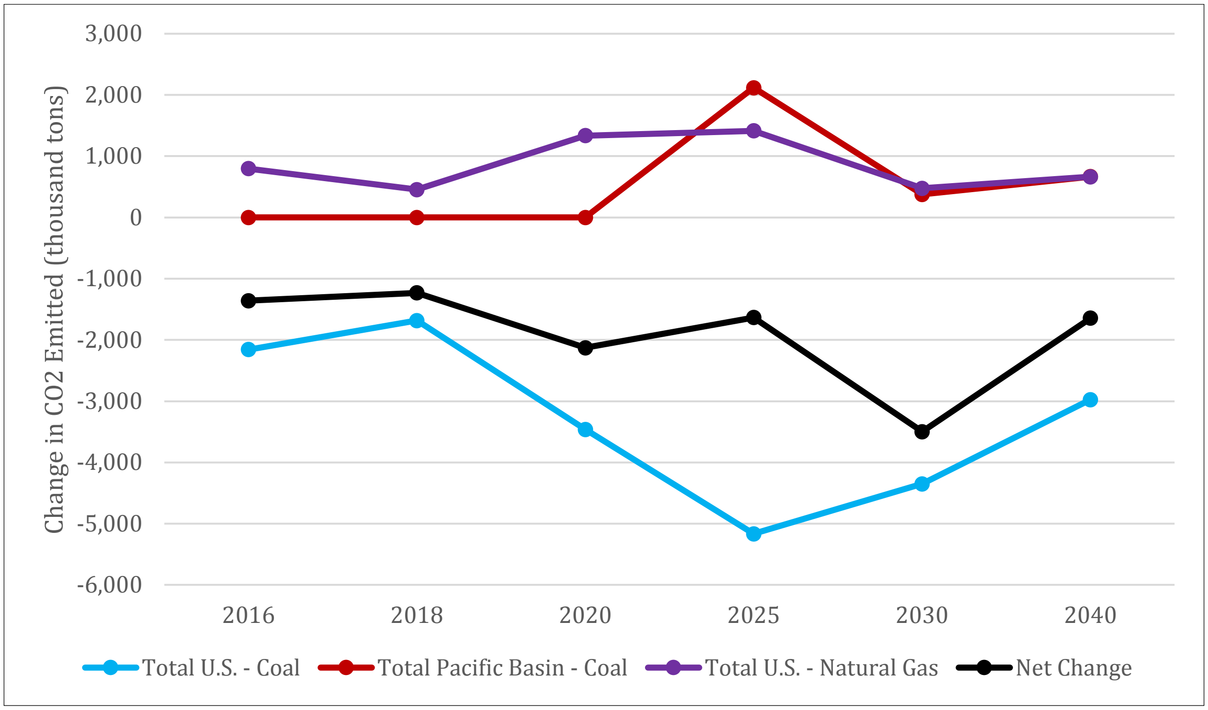
Table 56 shows the estimated change in CO_2 emissions for each region and the total net change across all regions. Total Pacific Basin CO_2 emissions from coal consumption would increase between 375 and 2,118 thousand metric tons starting in 2025 due to shifts in the type of coal consumed in China, Hong Kong, Japan, and South Korea, where the different coal types would have different CO_2 emissions rates. In contrast, U.S. coal CO_2 emissions would decrease in every year due to slightly higher coal prices that would depress U.S. coal demand. The slightly higher coal prices would result from the fact that an additional 44 million metric tons of coal would be mined and exported under the Proposed Action, which would shift the demand curve up and yield higher coal prices in the United States. The decrease in coal consumption would be offset by an increase in natural gas consumption, as is seen by the increase in CO_2 emissions from natural gas, which would average 809 thousand metric tons per year between 2025 and 2040. The total net change in CO_2 emissions would be a decrease of an average of 2,259 thousand metric tons per year between 2025 and 2040.

Table 56. Lower Bound Scenario Changes in CO_2 Emissions—Proposed Action minus No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	2,118	0	0	588
Hong Kong	0	0	0	0	74	0	25
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	0	0	344	134
South Korea	0	0	0	0	301	323	226
Taiwan	0	0	0	0	0	0	0
Pacific Basin - Coal	0	0	0	2,118	375	667	973
U.S. - Coal	-2,156	-1,684	-3,462	-5,165	-4,349	-2,974	-4,041
U.S. - Natural Gas	795	453	1,334	1,413	476	663	809
Total Change	-1,360	-1,231	-2,128	-1,634	-3,498	-1,643	-2,259

In the Lower Bound Scenario, coal combustion emissions of CO_2 would be higher under the Proposed Action in the Pacific Basin than under the No-Action Alternative. U.S. emissions would generally decline. Figure 29 shows the net change in CO_2 emissions between the No-Action Alternative and Proposed Action. The decrease in U.S. coal emissions would override the increase in Pacific Basin coal emissions and U.S. natural gas emissions and would drive the net change to be a net decrease in CO_2 emissions under the Proposed Action.

Figure 29. Lower Bound Scenario Changes in CO_2 Emissions by Region—Proposed Action minus No-Action Alternative



a. Total U.S. CO_2 emissions from the combustion of coal decrease because the proposed coal export terminal would be a new demand sink for U.S. coal, and thus, would cause coal prices to rise, and U.S. coal consumption to decrease in response to the higher prices.

b. Pacific Basin CO_2 emissions from the combustion of coal increase due to a larger quantity of lower heat content coal being consumed.

c. Total U.S. natural gas combustion CO_2 emissions increase because when coal consumption for electric generation declines, natural gas usage for electric generation increases to fill the gap.

6.4 Upper Bound Scenario

The Upper Bound Scenario uses the assumptions presented in Chapter 5, *Scenarios*, and represents the upper bound of global GHG emissions that could be reasonably expected if the scenario assumptions are realized. This scenario is designed to model the highest potential GHG emissions under the Proposed Action, and to provide a high GHG emissions environment into which the terminal is constructed and operated. This section presents the modeling results for the Upper Bound Scenario No-Action Alternative and Proposed Action for coal production, consumption, distribution, and CO_2 emissions.

6.4.1 Coal Production

The Upper Bound Scenario is designed to model high levels of coal consumption, and thus, increased CO_2 emissions. Therefore, coal production in the Upper Bound Scenario would be greater than the Past Conditions (2014) Scenario. Under the No-Action Alternative U.S. thermal coal production would average 979 million metric tons per year for the 2025 to 2040 period. In contrast, the average U.S. coal production over 2025 to 2040 under the Past Conditions (2014) Scenario would be 188 million metric tons lower at 791 million metric tons. The higher production under the Upper Bound

Scenario would be due to two factors. First, the assumed lower Powder River Basin coal prices in the Upper Bound Scenario would cause about 39 million metric tons more of Powder River Basin coal to be consumed. Second, exports out of the east coast and Canadian Pacific Northwest ports would be 100 to 185 million metric tons higher for the Upper Bound Scenario. U.S. coal production would fluctuate over the 2016 to 2040 period in response to both domestic demand and exports, and would end up being 33 million metric tons higher in 2040 than in 2016. Over the 2016 to 2040 period, non-U.S. coal production would grow at an average annual rate of 2.2% per year from 6.3 to 10.3 billion metric tons.

Powder River Basin coal production under the No-Action Alternative would average 405 million metric tons per year over 2025 to 2040. The modeled Powder River Basin average production in the Upper Bound Scenario, No-Action Alternative, would be 14% below the 2006 to 2011 historical production average of 473 million metric tons. After 2011 natural gas prices dropped to below $3/MMBtu, which significantly reduced coal demand and drove Powder River Basin production to around 435 million metric tons. Uinta Basin coal production under the No-Action Alternative would average 18.4 million metric tons per year over 2025 to 2040, with production gradually declining over the 2016 to 2040 period. Table 57 shows the No-Action Alternative coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 57. Upper Bound Coal Production—No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,266	6,678	7,119	8,122	9,175	10,342	9,337
Total U.S. Thermal Coal	986	1,047	962	960	947	1,019	979
Powder River Basin Coal	404	436	403	410	409	398	405
Uinta Basin Coal	27.6	24.5	22.8	22.0	20.0	14.4	18.4

Under the Proposed Action, U.S. thermal coal production would average 1,018 million metric tons per year for the 2025 to 2040 period. As with the No-Action Alternative, U.S. coal production would fluctuate and end at 66 million metric tons higher by 2040. The higher production by 2040 would be due to the additional exports through the terminal and higher domestic Powder River Basin coal consumption. Non-U.S. coal production would follow the same growth rate under the Proposed Action as it would under the No-Action Alternative, except production would decline by 16.8 to 34.4 million metric tons per year, once the terminal comes online. Thus, the coal exported from the terminal would displace some coal production in other countries. Powder River Basin coal production under the Proposed Action would average 435 million metric tons per year between 2025 and 2040 with production gradually increasing over time. Uinta Basin coal production would average 24.7 million metric tons per year between 2025 and 2040, with production declining through 2020 and then increasing to 35.2 million metric tons in 2025 because coal from the Uinta Basin would be exported through the terminal. After 2025, Uinta Basin production would decline as less coal from this basin is exported in each subsequent run year. Table 58 shows the Proposed Action coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 58. Upper Bound Scenario Coal Production—Proposed Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,259	6,660	7,119	8,102	9,141	10,325	9,313
Total U.S. Thermal Coal	989	1,059	958	996	994	1,055	1018
Powder River Basin Coal	398	434	400	427	438	438	435
Uinta Basin Coal	18.9	18.5	14.2	35.2	23.0	18.6	24.7

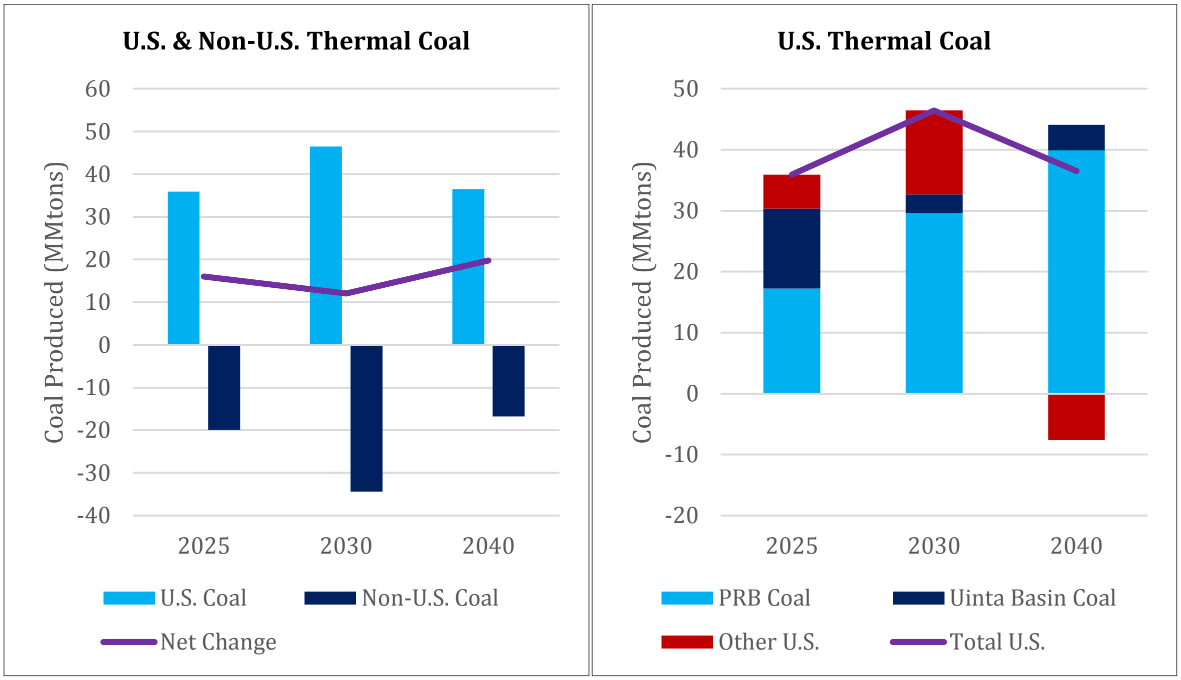
Table 59 shows the estimated change in coal production between the Proposed Action and the No-Action Alternative by model run year to generally be a decrease of less than 18 million metric tons for non-U.S. coal in the years before 2025 when the terminal was assumed to come online. The increase in U.S. coal production prior to 2025 is due to an increase in exports from the Appalachian basin. Once the terminal is online and exporting coal, total modeled U.S. coal production would be higher under the Proposed Action, primarily due to increases in the Powder River Basin and the Uinta Basin. In response to the increase in exports from the terminal, non-U.S. coal production would decrease by 16.8 to 34.4 million metric tons per year.

