MILLENNIUM BULK TERMINALS—LONGVIEW SEPA ENVIRONMENTAL IMPACT STATEMENT

SEPA GEOLOGY AND SOILS TECHNICAL REPORT

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Acronyms and Abbreviations

Applicant	Millennium Bulk Terminals—Longview, LLC
BMP	best management practice
BNSF	BNSF Railway Company
CRD	Columbia River Datum
CSZ	Cascadia Subduction Zone
Ecology	Washington State Department of Ecology
g	gravity
LVSW	Longview Switching Company
PGA	peak ground acceleration
Reynolds facility	Reynolds Metals Company facility
UP	United Pacific Railroad
USGS	U.S. Geological Survey

Chapter 1
Introduction

This technical report assesses the potential geology and soil impacts of the proposed Millennium Bulk Terminals—Longview project (Proposed Action) and the No-Action Alternative. For the purposes of this assessment, geology and soils refers to items such as earthquakes and site constraints that may affect project engineering and design. This report describes the regulatory setting, establishes the methods for assessing potential geology and soil impacts, presents the existing geologic and soil conditions in the study area, and assesses the potential for impacts on geology and soils.

1.1 Project Description

Millennium Bulk Terminals—Longview, LLC (Applicant) is proposing to construct and operate a coal export terminal (Proposed Action) 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 shipment. The coal export terminal would receive, stockpile, and load coal onto vessels and transport the coal via the Columbia River and Pacific Ocean to overseas markets in Asia.

1.1.1 Proposed Action

Under the Proposed Action, the Applicant would develop the coal export terminal on 190 acres (project area) primarily within an existing 540-acre site that is currently leased by the Applicant (Applicant's leased area). The project area is adjacent to the Columbia River in unincorporated Cowlitz County, Washington near Longview, Washington (Figure 2). The Applicant currently operates and would continue to operate a bulk product terminal within the Applicant's leased area.

BNSF Railway Company (BNSF) or Union Pacific Railroad (UP) trains would transport coal on BNSF main line routes in Washington State, and the BNSF Spur and Reynolds Lead in Cowlitz County to the project area. Coal would be unloaded from rail cars, stockpiled, and loaded by conveyor onto ocean-going vessels for export at two new docks (Docks 2 and 3) located in the Columbia River.

Once construction is complete, the Proposed Action could have a maximum annual throughput capacity of up to 44 million metric tons of coal per year. The coal export terminal would consist of one operating rail track, eight rail tracks for storing up to eight unit trains, rail car unloading facilities, a stockpile area for coal storage, conveyor and reclaiming facilities, two new docks in the Columbia River (Docks 2 and 3), and shiploading 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), and vessels would access the project area via the Columbia River. The Reynolds Lead and BNSF Spur track—both jointly owned by BNSF and UP and operated by Longview Switching Company (LVSW)—provide rail access to the project area from a point on the BNSF main line (Longview Junction) located to the east in Kelso, Washington. Coal export 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.

At full terminal operations, approximately 8 loaded unit trains each day would carry coal to the export terminal, 8 empty unit trains each day would leave the export terminal, and an average of 70 vessels per month or 840 vessels per year would be loaded, which would equate to 1,680 vessel transits in the Columbia River annually.

Figure 1. Project Vicinity