Table 59. Upper Bound Scenario Change in Coal Production—Proposed Action minus No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	-7.3	-17.7	0.0	-19.9	-34.4	-16.8	-23.5
Total U.S. Thermal Coal	3.2	12.1	-4.3	35.9	46.4	36.5	39.7
Powder River Basin Coal	-5.4	-1.4	-3.1	17.2	29.6	39.9	30.2
Uinta Basin Coal	-8.7	-5.9	-8.6	13.1	3.0	4.2	6.3

Figure 30 shows that total non-U.S. thermal coal production would decrease in proportion to the increase in U.S. coal production under the Proposed Action. The difference in the changes of U.S. and non-U.S. coal production are due to the 15 to 20 million metric ton increase in international coal demand due to induced demand caused by the lower coal prices of exported coal. This would indicate that U.S. thermal coal exports would take the place of some internationally produced coal.

Figure 30. Upper Bound Scenario Change in Coal Production—Proposed Action minus No-Action Alternative



6.4.2 Coal Consumption

In the Upper Bound Scenario, under the No-Action Alternative U.S. thermal coal consumption would average 809 million metric tons per year for the 2025 to 2040 period. U.S. coal consumption would be fairly flat between 2020 and 2040 as electric demand growth would be primarily met with natural gas and renewable generation. Over the 2016 to 2040 period, Pacific Basin coal consumption would grow at an average rate of 2.5% per year from about 5.0 to almost 9.0 billion metric tons. The growth in consumption would be driven by increasing coal consumption in China and India. Table 60 shows the No-Action Alternative coal consumption values for each model run year.

China is responsible for the largest share of global thermal coal consumption, burning 3,550 million metric tons of coal in 2016. This amount is projected to grow in the Upper Bound Scenario, No-Action Alternative to 6,350 million metric tons by 2040. Total U.S. coal consumption would remain relatively stable, fluctuating between 803 and 857 million metric tons. In the Upper Bound Scenario the growth in coal demand for countries in Asia is 2.5%, which would provide for a robust market environment for coal transported through the terminal.

Coal consumption under the Proposed Action follows similar patterns as the No-Action Alternative, with U.S. thermal coal consumption averaging 807 million metric tons per year for the 2025 to 2040 period. As under the No-Action Alternative, U.S. coal consumption is fairly flat between 2020 and 2040.

Table 60. Upper Bound Scenario Coal Consumption—No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	104	116	143	123
Australia	158	168	176	193	212	253	223
China	3,550	3,879	4,190	4,952	5,729	6,346	5,753
Hong Kong	14	14	14	15	15	17	16
India	691	749	806	971	1,158	1,565	1,264
Indonesia	165	181	195	228	264	357	290
Japan	138	132	132	131	136	130	132
South Korea	89	89	88	84	83	83	83
Taiwan	70	71	70	72	79	85	79
Total Pacific Basin Coal Consumption	4,950	5,364	5,765	6,750	7,793	8,978	7,964
Total U.S. Coal Consumption	821	857	803	817	805	808	809

Over the 2016 to 2040 period, Pacific Basin coal consumption under the Proposed Action grows from 4.9 to about 9.0 billion metric tons, similar to the No-Action Alternative. However, under the Proposed Action there is an average 1.65% increase in demand in Hong Kong, India, Japan, South Korea, and Taiwan that is induced due to lower delivered coal prices. Table 61 shows the Proposed Action coal consumption values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 61. Upper Bound Scenario Coal Consumption—Proposed Action (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	104	116	143	123
Australia	158	168	176	193	212	253	223
China	3,550	3,879	4,190	4,953	5,725	6,347	5,753
Hong Kong	14	14	14	15	16	18	16
India	691	749	806	985	1,170	1,581	1,279
Indonesia	165	181	195	228	264	357	290
Japan	137	131	132	134	137	133	135
South Korea	89	89	88	85	85	85	85
Taiwan	70	70	70	73	80	86	80
Total Pacific Basin Coal Consumption	4,949	5,362	5,765	6,771	7,806	9,002	7,984
Total U.S. Coal Consumption	818	853	799	813	802	807	807

Table 62 shows the estimated change in coal consumption between the Proposed Action and the No-Action Alternative by model run year to be close to zero in the Pacific Basin before 2025 when the terminal was assumed to come online. Once the terminal is online and exporting coal, total Pacific Basin coal consumption would be higher by an average of 19.3 million metric tons between 2025 and 2040, while U.S. coal consumption would be slightly down by an average of 2.5 million metric tons per year over the 2025 to 2040 period under the Proposed Action.

In the Pacific Basin, coal consumption would be higher on average by 19.3 million metric tons per year between 2025 and 2040, with the increase driven by the induced demand from the lower coal prices when the terminal comes online in 2025. India's consumption would have the largest increase with an average of 14.6 million metric tons per year between 2025 and 2040. Some of the changes in consumption would be due to changes in the mix of coal, such as in China, where there was no induced demand due to lower delivered coal prices.

Table 62. Upper Bound Scenario Change in Coal Consumption—Proposed Action minus No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia – Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	1.5	-3.6	0.6	-0.5
Hong Kong	0	0	0	0.2	0.2	0.2	0.2
India	0	0	0	14.2	12.5	16.6	14.6
Indonesia	0	0	0	0	0	0	0
Japan	-0.9	-0.7	0	2.5	0.8	3.2	2.2
South Korea	0	0	0	1.0	2.0	2.6	2.0
Taiwan	0	-1.3	0	0.9	1.0	1.0	0.9
Total Pacific Basin Coal Consumption	-0.9	-1.9	0.0	20.3	12.9	24.1	19.3
Total U.S. Coal Consumption	-3.4	-3.5	-4.4	-4.1	-3.4	-0.5	-2.5

6.4.3 Coal Distribution

As with the Past Conditions (2014) Scenario, distribution patterns for Powder River Basin and Uinta Basin coal are expected to remain largely unchanged under the Proposed Action. This section focuses on the distribution of coal in the Pacific Basin and how that distribution would be expected to change with the construction of the terminal. Under the No-Action Alternative, there would be no coal exported through the terminal; however, there would be 615 million metric tons of coal distributed in the Pacific Basin by ship in the seaborne coal market in 2016. Table 63 shows the tons of coal that would be imported by each country in the Pacific Basin under the No-Action Alternative. By 2040, 1,175 million metric tons of coal are expected to be distributed in the seaborne coal market in the Pacific Basin.

Table 63. Upper Bound Scenario Seaborne Coal Imports in Pacific Basin—No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	104	116	143	123
Australia	0	0	0	0	0	0	0
China	227	227	227	318	318	726	476
Hong Kong	14	14	14	15	15	17	16
India	43	41	36	38	37	0	23
Indonesia	0	0	0	0	0	0	0
Japan	138	132	132	131	136	130	132
South Korea	48	47	44	68	76	74	73
Taiwan	70	71	70	72	79	85	79
Total Pacific Basin Coal sent via ship	615	613	616	746	777	1,175	923

To understand how coal distribution is changing in more detail than the tons of coal imported by each country, the tons of coal shipped to each country were multiplied by the distance in nautical miles that the coal is shipped. The change in tons imported might not change significantly; however, where the coal is sourced might change, which would have a significant impact on the emissions associated with shipping. Table 64 shows the ton-nautical miles for coal shipped to each country under the No-Action Alternative.

Table 64. Upper Bound Scenario Distance Weighted Seaborne Coal Imports in Pacific Basin—No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	4,798	32,290	106,870	123,074	140,747	178,803	150,637
Australia	0	0	0	0	0	0	0
China	386,461	386,461	386,461	541,045	555,523	1,602,575	958,688
Hong Kong	27,007	27,404	27,806	28,838	29,908	59,514	41,124
India	141,530	125,520	109,856	116,765	114,231	0	70,512
Indonesia	0	0	0	0	0	0	0
Japan	531,038	415,489	380,241	377,452	541,404	512,386	484,577
South Korea	112,335	122,121	99,830	177,011	263,975	260,019	238,280
Taiwan	241,300	189,341	104,144	108,008	259,410	280,908	225,714
Total Pacific Basin Coal sent via ship	1,444,470	1,298,624	1,215,208	1,472,192	1,905,197	2,894,204	2,169,532

Under the Proposed Action, coal would be exported through the terminal to destinations in the Pacific Basin. Table 65 shows that the coal exported from the terminal would be distributed by the model to China, Japan, and South Korea. In the Past Conditions (2014) Scenario, all of the exported coal goes to Japan. In the Upper Bound Scenario, coal would be exported to China because at the higher coal consumption levels in this scenario, the Indonesian bituminous coal that would be sent to China would become depleted and coal from the Uinta basin would replace some of the coal that was being delivered from Indonesia. The situation would be similar in South Korea, except that it would be South Korean bituminous coal reserves that become depleted in the 2025 run year, and thus additional coal must be imported in 2030 and 2040. Imports to South Korea through the terminal would increase from 11.1 to 17.1 million metric tons between 2030 and 2040 because less coal from Russia would be imported in 2040.

Table 65. Upper Bound Scenario Distribution of Coal Exported through the Proposed Coal Export Terminal—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040
China	0	0	0	0	0	10.5
Hong Kong	0	0	0	0	0	0
Japan	0	0	0	44.0	32.9	16.5
South Korea	0.0	0	0	0	11.1	17.1
Taiwan	0	0	0	0	0	0
Total Pacific Basin Coal sent via ship through MBTL	0	0	0	44.0	44.0	44.0

Under the Proposed Action, a similar number of tons would be distributed in the seaborne coal market as the No-Action Alternative, except for an increase in imports to India in 2025 and 2030 (Table 66). The distance weighted coal distribution in the Pacific Basin is presented in Table 67 for the Proposed Action.

Table 66. Upper Bound Scenario Seaborne Coal Imports in Pacific Basin—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	75	82	94	104	116	143	123
Australia	0	0	0	0	0	0	0
China	227	227	227	318	318	726	476
Hong Kong	14	14	14	15	16	18	16
India	43	41	36	52	62	0	35
Indonesia	0	0	0	0	0	0	0
Japan	137	131	132	134	137	133	135
South Korea	48	47	44	68	78	77	75
Taiwan	70	70	70	73	80	86	80
Total Pacific Basin Coal sent via ship	614	611	616	764	806	1,182	941

Table 67. Upper Bound Scenario Distance Weighted Seaborne Coal Imports in Pacific Basin—Proposed Action (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	4,798	32,290	106,870	123,074	140,747	178,803	150,637
Australia	0	0	0	0	0	0	0
China	386,461	386,461	386,461	541,045	546,450	1,607,131	957,436
Hong Kong	27,007	27,404	27,806	29,196	30,266	60,330	41,660
India	141,530	125,520	109,856	160,813	191,943	0	108,651
Indonesia	0	0	0	0	0	0	0
Japan	524,301	436,271	380,241	461,622	590,289	578,555	549,985
South Korea	112,562	122,121	99,830	179,568	313,560	334,087	284,323
Taiwan	241,300	140,231	104,144	109,334	263,388	284,886	228,956
Total Pacific Basin Coal sent via ship	1,437,960	1,270,297	1,215,208	1,604,652	2,076,644	3,043,793	2,321,648

As can be seen in Table 68, which shows the estimated change in tons of coal imported by each of the regions, the changes in coal imports between the No-Action Alternative and the Proposed Action generally mirror the changes in consumption, except for China and India. The change in coal imports between the Proposed Action and the No Action differ from the change in consumption for China because the mix of coal consumed by China changes in the two alternatives. For India, the change in seaborne imports in 2040 is not similar to the change in consumption because in 2040 13.3 million metric tons of coal is imported via overland routes and not via seaborne routes.

Table 68. Upper Bound Scenario Change in Seaborne Coal Imports in Pacific Basin—Proposed Action minus No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia – Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0
Hong Kong	0	0	0	0.2	0.2	0.2	0.2
India	0	0	0	14.2	25.1	0	12.3
Indonesia	0	0	0	0	0	0	0
Japan	-0.9	-0.7	0	2.5	0.8	3.2	2.2
South Korea	0	0	0	1.0	2.0	2.6	2.0
Taiwan	0	-1.3	0	0.9	1.0	1.0	0.9
Total Pacific Basin Coal sent via ship	-0.9	-1.9	0	18.8	29.1	6.9	17.6

The changes in the total tons of coal imported to each region are magnified or diminished depending on how the sources of the coal are shifting. There are some relatively large changes in the ton-mile values, as shown in Table 69. For example, in Japan in 2025, coal imports increase by 1.9% while the ton-miles increase by 22.3%.

Table 69. Upper Bound Scenario Change in Distance Weighted Seaborne Coal Imports in Pacific Basin—Proposed Action minus No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	Annual Average
Asia - Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	0	-9,073	4,557	-1,252
Hong Kong	0	0	0	358	358	816	536
India	0	0	0	44,048	77,712	0	38,140
Indonesia	0	0	0	0	0	0	0
Japan	-6,737	20,783	0	84,170	48,885	66,169	65,408
South Korea	227	0	0	2,557	49,586	74,069	46,043
Taiwan	0	-49,109	0	1,326	3,978	3,978	3,242
Total Pacific Basin Coal sent via ship	-6,510	-28,327	0	132,460	171,447	149,589	152,117

6.4.4 CO_2 Emissions

This section presents the CO_2 estimated emissions from coal combusted in the United States and the Pacific Basin in the Upper Bound Scenario. In addition, CO_2 emissions from natural gas consumption in the United States are included because decreases in coal consumption may be offset by increases in natural gas consumption. Table 70 presents the CO_2 emissions under the No-Action Alternative. Total U.S. CO_2 emissions from coal gradually decline and average 1,525 million metric tons between 2025 and 2040, which reflects the gradually declining coal consumption in the U.S. Pacific Basin CO_2 emissions average 15,260 million metric tons per year between 2025 and 2040, which is 10 times the total coal CO_2 emissions from the United States. Natural gas CO_2 emissions average 466 million metric tons per year, or about one third of U.S. coal CO_2 emissions. Between 2030 and 2040, CO_2 emissions from natural gas increase by 188 million metric tons. This increase is due to nuclear units retiring in this period and natural gas-fired generation replacing the retired nuclear generation.

Table 71 presents the CO_2 emissions under the Proposed Action. Total CO_2 emissions under the Proposed Action follow the same trends as under the No-Action Alternative, and are within 2% of the coal CO_2 emissions under the No-Action Alternative.

Table 70. Upper Bound Scenario CO_2 Emissions—No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	196,125	220,787	273,997	234,629
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	7,260,862	7,916,147	8,536,087	10,032,545	11,514,543	12,571,160	11,513,784
Hong Kong	32,192	32,675	33,166	34,425	35,732	38,498	36,445
India	1,135,920	1,216,497	1,304,198	1,560,679	1,852,812	2,452,270	2,004,787
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	305,003	303,770	304,841	302,552	299,415	287,620	295,700
South Korea	193,004	191,589	189,564	185,299	180,563	178,736	181,168
Taiwan	156,232	158,808	161,194	167,314	173,668	187,108	177,129
Pacific Basin - Coal	9,752,567	10,546,203	11,306,885	13,160,831	15,045,236	16,942,721	15,259,701
U.S. - Coal	1,564,980	1,633,641	1,524,593	1,546,138	1,516,225	1,516,980	1,524,828
U.S. - Natural Gas	442,260	409,224	409,458	383,544	396,159	584,167	465,769

Table 71. Upper Bound Scenario CO_2 Emissions—Proposed Action (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	196,125	220,787	273,997	234,629
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	7,260,862	7,916,147	8,536,087	10,032,838	11,513,995	12,571,286	11,513,731
Hong Kong	32,192	32,675	33,166	34,884	36,191	38,956	36,903
India	1,135,920	1,216,497	1,304,198	1,589,150	1,881,675	2,480,229	2,033,189
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	304,679	302,953	304,841	306,096	302,555	292,150	299,492
South Korea	193,004	191,589	189,564	187,721	183,374	181,758	183,953
Taiwan	156,232	158,808	161,194	169,518	175,871	189,311	179,333
Pacific Basin - Coal	9,752,243	10,545,385	11,306,885	13,198,223	15,082,165	16,981,019	15,297,291
U.S. - Coal	1,560,176	1,625,710	1,516,370	1,536,424	1,505,925	1,507,002	1,514,816
U.S.- Natural Gas	442,892	411,246	411,755	385,646	397,726	587,015	467,983

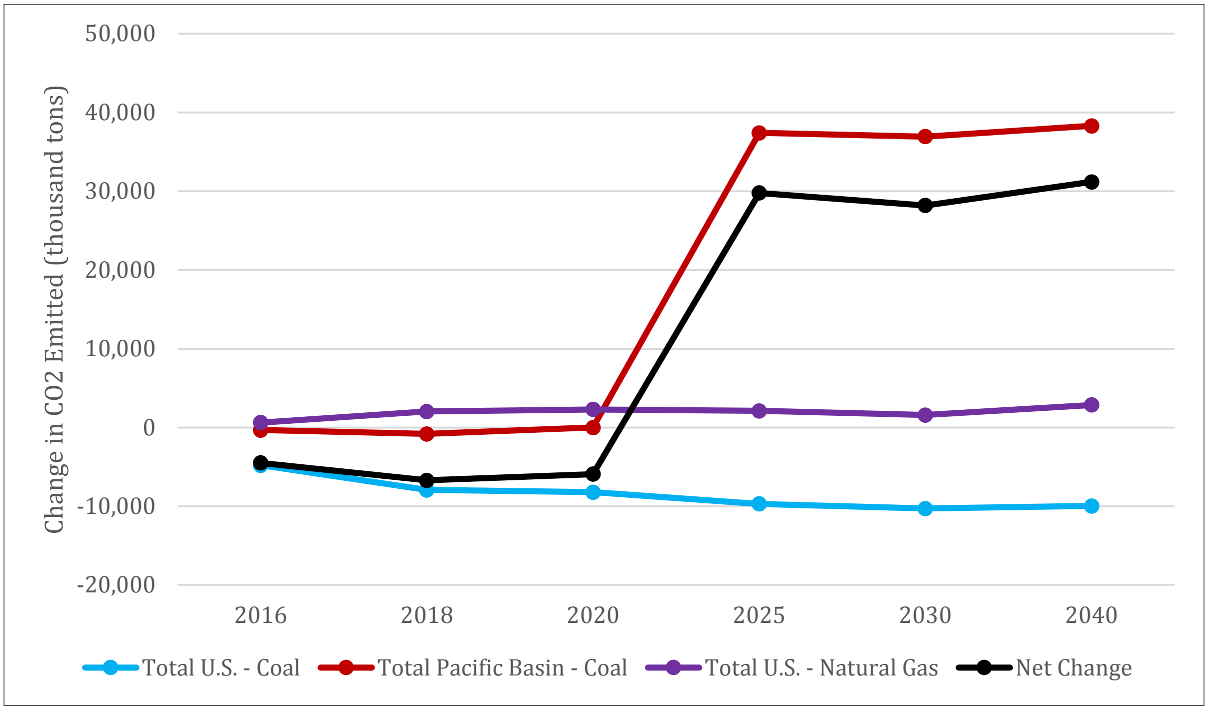
Table 72 shows the estimated change in CO_2 emissions for each region, as well as the total net change across all regions. Total Pacific Basin CO_2 emissions from coal consumption would increase between 36,928 and 38,298 thousand metric tons starting in 2025, due to induced demand from the reduction in delivered coal prices under the Proposed Action and because of shifts in the type of coal consumed. In contrast, U.S. coal CO_2 emissions would decrease in every year due to slightly higher coal prices that would depress coal demand by about 2.5 million metric tons per year. The slightly higher coal prices would result from the fact that an additional 44 million metric tons of coal would be mined and exported under the Proposed Action, which would shift the demand curve up and yield higher coal prices in the United States. The shift would be to the coal demand curve because from the perspective of the U.S. coal market the terminal would be a new source of demand. The decrease in coal consumption would be offset by an increase in natural gas consumption, as is seen by the increase in CO_2 emissions from natural gas, which would average an increase of 2,214 thousand metric tons per year between 2025 and 2040. The total net change in CO_2 emissions would be an average increase of 29,792 thousand metric tons per year.

Table 72. Upper Bound Scenario Changes in CO_2 Emissions—Proposed Action minus No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0
China	0	0	0	293	-547	126	-52
Hong Kong	0	0	0	459	459	459	459
India	0	0	0	28,471	28,863	27,959	28,402
Indonesia	0	0	0	0	0	0	0
Japan	-324	-818	0	3,544	3,140	4,529	3,792
South Korea	0	0	0	2,422	2,811	3,022	2,785
Taiwan	0	0	0	2,203	2,203	2,203	2,203
Pacific Basin - Coal	-324	-818	0	37,392	36,928	38,298	37,590
U.S. - Coal	-4,804	-7,931	-8,223	-9,714	-10,300	-9,978	-10,012
U.S. - Natural Gas	632	2,023	2,297	2,102	1,567	2,848	2,214
Total Change	-4,496	-6,726	-5,926	29,780	28,195	31,168	29,792

In the Upper Bound Scenario the change in coal combustion emissions between the No-Action Alternative and Proposed Action would fluctuate for both the Pacific Basin and the U.S. The change in U.S. CO_2 emissions from natural gas are expected to grow from 2016 to 2018 and fluctuate from 2018 to 2040 while remaining relatively flat overall. Figure 31 shows the net change in CO_2 emissions between the No-Action Alternative and Proposed Action. In the long term, the increase in Pacific Basin coal emissions would drive the net change to be a net increase in CO_2 emissions under the Proposed Action.

Figure 31. Upper Bound Scenario Changes in CO_2 Emissions by Region—Proposed Action minus No-Action Alternative[a,b,c]



a Total U.S. CO_2 emissions from the combustion of coal decrease because the proposed coal export terminal would be a new demand sink for U.S. coal, and thus, would cause coal prices to rise and U.S. coal consumption to decrease in response to the higher prices.

b Pacific Basin CO_2 emissions from the combustion of coal increase due to a larger quantity of lower heat content coal being consumed and due to induced demand from the lower delivered coal prices when the terminal comes online in 2025.

c Total U.S. natural gas combustion CO_2 emissions increase because when coal consumption for electric generation declines, natural gas usage for electric generation increases to fill the gap.

6.5 2015 Energy Policy Scenario

The 2015 Energy Policy Scenario uses the assumptions presented in Chapter 5, *Scenarios*, and is intended to represent a scenario in which the United States and China have implemented policies to reduce GHG emissions. These policies would also reduce coal consumption, and thus production, especially in the long term. This section presents the modeling results for the 2015 Energy Policy Scenario No-Action Alternative and Proposed Action for coal production, consumption, distribution, and CO_2 emissions.

6.5.1 Coal Production

Under the No-Action Alternative U.S. thermal coal production would average 615 million metric tons per year for the 2025 to 2040 period. Annual U.S. coal production would decline by 158 million metric tons between 2016 and 2040 because the climate policies would drive down coal demand. Over the 2016 to 2040 period, non-U.S. coal production would grow at an average annual rate of 0.7% per year from 6.1 to 7.2 billion metric tons. Powder River Basin coal production under the No-Action Alternative would average 236 million metric tons per year over 2025 to 2040. Uinta Basin coal production under the No-Action Alternative would average 14.3 million metric tons per year, with production gradually declining to a low of 13.7 million metric tons in 2020 and then gradually increasing to 14.5 million metric tons by 2040. Uinta Basin coal production would increase between 2020 and 2040 because several coal plants in Utah would increase their coal consumption and electrical output in this period. Table 73 shows the No-Action Alternative coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 73. 2015 Energy Policy Scenario Coal Production—No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,127	6,279	6,441	6,689	6,932	7,244	6,986
Total U.S. Thermal Coal	783	767	622	619	601	625	615
Powder River Basin Coal	321	323	241	241	225	242	236
Uinta Basin Coal	17.0	16.2	13.7	13.9	14.4	14.5	14.3

Under the Proposed Action, U.S. thermal coal production would average 654 million metric tons per year for the 2025 to 2040 period. As with the No-Action Alternative, U.S. coal production would decline. Non-U.S. coal production would follow the same growth rate under the Proposed Action as it would under the No-Action Alternative, except production would decline by 22 to 44 million metric tons per year once the terminal comes online. Thus, the coal exported from the terminal would displace some coal production in other countries. Powder River Basin coal production under the Proposed Action would average 268 million metric tons per year with production declining to 241 million metric tons by 2020 and then staying below 275 million metric tons. Uinta Basin coal production would average 18.7 million metric tons per year, with production declining through 2030 to 11.8 million metric tons and then spiking in 2040 when production jumps to 28.7 million metric tons due to exports of Uinta Basin coal to Japan. Table 74 shows the Proposed Action coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 74. 2015 Energy Policy Scenario Coal Production—Proposed Action (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,127	6,279	6,441	6,668	6,898	7,200	6,951
Total U.S. Thermal Coal	782	766	621	648	643	668	654
Powder River Basin Coal	320	323	241	272	267	266	268
Uinta Basin Coal	17.0	16.2	12.8	13.1	11.8	28.7	18.7

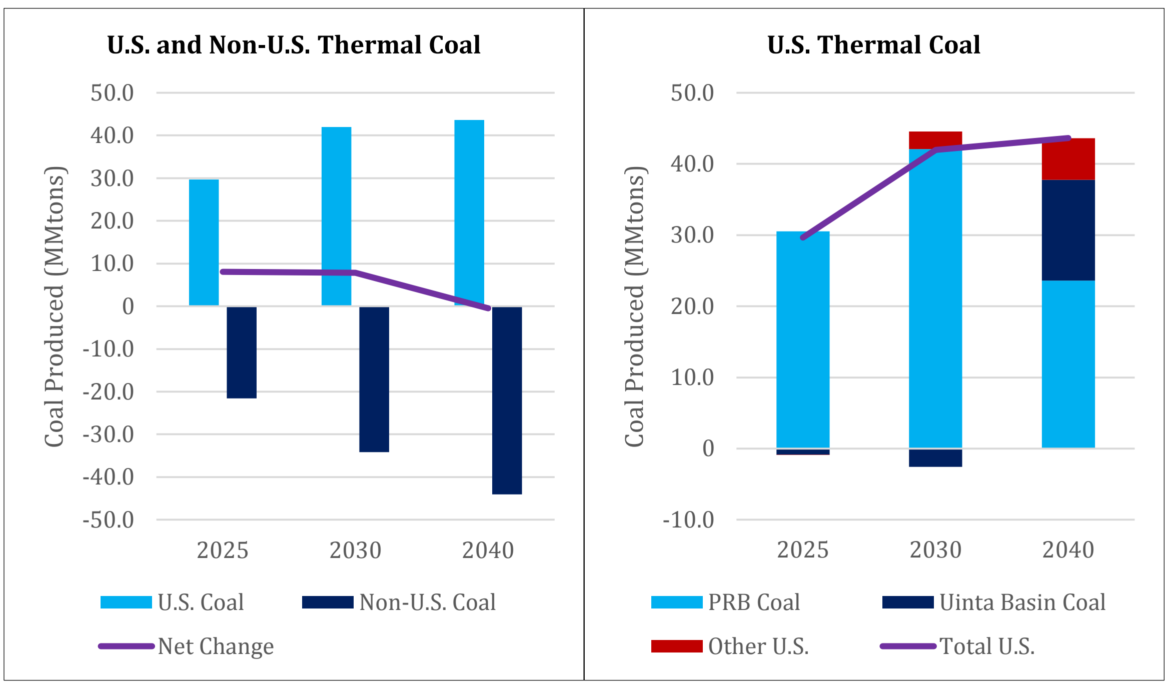
Table 75 shows the estimated change in coal production between the Proposed Action and the No-Action Alternative by model run year. Assuming the terminal is online and exporting coal, total modeled U.S. coal production would be higher under the Proposed Action, primarily due to increases in Powder River Basin and the Uinta Basin.

Table 75. 2015 Energy Policy Scenario Change in Coal Production—Proposed Action minus No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	0	0	0	-21.6	-34.2	-44.1	-34.5
Total U.S. Thermal Coal	-1.0	-1.1	-1.0	29.7	42.0	43.6	39.2
Powder River Basin Coal	-1.1	-0.5	-0.2	30.5	42.1	23.6	31.7
Uinta Basin Coal	0	0	-0.9	-0.8	-2.6	14.2	4.4

Figure 32 shows that total non-U.S. thermal coal production would decrease in proportion to the increase in U.S. coal production under the Proposed Action. The difference in the changes of U.S. and non-U.S. coal production are due to the fact that the increase in U.S. coal production would be lower heat content subbituminous coal and the decrease in non-U.S. coal production would be higher heat content bituminous coal.

Figure 32. 2015 Energy Policy Scenario Change in Coal Production—Proposed Action minus No-Action Alternative



6.5.2 Coal Consumption

In the 2015 Energy Policy Scenario, under the No-Action Alternative U.S. thermal coal consumption would average 615 million metric tons per year for the 2025 to 2040 period. U.S. coal consumption would decline steeply between 2016 and 2020, and then would be fairly flat between 2020 and 2040, as electric demand growth is primarily met with natural gas and renewable generation. The steep decline through 2020 would be due to the implementation of EPA's Clean Power Plan in the model. Over the 2016 to 2040 period, Pacific Basin coal consumption would grow at an average rate of 0.8% per year from 4.6 to 5.6 billion metric tons. The growth in consumption would be driven by increasing coal consumption in Australia, China, India, and Indonesia. Table 76 shows the No-Action Alternative coal consumption values for each model run year.

Table 76. 2015 Energy Policy Scenario Coal Consumption—No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	108	126	143	127
Australia	158	168	176	193	212	253	223
China	3,260	3,331	3,400	3,529	3,623	3,581	3,581
Hong Kong	14	14	14	15	15	16	15
India	686	719	745	801	859	982	891
Indonesia	165	181	195	228	264	357	290
Japan	124	125	132	129	125	116	123
South Korea	83	81	86	78	72	71	73
Taiwan	63	65	68	73	74	75	74
Total Pacific Basin Coal Consumption	4,627	4,766	4,910	5,153	5,371	5,593	5,397
Total U.S. Coal Consumption	776	754	607	607	601	631	615

China is responsible for the largest share of global thermal coal consumption, burning 3,260 million metric tons of coal in 2016. This amount is projected to grow in the 2015 Energy Policy Scenario No-Action Alternative to 3,581 million metric tons by 2040. Under the 2015 Energy Policy Scenario the growth in coal demand in countries in Asia would be only 0.8%, which would be a challenging market environment for coal transported through the terminal.

Coal consumption under the Proposed Action would follow similar patterns as the No-Action Alternative, with U.S. thermal coal consumption averaging 614 million metric tons per year for the 2025 to 2040 period. As under the No-Action Alternative, U.S. coal consumption would decline steeply through 2020, and then would be fairly flat between 2020 and 2040.

Over the 2016 to 2040 period, Pacific Basin coal consumption would follow the same pattern as it would grow from 4.6 to 5.6 billion metric tons. However, under the Proposed Action there would be a 0.13% increase in demand that would be induced due to lower delivered coal prices to Hong Kong, Japan, South Korea, and Taiwan. Table 77 shows the Proposed Action coal consumption values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 77. 2015 Energy Policy Scenario Coal Consumption—Proposed Action (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	108	121	143	126
Australia	158	168	176	193	212	253	223
China	3,260	3,331	3,400	3,536	3,623	3,581	3,583
Hong Kong	14	14	14	15	15	16	15
India	686	719	745	801	859	982	891
Indonesia	165	181	195	228	264	357	290
Japan	124	125	132	130	126	115	123
South Korea	83	81	86	78	72	71	73
Taiwan	63	65	68	73	74	76	75
Total Pacific Basin Coal Consumption	4,627	4,766	4,910	5,162	5,367	5,592	5,398
Total U.S. Coal Consumption	775	753	606	607	601	631	614

Table 78 shows the estimated change in coal consumption between the Proposed Action and the No-Action Alternative by model run year. Assuming the terminal is online and exporting coal, total Pacific Basin coal consumption would be higher with an average of 0.6 million metric tons between 2025 and 2040, while U.S. coal consumption would be slightly down at an average of 0.3 million metric tons per year over the 2025 to 2040 period under the Proposed Action. However, Pacific Basin coal consumption, on a tonnage basis, would only be higher in 2025, because in 2030 and 2040 there is a shift in the mix of coal being consumed to higher heat content coal.

Table 78. 2015 Energy Policy Scenario Change in Coal Consumption—Proposed Action minus No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia – Other	0	0	0	0	-4.8	0	-1.6
Australia	0	0	0	0	0	0	0
China	0	0	0	7.7	0	0	2.1
Hong Kong	0	0	0	0	0	0	0
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	0.8	1.1	-1.6	-0.03
South Korea	0	0	0	0.1	0.1	-0.1	0.01
Taiwan	0	0	0	0.1	0.1	0.1	0.1
Total Pacific Basin Coal Consumption	0	0	0	8.7	-3.6	-1.6	0.6
Total U.S. Coal Consumption	-1.2	-1.1	-1.0	-0.6	0.0	-0.3	-0.3

In the Pacific Basin, coal consumption would be higher on average by 0.6 million metric tons per year between 2025 and 2040. The changes in consumption would be primarily due to changes in the mix of coal consumed and the differences in heat content of the coal being consumed, as the amount of induced demand is only about 0.45 million metric tons. Under the Proposed Action, a larger quantity of lower heat content coal would be being consumed than under the No-Action Alternative in 2025. This makes it appear that total coal consumption would increase in 2025, and then decrease in 2030 and 2040.

6.5.3 Coal Distribution

In the 2015 Energy Policy Scenario, as with the Past Conditions (2014) Scenario, distribution patterns for Powder River Basin and Uinta Basin coal are expected to remain largely unchanged under the Proposed Action. Thus, this section focuses on the distribution of coal in the Pacific Basin and how that distribution would be expected to change with the construction of the terminal. Under the No-Action Alternative, no coal would be exported through the terminal; however, there would be 461 million metric tons of coal distributed in the Pacific Basin by ship in the seaborne coal market in 2016. Table 79 shows the tons of coal that would be imported by each country in the Pacific Basin under the No-Action Alternative. By 2040, 730 million metric tons of coal are estimated to be distributed in the seaborne coal market in the Pacific Basin.

Table 79. 2015 Energy Policy Scenario Seaborne Coal Imports in Pacific Basin—No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	108	126	143	127
Australia	0	0	0	0	0	0	0
China	106	227	227	227	272	318	277
Hong Kong	14	14	14	15	15	16	15
India	38	11	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	124	125	132	129	125	116	123
South Korea	42	39	42	61	65	63	63
Taiwan	63	65	68	73	74	75	74
Total Pacific Basin Coal sent via ship	461	563	576	612	677	730	680

To understand how coal distribution is changing in more detail than the tons of coal imported by each country, the tons of coal shipped to each country were multiplied by the distance in nautical miles that the coal is shipped. The change in tons imported might not change significantly; however, where the coal is sourced might change, which might have a significant impact on the emissions associated with shipping. Table 80 shows the ton-nautical miles for coal shipped to each country for the No-Action Alternative.

Table 80. 2015 Energy Policy Scenario Distance Weighted Seaborne Coal Imports in Pacific Basin—No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	4,798	32,290	106,870	178,116	289,700	178,803	215,578
Australia	0	0	0	0	0	0	0
China	179,881	386,461	386,461	386,461	463,753	541,045	472,341
Hong Kong	27,007	27,278	27,552	28,247	28,961	30,140	29,221
India	117,868	32,724	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	323,825	338,842	355,221	347,855	316,547	437,700	372,359
South Korea	111,406	102,324	108,897	160,162	170,306	170,514	167,569
Taiwan	93,465	158,886	102,169	192,467	194,885	246,318	214,215
Total Pacific Basin Coal sent via ship	858,252	1,078,804	1,087,169	1,293,308	1,464,151	1,604,519	1,471,282

Under the Proposed Action, coal would be exported through the terminal to destinations in the Pacific Basin. Table 81 shows that the coal exported from the terminal would be distributed by the model to Japan, because this is the closest destination, and thus, allows for the greatest reduction in system costs when the model calculates a solution.

Table 81. 2015 Energy Policy Scenario Distribution of Coal Exported through the Proposed Coal Export Terminal—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040
China	0	0	0	0	0	0
Hong Kong	0	0	0	0	0	0
Japan	0	0	0	44.0	44.0	44.0
South Korea	0	0	0	0	0	0
Taiwan	0	0	0	0	0	0
Total Pacific Basin Coal sent via ship through the Terminal	0	0	0	44.0	44.0	44.0

Under the Proposed Action, a similar number of tons would be distributed in the seaborne coal market as it would under the No-Action Alternative (Table 82). The distance weighted coal distribution in the Pacific Basin is presented in Table 83 for the Proposed Action.

Table 82. 2015 Energy Policy Scenario Seaborne Coal Imports in Pacific Basin—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	75	82	94	108	121	143	126
Australia	0	0	0	0	0	0	0
China	106	227	227	227	272	318	277
Hong Kong	14	14	14	15	15	16	15
India	38	11	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	124	125	132	130	126	115	123
South Korea	42	39	42	61	65	63	63
Taiwan	63	65	68	73	74	76	75
Total Pacific Basin Coal sent via ship	461	563	576	613	673	729	678

Table 83. 2015 Energy Policy Scenario Distance Weighted Seaborne Coal Imports in Pacific Basin—Proposed Action (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Avg.
Asia - Other	4,798	32,290	106,870	178,116	213,186	178,803	190,073
Australia	0	0	0	0	0	0	0
China	179,881	386,461	386,461	386,461	463,753	541,045	472,341
Hong Kong	27,007	27,278	27,552	28,282	28,995	30,174	29,256
India	117,868	32,724	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	323,825	338,842	355,221	408,241	398,770	457,402	424,202
South Korea	111,406	102,324	108,897	160,393	170,537	163,982	165,170
Taiwan	93,465	158,886	102,169	192,592	195,010	246,693	214,437
Total Pacific Basin Coal sent via ship	858,252	1,078,804	1,087,169	1,354,085	1,470,251	1,618,100	1,495,480

As seen in Table 84, which shows the estimated change in tons of coal imported by each of the regions, the changes in coal imports between the No-Action Alternative and the Proposed Action would mirror the changes in consumption, except for China. The change in consumption in China would be due to changes in the mix of coal; however, the same total tons of coal would be imported into China and the change in the tons consumed would be met with coal supplies from within China.

Table 84. 2015 Energy Policy Scenario Change in Seaborne Coal Imports in Pacific Basin—Proposed Action minus No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia – Other	0	0	0	0	-4.8	0	-1.6
Australia	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0
Hong Kong	0	0	0	0	0	0	0
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	0.8	1.1	-1.6	-0.03
South Korea	0	0	0	0.1	0.1	-0.1	0.01
Taiwan	0	0	0	0.1	0.1	0.1	0.1
Total Pacific Basin Coal sent via ship	0	0	0	1.0	-3.6	-1.6	-1.5

The changes in the total tons of coal imported to each region would be magnified or diminished depending on how the sources of the coal shift. There would be some relatively large changes in the ton-mile values, as shown in Table 85. For example, in Japan in 2030, coal imports would increase by 0.9% while the ton-miles would increase by 26.0%

Table 85. 2015 Energy Policy Scenario Change in Distance Weighted Seaborne Coal Imports in Pacific Basin—Proposed Action minus No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	Annual Average
Asia - Other	0	0	0	0	-76,513	0	-25,504
Australia	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0
Hong Kong	0	0	0	35	35	35	35
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	60,386	82,223	19,702	51,843
South Korea	0	0	0	231	231	-6,532	-2,399
Taiwan	0	0	0	125	125	376	223
Total Pacific Basin Coal sent via ship	0	0	0	60,777	6,101	13,581	24,198

6.5.4 CO_2 Emissions

This section presents the CO_2 estimated emissions from coal combusted in the United States and the Pacific Basin in the 2015 Energy Policy Scenario. In addition, CO_2 emissions from natural gas consumption in the United States are included because decreases in coal consumption may be offset by increases in natural gas consumption.

Table 86 presents the CO_2 emissions under the No-Action Alternative. Total U.S. CO_2 emissions from coal would decline gradually through 2030, before increasing slightly in 2040, and would average 1,138 million metric tons per year between 2025 and 2040. Coal emissions would increase post 2030, as greater renewable energy resource implementation in 2040 would allow for more coal consumption without exceeding the Clean Power Plan emissions rate limits, which remain flat after 2030. This increase in coal consumption post 2030, was identified in EPA's own modeling of the Clean Power Plan in its Rate Based case results. Pacific Basin CO_2 emissions would average 10,056 million metric tons per year between 2025 and 2040, which would be 8.8 times the total coal CO_2 emissions from the U.S. Natural gas CO_2 emissions average 591 million metric tons per year, or about one-half of coal CO_2 emissions. Between 2030 and 2040, CO_2 emissions from natural gas would increase by 172 million metric tons. This increase would be due to nuclear units retiring in this period and natural gas-fired generation replacing the retired nuclear generation.

Table 87 presents the CO_2 emission sunder the Proposed Action. Total CO_2 emissions under the Proposed Action would follow the same trends as under the No-Action Alternative, and would be within 0.5% of the coal CO_2 emissions under the No-Action Alternative.

Table 86. 2015 Energy Policy Scenario CO_2 Emissions—No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	195,403	218,834	273,997	233,778
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	6,562,991	6,735,018	6,906,016	7,035,199	7,139,055	6,848,958	6,997,391
Hong Kong	32,192	32,514	32,840	33,670	34,520	35,925	34,830
India	1,134,742	1,161,652	1,189,727	1,264,655	1,340,727	1,475,993	1,372,199
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	303,669	303,749	303,901	297,112	288,383	256,423	278,379
South Korea	191,810	186,871	183,147	170,235	160,070	155,197	160,999
Taiwan	155,281	156,058	158,029	159,136	161,135	166,121	162,519
Pacific Basin - Coal	9,050,038	9,302,578	9,551,496	9,837,301	10,110,439	10,165,947	10,056,154
U.S. - Coal	1,500,666	1,455,861	1,142,218	1,134,297	1,113,549	1,161,957	1,138,138
U.S. - Natural Gas	464,255	466,711	548,527	524,814	523,079	695,232	590,509

Table 87. 2015 Energy Policy Scenario CO_2 Emissions—Proposed Action (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	195,403	219,837	273,997	234,112
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	6,562,991	6,735,018	6,906,016	7,036,660	7,139,055	6,848,958	6,997,797
Hong Kong	32,192	32,514	32,840	33,714	34,564	35,969	34,875
India	1,134,742	1,161,652	1,189,727	1,264,655	1,340,727	1,475,993	1,372,199
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	303,669	303,749	303,901	297,493	288,764	255,937	278,423
South Korea	191,810	186,871	183,147	170,455	160,289	155,417	161,218
Taiwan	155,281	156,058	158,029	159,344	161,343	166,329	162,727
Pacific Basin - Coal	9,050,038	9,302,578	9,551,496	9,839,616	10,112,295	10,165,933	10,057,410
U.S. - Coal	1,498,671	1,453,918	1,141,076	1,133,145	1,113,873	1,162,272	1,138,048
U.S.- Natural Gas	464,842	467,245	549,124	525,365	522,996	695,057	590,567

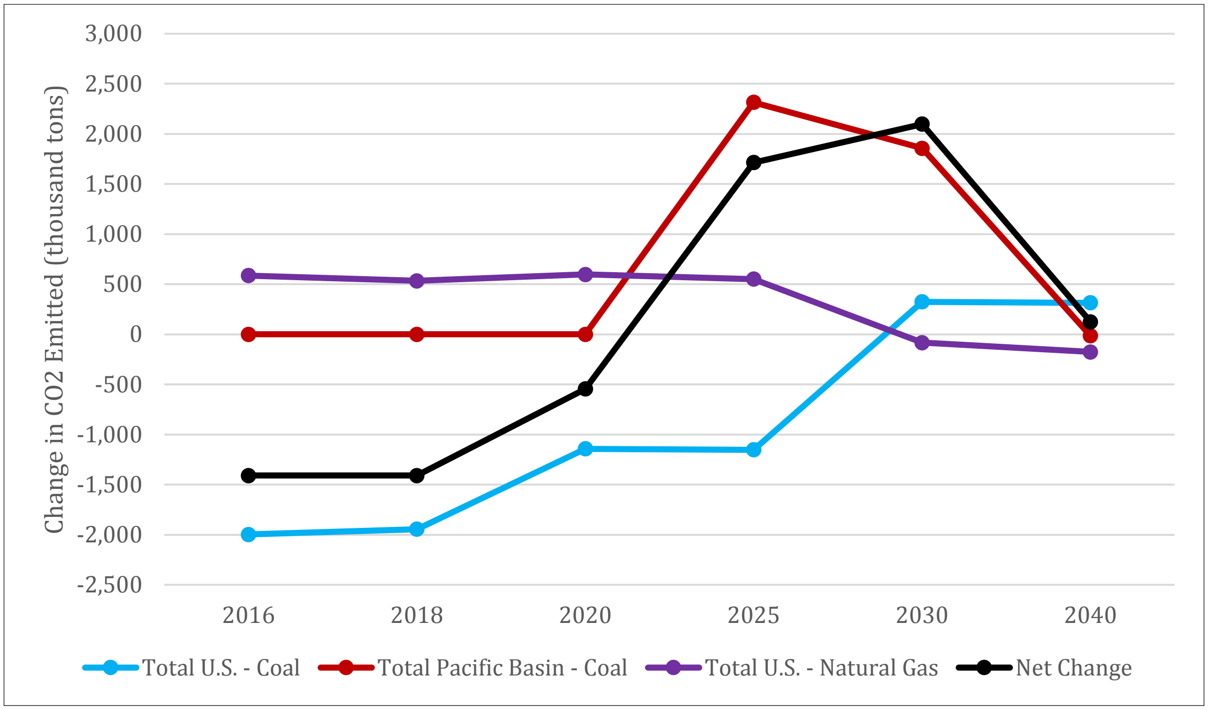
Table 88 shows the estimated change in CO_2 emissions for each region, as well as the total net change across all regions. Total Pacific Basin CO_2 emissions from coal consumption would range from a decrease of 14 thousand metric tons to an increase of 2,315 thousand metric tons starting in 2025, due to shifts in the type of coal consumed, where the different coal types have different CO_2 emissions rates, and the induced demand of about 0.45 million metric tons of coal. In contrast, U.S. coal CO_2 emissions would decrease in every year, except for 2030 and 2040. In these years, the higher penetration of renewable energy resources would make room for more coal consumption, while still meeting the emissions rate targets under the Clean Power Plan. The decrease in coal consumption through 2025 would be offset by an increase in natural gas consumption, as is seen by the increase in CO_2 emissions from natural gas, which would average 57 thousand metric tons per year between 2025 and 2040. The total net change in CO_2 emissions would be an increase of an average of 1,224 thousand metric tons per year between 2025 and 2040.

Table 88. 2015 Energy Policy Scenario Changes in CO_2 Emissions—Proposed Action minus No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	0	0	0	0	1,003	0	334
Australia	0	0	0	0	0	0	0
China	0	0	0	1,461	0	0	406
Hong Kong	0	0	0	45	45	45	45
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	381	381	-486	44
South Korea	0	0	0	219	219	219	219
Taiwan	0	0	0	208	208	208	208
Pacific Basin - Coal	0	0	0	2,315	1,857	-14	1,256
U.S. - Coal	-1,996	-1,943	-1,141	-1,152	324	315	-89
U.S. - Natural Gas	587	534	597	551	-83	-175	57
Total Change	-1,409	-1,409	-544	1,714	2,098	126	1,224

In the 2015 Energy Policy Scenario the change in coal combustion emissions between the No-Action Alternative and the Proposed Action in the Pacific Basin would decline between 2025 and 2040. The changes in Pacific Basin CO_2 emissions would be due to changes in the mix of coal consumed and the differing CO_2 emissions rates of the different coal types. Emissions of CO_2 from coal combustion in the United States would decline through 2030, and then increase slightly as greater renewable energy resource implementation in 2030 would allow for more coal consumption without exceeding the Clean Power Plan emissions rate limits. This increase in coal consumption post 2030 was identified in EPA's own modeling of the Clean Power Plan in its Rate Based case results. The change in U.S. CO_2 emissions from natural gas are estimated to remain relatively flat over the 2016 to 2025 period and then decline as coal consumption increases. Figure 33 shows the net change in CO_2 emissions between the No-Action Alternative and Proposed Action. In the long term, the increase in Pacific Basin coal emissions would drive the net change to be a net increase in CO_2 emissions under the Proposed Action.

Figure 33. 2015 Energy Policy Scenario Changes in CO_2 Emissions by Region—Proposed Action minus No-Action Alternative



[a] Total U.S. CO_2 emissions from the combustion of coal decrease through 2025 because the proposed coal export terminal would be a new demand sink for U.S. coal, and thus, would cause coal prices to rise and U.S. coal consumption to decrease in response to the higher prices. In 2030 and 2040, U.S. coal combustion emissions of CO_2 would increase as greater renewable energy generation would allow for increased coal consumption without exceeding the emissions rates under the Clean Power Plan.

[b] Pacific Basin CO_2 emissions from the combustion of coal would increase due to a larger quantity of lower heat content coal being consumed and due to induced demand from the lower delivered coal prices when the terminal comes online in 2025.

[c] Total U.S. natural gas combustion CO2 emissions would increase and then decrease in response to the changes in coal consumption.

6.6 Cumulative Scenario

The Cumulative Scenario is the same as the Past Conditions (2014) Scenario, except that all of the proposed export terminals in the Pacific Northwest would be constructed and online by 2030, and operating at full capacity. This section presents the modeling results for the Cumulative Scenario No-Action Alternative and Proposed Action for coal production, consumption, distribution, and CO_2 emissions. Note that the Cumulative Scenario No-Action Alternative is the same as the Past Conditions (2014) Scenario No-Action Alternative.

6.6.1 Coal Production

Under the No-Action Alternative U.S. thermal coal production would average 791 million metric tons per year for the 2025 to 2040 period. Over the 2016 to 2040 period, non-U.S. coal production would grow at an average annual rate of 1.57% per year from 6.4 to 9.4 billion metric tons. Powder River Basin coal production under the No-Action Alternative would average 337 million metric tons per year over 2016 to 2040, with production remaining relatively flat. Uinta Basin coal production under the No-Action Alternative would average 15.6 million metric tons per year, with production gradually declining over the 2016 to 2040 period.

Table 89 shows the No-Action Alternative coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 89. Cumulative Scenario Coal Production—No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,448	6,786	7,048	7,805	8,463	9,373	8,634
Total U.S. Thermal Coal	799	838	785	797	788	789	791
Powder River Basin Coal	334	366	329	336	331	344	337
Uinta Basin Coal	18.8	18.4	17.1	16.5	16.3	14.3	15.6

Under the Proposed Action, U.S. thermal coal production would average 859 million metric tons per year for the 2025 to 2040 period. U.S. coal production would have an upward trend as production increases to meet the increased exports. Non-U.S. coal production would have a slightly lower annual growth rate of 1.54% under the Proposed Action than the No-Action Alternative, because some of the exported coal displaces some international coal production. Powder River Basin coal production under the Proposed Action would average 390 million metric tons per year with production generally increasing over time. Uinta Basin coal production would average 19.0 million metric tons per year, with production declining through 2025 and then increasing as Uinta Basin coal is exported in larger quantities. Table 90 shows the Proposed Action coal production values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 90. Cumulative Scenario Coal Production—Proposed Action (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	6,449	6,786	7,047	7,769	8,415	9,303	8,581
Total U.S. Thermal Coal	790	828	773	830	872	870	859
Powder River Basin Coal	319	351	311	361	407	396	390
Uinta Basin Coal	18.2	17.5	14.9	12.9	14.2	27.4	19.0

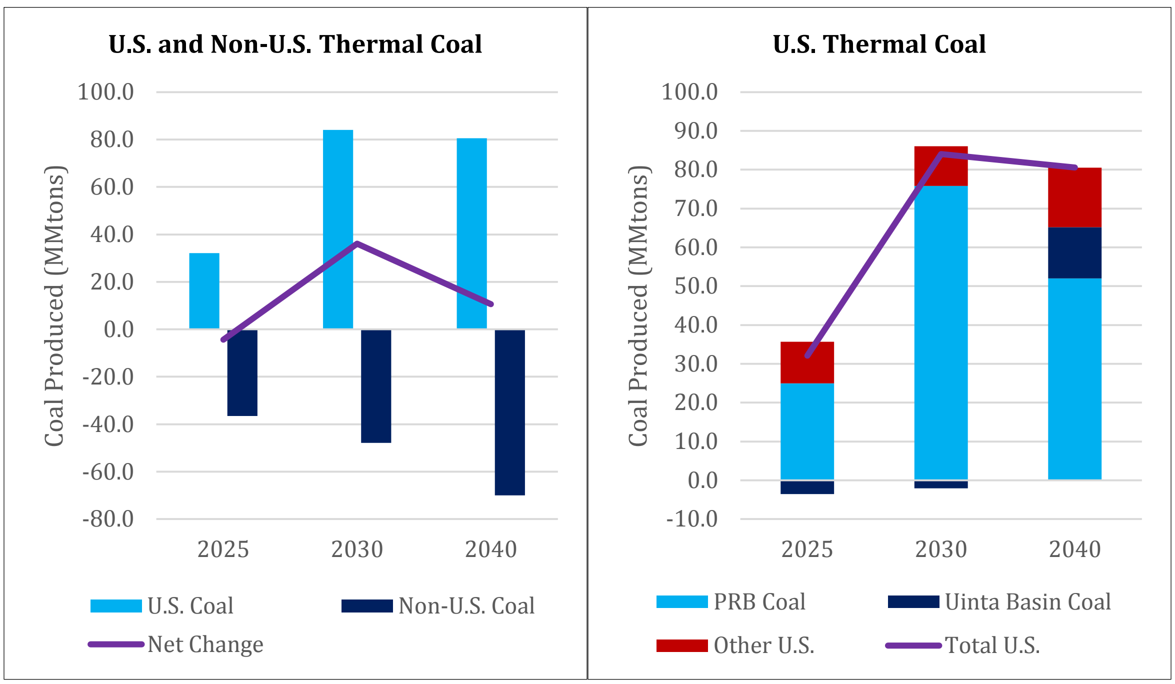
Table 91 shows the estimated change in coal production between the Proposed Action and the No-Action Alternative by model run year. Since IPM® is forward–looking and solves all years simultaneously, the model shows that there would be changes to production under the Proposed Action before the terminal is modeled to come online in 2025. The changes in coal production prior to 2025 reflect the model optimizing the overall solution based on what it calculates will be happening in the future. Once the terminal is online and exporting coal, total average modeled U.S. coal production would be higher under the Proposed Action by 68.2 million metric tons per year, primarily due to increases in Powder River Basin and the Uinta Basin coal production.

Table 91. Cumulative Scenario Change in Coal Production—Proposed Action minus No-Action Alternative (million metric tons)

Producing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Total Non-U.S. Thermal Coal	0.1	0.0	-0.6	-36.5	-47.9	-69.9	-53.3
Total U.S. Thermal Coal	-8.7	-10.3	-11.7	32.1	84.0	80.6	68.2
Powder River Basin Coal	-15.2	-15.1	-17.7	25.0	75.8	52.0	52.4
Uinta Basin Coal	-0.7	-0.9	-2.2	-3.6	-2.0	13.1	3.4

Figure 34 shows that total non-U.S. thermal coal production would decrease as U.S. coal production increases under the Proposed Action. This indicates that U.S. thermal coal exports would take the place of some internationally produced coal, instead of just adding to overall global coal demand.

Figure 34. Cumulative Scenario Change in Coal Production—Proposed Action minus No-Action Alternative



6.6.2 Coal Consumption

Under the No-Action Alternative U.S. thermal coal consumption would average 785 million metric tons per year for the 2025 to 2040 period. U.S. coal consumption would be fairly flat between 2020 and 2040, as electric demand growth would be primarily met with natural gas and renewable generation. Over the 2016 to 2040 period, Pacific Basin coal consumption would grow at an average rate of 1.89% per year from 4.95 to 7.77 billion metric tons. The growth in consumption would be driven primarily by increasing coal consumption in China and India. Table 92 shows the No-Action Alternative coal consumption values for each model run year.

China is responsible for the largest share of global thermal coal consumption, burning 3,550 million metric tons of coal in 2016. This amount is projected to grow in the Cumulative Scenario No-Action

Alternative to 5,431 million metric tons by 2040. Total U.S. coal consumption would remain relatively stable, hovering in the high 700 to low 800 million metric tons.

Table 92. Cumulative Scenario Coal Consumption—No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia – Other	75	82	94	104	119	165	133
Australia	158	168	176	193	212	253	223
China	3,550	3,802	3,975	4,548	5,013	5,431	5,047
Hong Kong	14	14	14	15	15	17	16
India	691	732	783	900	1,010	1,249	1,072
Indonesia	165	181	195	228	264	357	290
Japan	139	133	132	131	128	128	129
South Korea	90	88	87	83	74	82	80
Taiwan	68	72	69	71	81	85	79
Total Pacific Basin Coal Consumption	4,950	5,272	5,526	6,273	6,916	7,767	7,068
Total U.S. Coal Consumption	792	826	772	787	777	790	785

Coal consumption under the Proposed Action would follow similar patterns as the No-Action Alternative, although the U.S. thermal coal consumption, averaging 768 million metric tons per year for the 2025 to 2040 period, would average 17 million metric tons less due to lower demand in the U.S. Coal demand in the U.S. would be lower under the Proposed Action Alternative due to Powder River Basin coal prices that are on average 16.6% higher due to the greater export demand for this coal. As under the No-Action Alternative, U.S. coal consumption would be fairly flat between 2020 and 2040, as electric demand growth would be primarily met with natural gas and renewable generation.

Over the 2016 to 2040 period, Pacific Basin coal consumption would follow the same pattern as it grows from 4.95 to 7.80 billion metric tons. However, under the Proposed Action there would be a 0.44% increase in demand in 2025 and a 3.8% increase in demand in 2030 that would be induced due to lower delivered coal prices from the terminal and the other proposed terminals that are modeled to come online in 2030.

Table 93 shows the Proposed Action coal consumption values for each model run year. The average values in the last column of the table were derived by weighting the modeled values based on the number of calendar years mapped to each model run year.

Table 93. Cumulative Scenario Coal Consumption—Proposed Action (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia – Other	75	82	94	104	116	160	130
Australia	158	168	176	193	212	253	223
China	3,550	3,802	3,975	4,553	5,018	5,431	5,050
Hong Kong	14	14	14	15	15	16	15
India	691	732	783	900	1,058	1,297	1,107
Indonesia	165	181	195	228	264	357	290
Japan	139	133	132	132	131	128	130
South Korea	90	88	87	83	77	79	80
Taiwan	68	72	69	71	76	82	77
Total Pacific Basin Coal Consumption	4,950	5,272	5,526	6,280	6,968	7,804	7,102
Total U.S. Coal Consumption	784	815	759	775	762	770	768

Table 94 shows the estimated change in coal consumption between the Proposed Action and the No-Action Alternative by model run year to be zero, or near zero, in the Pacific Basin before 2025 when the terminal was assumed to come online. Once the terminal is online and exporting coal, total Pacific Basin coal consumption would be higher with an average change of 34.1 million metric tons per year between 2025 and 2040, while U.S. coal consumption would decrease by an average of 16.3 million metric tons per year under the Proposed Action. The increase in Pacific Basin demand is due to the induced demand from the lower-priced coal being exported through the terminal.

In the Pacific Basin, coal consumption would be higher on average by 34.1 million metric tons per year between 2025 and 2040, with China and India having the largest increases. India's consumption would increase because of induced demand from the lower coal prices when the other proposed terminals come online in 2030. The changes in Chinese consumption would be due to changes in the mix of coal consumed and the differences in heat content of the coal being consumed. Under the Proposed Action, a larger quantity of lower heat content coal would be consumed than under the No-Action Alternative, making it appear that total coal consumption would increase, while the total heating value of the China coal demand does not change between the alternatives.

Table 94. Cumulative Scenario Change in Coal Consumption—Proposed Action minus No-Action Alternative (million metric tons)

Consuming Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia – Other	0	0	0	0	-2.2	-4.3	-2.4
Australia	0	0	0	0	0	0	0
China	0	0	0.3	5.3	4.7	0	3.0
Hong Kong	0	0	0	0.1	0.1	-0.9	-0.3
India	0	0	0	0	48.2	48.2	34.8
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	1.3	3.3	0.2	1.5
South Korea	0	0	0	0.5	2.9	-3.2	-0.1
Taiwan	0	0	0	0.3	-4.2	-2.9	-2.4
Total Pacific Basin Coal Consumption	0	0	0.3	7.4	52.8	37.2	34.1
Total U.S. Coal Consumption	-8.7	-10.3	-12.7	-11.8	-15.8	-19.8	-16.3

6.6.3 Coal Distribution

As with the Past Conditions (2014) Scenario, distribution patterns for Powder River Basin and Uinta Basin coal are expected to remain largely unchanged under the Proposed Action in the Cumulative Scenario. Thus, this section focuses on the distribution of coal in the Pacific Basin and how that distribution would be expected to change with the construction of the terminal. Under the No-Action Alternative, there would be no coal exported through the terminal; however, there would be 615 million metric tons of coal distributed in the Pacific Basin by ship in the seaborne coal market in 2016. Table 95 shows the tons of coal that would be imported by each country in the Pacific Basin under the No-Action Alternative. By 2040, a total of 1,194 million metric tons of coal are expected to be distributed in the seaborne coal market in the Pacific Basin.

Table 95. Cumulative Scenario Seaborne Coal Distribution in Pacific Basin—No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	104	119	165	133
Australia	0	0	0	0	0	0	0
China	227	227	227	318	318	726	476
Hong Kong	14	14	14	15	15	17	16
India	44	24	12	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	139	133	132	131	128	128	129
South Korea	49	46	43	66	67	74	69
Taiwan	68	72	69	71	81	85	79
Total Pacific Basin Coal sent via ship	615	598	591	704	726	1,194	902

To understand how coal distribution is changing in more detail than the tons of coal imported by each country, ICF multiplied the tons of coal shipped to each country by the distance in nautical miles that the coal is shipped. The change in tons imported might not change significantly; however, where the coal is sourced might change, which might have a significant impact on the emissions associated with shipping. Table 96 shows the ton-nautical miles for coal shipped to each country for the No-Action Alternative.

Table 96. Cumulative Scenario Distance Weighted Seaborne Coal Distribution in Pacific Basin—No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	4,798	32,290	106,870	123,074	176,042	532,288	299,869
Australia	0	0	0	0	0	0	0
China	386,461	386,461	386,461	541,045	541,045	1,236,674	811,567
Hong Kong	27,007	27,278	27,552	28,247	28,961	65,231	42,868
India	135,789	73,478	38,193	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	535,267	378,469	355,049	352,952	345,299	568,913	434,385
South Korea	128,027	120,235	112,984	173,889	123,473	371,891	234,084
Taiwan	267,987	234,316	103,192	105,797	342,100	359,595	283,264
Total Pacific Basin Coal sent via ship	1,485,335	1,252,527	1,130,299	1,325,005	1,556,918	3,134,591	2,106,037

Under the Proposed Action, coal would be exported through the terminal to destinations in the Pacific Basin. Table 97 shows that the coal exported from the terminal would be distributed by the model to Japan, South Korea, and China.

Table 97. Cumulative Scenario Distribution of Coal Exported through the Proposed Coal Export Terminal—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040
China	0	0	0	0	11.3	0
Hong Kong	0	0	0	0	0	0
Japan	0	0	0	33.6	6.5	19.3
South Korea	0	0	0	10.4	26.2	24.7
Taiwan	0	0	0	0	0	0
Total Pacific Basin Coal sent via ship through MBTL	0	0	0	44.0	44.0	44.0

Under the Proposed Action, a similar number of tons would be distributed in the seaborne coal market as it would under the No-Action Alternative, as seen in Table 98. The distance weighted coal distribution in the Pacific Basin is presented in Table 99 for the Proposed Action.

Table 98. Cumulative Scenario Seaborne Coal Distribution in Pacific Basin—Proposed Action (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	75	82	94	104	116	160	130
Australia	0	0	0	0	0	0	0
China	227	227	227	318	318	726	476
Hong Kong	14	14	14	15	15	16	15
India	44	24	12	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	139	133	132	132	131	128	130
South Korea	49	46	43	67	70	71	69
Taiwan	68	72	69	71	76	82	77
Total Pacific Basin Coal sent via ship	615	598	591	706	726	1,183	898

Table 99. Cumulative Scenario Distance Weighted Seaborne Coal Distribution in Pacific Basin—Proposed Action (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	4,798	32,290	106,870	123,074	140,747	463,478	261,344
Australia	0	0	0	0	0	0	0
China	386,461	386,461	386,461	541,045	582,144	1,236,674	825,267
Hong Kong	27,007	27,278	27,552	28,366	29,176	48,439	36,442
India	135,789	73,478	38,193	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	535,267	378,469	357,047	419,513	419,980	559,682	474,179
South Korea	128,027	120,235	112,984	195,053	232,175	335,929	262,212
Taiwan	267,987	234,316	103,192	106,233	322,604	370,504	281,129
Total Pacific Basin Coal sent via ship	1,485,335	1,252,527	1,132,297	1,413,283	1,726,826	3,014,706	2,140,573

As seen in Table 100, which shows the estimated change in tons of coal imported by each of the regions, the changes in coal imports between the No-Action Alternative and the Proposed Action would mirror the changes in consumption, except for China and India. This indicates that the changes in consumption for China and India would be due to shifts in the coal types consumed or that domestic production in these countries would increase to meet the higher demand.

Table 100. Cumulative Scenario Change in Seaborne Coal Distribution in Pacific Basin—Proposed Action minus No-Action Alternative (million metric tons)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia – Other	0	0	0	0	-2.2	-4.3	-2.4
Australia	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0
Hong Kong	0	0	0	0.1	0.1	-0.9	-0.3
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	1.3	3.3	0.2	1.5
South Korea	0	0	0	0.5	2.9	-3.2	-0.1
Taiwan	0	0	0	0.3	-4.2	-2.9	-2.4
Total Pacific Basin Coal sent via ship	0	0	0	2.1	-0.1	-11.0	-3.7

The changes in the total tons of coal imported to each region would be magnified or diminished depending on how the sources of the coal shift, and there would be some relatively large changes in the ton-mile values, as shown in Table 101. For example, in Japan in 2025, coal imports would increase by 1.0% while the ton-miles would increase by 18.9%.

Table 101. Cumulative Scenario Change in Distance Weighted Seaborne Coal Distribution in Pacific Basin—Proposed Action minus No-Action Alternative (million metric ton-nautical miles)

Importing Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	0	0	0	0	-35,294	-68,810	-38,524
Australia	0	0	0	0	0	0	0
China	0	0	0	0	41,099	0	13,700
Hong Kong	0	0	0	118	215	-16,792	-6,426
India	0	0	0	0	0	0	0
Indonesia	0	0	0	0	0	0	0
Japan	0	0	1,998	66,561	74,681	-9,230	39,793
South Korea	0	0	0	21,164	108,702	-35,962	28,128
Taiwan	0	0	0	435	-19,495	10,909	-2,135
Total Pacific Basin Coal sent via ship	0	0	1,998	88,278	169,908	-119,885	34,536

6.6.4 CO_2 Emissions

This section presents the CO_2 estimated emissions from coal combusted in the United States and the Pacific Basin in the Cumulative Scenario. In addition, CO_2 emissions from natural gas consumption in the United States are included because decreases in coal consumption may be offset by increases in natural gas consumption. Table 118 presents the CO_2 emissions under the No-Action Alternative. Total U.S. CO_2 emissions from coal would be relatively flat and average 1,505 million metric tons per year over 2025 to 2040. Pacific Basin CO_2 emissions would average 13,407 million metric tons per year between 2025 and 2040, which would be 8.9 times the total coal CO_2 emissions from the U.S. Natural gas CO_2 emissions average 470 million metric tons per year, or about one-third of U.S. coal CO_2 emissions. Between 2030 and 2040, CO_2 emissions from natural gas would increase by 184 million metric tons. This increase would be due to nuclear units retiring in this period and natural gas-fired generation replacing the retired nuclear generation.

Table 103 presents the CO_2 emissions under the Proposed Action. Total CO_2 emissions under the Proposed Action for this scenario would follow the same trends as the No-Action Alternative, and would be within 5.1% of the coal CO_2 emissions under the No-Action Alternative. The higher emissions in this scenario are due to the higher induced demand compared to the other scenarios.

Table 102. Cumulative Scenario CO_2 Emissions—No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	196,125	220,325	269,361	232,672
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	7,260,862	7,757,297	8,092,857	9,192,572	10,001,116	10,625,911	10,019,496
Hong Kong	32,192	32,514	32,840	33,670	34,520	36,086	34,893
India	1,136,069	1,182,859	1,257,877	1,430,059	1,592,500	1,923,614	1,676,144
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	305,620	304,862	305,584	301,809	294,803	273,014	288,276
South Korea	193,262	189,802	186,751	182,342	167,305	163,906	170,160
Taiwan	155,582	158,027	159,611	163,642	166,852	175,385	169,279
Pacific Basin - Coal	9,752,941	10,352,077	10,813,357	12,182,110	13,245,137	14,420,611	13,406,980
U.S. - Coal	1,538,695	1,606,196	1,490,678	1,515,506	1,495,512	1,506,365	1,505,286
U.S. - Natural Gas	449,418	417,456	421,240	392,499	400,710	585,198	470,174

Table 103. Cumulative Scenario CO_2 Emissions—Proposed Action (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	147,182	160,511	173,771	196,125	220,787	270,264	233,177
Australia	246,894	267,557	285,312	321,771	361,963	448,680	384,522
China	7,260,862	7,757,297	8,092,909	9,193,571	10,001,957	10,625,911	10,020,054
Hong Kong	32,192	32,514	32,840	33,821	34,795	36,561	35,211
India	1,136,069	1,182,859	1,257,877	1,430,059	1,673,183	2,004,297	1,734,415
Indonesia	275,278	298,648	318,752	360,120	405,754	504,652	431,538
Japan	305,620	304,862	305,584	303,128	298,168	273,798	290,069
South Korea	193,262	189,802	186,751	183,141	169,616	166,198	172,043
Taiwan	155,582	158,027	159,611	164,365	168,770	177,170	170,813
Pacific Basin - Coal	9,752,941	10,352,077	10,813,408	12,186,102	13,334,994	14,507,532	13,471,844
U.S. - Coal	1,525,873	1,590,003	1,469,797	1,493,962	1,464,483	1,468,715	1,474,318
U.S. - Natural Gas	453,457	423,086	427,952	399,133	411,164	595,999	479,702

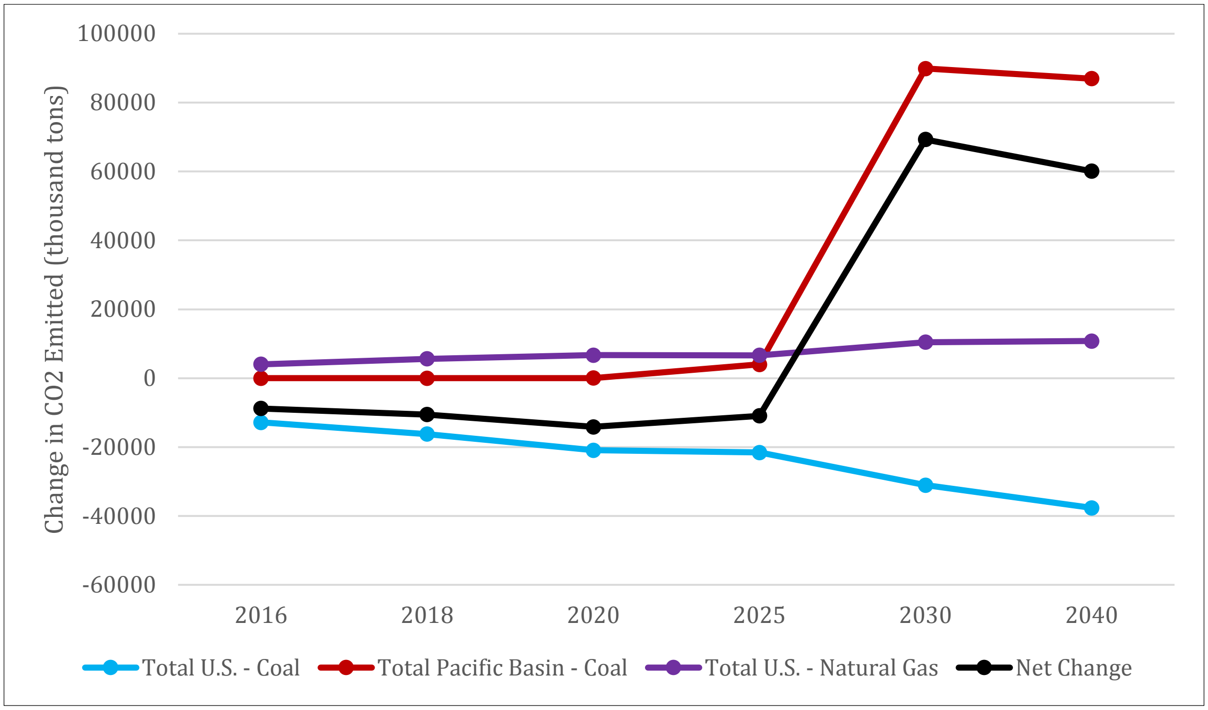
Table 104 shows the estimated change in CO_2 emissions for each region, as well as the total net change across all regions. Total Pacific Basin CO_2 emissions from coal consumption would increase between 3,992 and 89,857 thousand metric tons starting in 2025 due to induced demand from the reduction in delivered coal prices under the Proposed Action, and because of shifts in the type of coal consumed. In contrast, U.S. coal CO_2 emissions would decrease in every year due to higher coal prices that depress domestic coal demand. The higher coal prices result from the fact that an additional 44 million metric tons of coal is mined and exported starting in 2025, and another 56 million metric tons of coal is mined and exported starting in 2030 under the Proposed Action, which shifts the demand curve up and yields higher coal prices in the United States. The decrease in coal consumption is offset by an increase in natural gas consumption, as is seen by the increase in CO_2 emissions from natural gas, which would average 9,528 thousand metric tons per year over 2025 to 2040. The total net change in CO_2 emissions would be an increaseof an average of 43,423 thousand metric tons per year over 2025 to 2040.

Table 104. Cumulative Scenario Changes in CO_2 Emissions—Proposed Action minus No-Action Alternative (thousand metric tons)

Region	2016	2018	2020	2025	2030	2040	2025–2040 Average
Asia - Other	0	0	0	0	463	902	505
Australia	0	0	0	0	0	0	0
China	0	0	51	1,000	841	0	558
Hong Kong	0	0	0	151	276	475	319
India	0	0	0	0	80,683	80,683	58,271
Indonesia	0	0	0	0	0	0	0
Japan	0	0	0	1,318	3,366	784	1,793
South Korea	0	0	0	799	2,311	2,292	1,883
Taiwan	0	0	0	724	1,918	1,785	1,535
Pacific Basin - Coal	0	0	51	3,992	89,857	86,921	64,864
U.S. - Coal	-12,822	-16,193	-20,880	-21,543	-31,028	-37,651	-30,969
U.S. - Natural Gas	4,039	5,630	6,712	6,634	10,454	10,801	9,528
Net Change	-8,783	-10,563	-14,117	-10,918	69,283	60,072	43,423

In the Cumulative Scenario, the change in coal combustion emissions between the No-Action Alternative and the Proposed Action in the Pacific Basin would grow over time, while the change in U.S. emissions would generally decline. U.S. CO_2 emissions from natural gas are estimated to increase over the 2016 to 2040 period. Figure 35 shows the net change in CO_2 emissions between the No-Action Alternative and Proposed Action. In the long term, the increase in Pacific Basin coal emissions would drive the net change to be a net increase in CO_2 emissions under the Proposed Action.

Figure 35. Cumulative Scenario Changes in CO_2 Emissions by Region—Proposed Action minus No-Action Alternative



[a] Total U.S. CO_2 emissions from the combustion of coal would decrease because the proposed coal export terminal would be a new demand sink for U.S. coal, and thus, would cause coal prices to rise and U.S. coal consumption to decrease in response to the higher prices.

[b] Pacific Basin CO_2 emissions from the combustion of coal would increase due to a larger quantity of lower heat content coal being consumed and due to induced demand from the lower delivered coal prices when the terminal comes online in 2025.

[c] Total U.S. natural gas combustion CO_2 emissions would increase because when coal consumption for electric generation declines, natural gas usage for electric generation increases to fill the gap.

Chapter 7
Conclusions

This analysis examined the coal production, consumption, distribution, and CO_2 emissions associated with the operation of the terminal under five scenarios. The results of the analysis show that the operation of the terminal would likely cause changes in the production, consumption, and distribution of coal in the United States and the Pacific Basin. These changes would cause a change in CO_2 emissions as well, with the net average annual emissions ranging from a decrease of 2.551 and 2.259 million metric tons CO_2 in the in the Past Conditions (2014) and Lower Bound Scenarios to an increase of 29.792 and 43.423 million metric tons CO_2 in the Upper Bound and Cumulative Scenarios, when averaged over 2025 to 2040.

7.1 Summary of Key Results

The Co-Lead Agencies defined the study area for the coal market analysis as the United States and the Pacific Basin coal markets. Within the United States, results for the CO_2 emissions from the combustion of coal and natural gas are the primary results from this analysis that are used in the GHG analysis report. Additionally, the GHG analysis uses the change in the distribution of coal in the Pacific Basin to estimate the CO_2 emissions from the change in the transportation of coal.

7.1.1 Coal Production

This analysis shows that coal production in the United States would increase in all five scenarios under the Proposed Action as the export of coal through the terminal would cause additional coal to be mined in the United States, beyond that which is produced for domestic consumption under the No-Action Alternative. If production did not increase under each scenario, it would imply either that there is a decrease in the consumption of Powder River Basin and Uinta Basin coal in the United States, or that exports of other coal are decreasing. The results also show that coal production in the Pacific Basin would decrease in all five scenarios, as the exported coal displaces some coal production from Pacific Basin coal producing countries.

The amount of increase in production varies by scenario and by year in each scenario. The Past Conditions (2014) Scenario has the lowest change in U.S. coal production at an average of 27.8 million metric tons, because the coal that was being exported through Canadian coal export terminals under the No-Action Alternative shifts to the terminal under the Proposed Action. Thus, the amount of U.S. coal being exported through Pacific Northwest ports does not increase by the full 44 million metric tons of the proposed coal export terminal's annual capacity. In the Lower Bound Scenario, there are no exports of Powder River Basin or Uinta Basin coal under the No-Action Alternative, thus, when the terminal comes online, U.S. coal production increases by an average of 42.1 million metric tons per year. There is a small decrease in U.S. consumption of these coals, which accounts for the increase not being the full 44 million metric tons.

In the Upper Bound Scenario, international demand for coal is higher than under the Past Conditions (2014) Scenario, and thus, the coal exported through the terminal helps meet that growing demand and results in 39.7 million metric tons of increased U.S. coal production. There are changes in both domestic consumption of coal and exports of non-Powder River Basin coal, which keep the increase in production below the 44 million metric tons of export terminal capacity.

The 2015 Energy Policy Scenario is similar to the Past Conditions (2014) Scenario in that U.S. coal production increases, but not as much as the full terminal capacity, as coal exported from Canadian terminals under the No-Action Alternative is shifted to the terminal under the Proposed Action. Coal production in the United States increases an average 39.2 million metric tons per year under the 2015 Energy Policy Scenario. The increase is higher than under the Past Conditions (2014) Scenario because there is a larger change in production in 2030 and later.

Finally, the Cumulative Scenario has an average annual increase in U.S. coal production of 68.2 million metric tons. In this scenario Powder River Basin coal demand in the United States declines by 28.5 million metric tons in the long term as the higher export demand on Powder River Basin coal increases the prices, which in turn, suppresses domestic demand for Powder River Basin coal.

7.1.2 Coal Consumption

This analysis shows that coal consumption in the United States would decrease in all five scenarios under the Proposed Action as the export of coal through the terminal would cause additional demand for U.S. coal, which causes coal prices to rise. In response to the higher coal prices, U.S. coal plants consume between 0.3 and 16.3 million metric tons per year less coal. If flatter coal supply curves were used in this analysis, then the decrease in U.S. coal consumption would be less. Similarly, if steeper coal supply curves were used in this analysis, then the decrease in U.S. coal consumption would be greater.

The results also show that coal consumption in the Pacific Basin would increase in all scenarios. The exported coal has a lower heat content than the coal that it displaces, and thus, more coal must be consumed to achieve the same electric power output. Another factor causing higher coal consumption in the Pacific Basin is induced demand from lower delivered coal prices in the Past Conditions (2014), Upper Bound, 2015 Energy Policy, and Cumulative Scenarios. In all but the Cumulative Scenario, the amount of induced demand is less than 15.0 million metric tons per year. In fact, in all but the Upper Bound and Cumulative Scenarios, the amount of induced demand is less than 1.5 million metric tons. One of the factors causing greater induced demand in the Upper Bound and Cumulative Scenarios is the change in prices in India caused by a change in exports of coal from India, which is caused by the export of coal from the terminal.

7.1.3 Coal Distribution

Coal distribution in the Pacific Basin changes when the terminal comes online in the model in 2025 because the coal exported through the terminal displaces coal from other sources. Primarily the exported coal displaces coal from Australia, China, and Indonesia. The change in coal distribution under the Proposed Action is less than 4.9 million metric tons in all years and under all scenarios, except for the Upper Bound Scenario. In the Upper Bound Scenario the change in coal distribution is less than 25.2 million metric tons in all years. The average annual change in coal distribution is 2.0 million metric tons across all five scenarios under the Proposed Action.

7.1.4 CO_2 Emissions from Coal Consumption

The CO_2 emissions from the combustion of coal follow the same pattern as the changes in consumption under the Proposed Action. Thus, in the United States, CO_2 emissions from coal would decrease, while CO_2 emissions from the Pacific Basin would increase. The Past Conditions (2014) Scenario would result in an average decrease in U.S. CO_2 emissions from the combustion of coal of 6.9 million metric tons under the Proposed Action. The largest changes would be in the Upper Bound and Cumulative Scenarios, where U.S. CO_2 emissions from the combustion of coal would decrease under the Proposed Action by 10.0 and 16.7 million metric tons, respectively. These two scenarios would have the largest changes in U.S. CO_2 emissions because they would have the largest increase in Powder River Basin coal prices, and thus, the largest response in the decrease of U.S. demand. The scenario with the smallest average decrease in U.S. CO_2 emissions from the combustion of coal would be the 2015 Energy Policy Scenario at 0.1 million metric tons per year. Table 105 shows the CO_2 emissions results by scenario and region of origin.

Table 105. Average Change in CO_2 Emissions by Scenario and Region—Proposed Action minus No-Action Alternative (million metric tons)

Scenario	Pacific Basin Coal	U.S. Coal	U.S. Natural Gas	Total
Past Conditions (2014)	2.554	-6.948	1.843	-2.551
Lower Bound	0.972	-4.041	0.809	-2.259
Upper Bound	37.590	-10.012	2.214	29.792
2015 Energy Policy	1.256	0.089	0.057	1.224
Cumulative	64.864	-30.969	9.528	43.423

The results show that the net change in average CO_2 emissions from the combustion of coal would be a net positive for the Upper Bound 2015 Energy Policy, and Cumulative Scenarios. The other two scenarios have a net decrease in the average CO_2 emissions from the combustion of coal.

This analysis also estimated the change in CO_2 emissions from the combustion of natural gas in the United States for use in electric power generation. When the emissions from the consumption of natural gas are included, the net change in CO_2 emissions under the Proposed Action shift higher, but none of the values change sign.

Chapter 8
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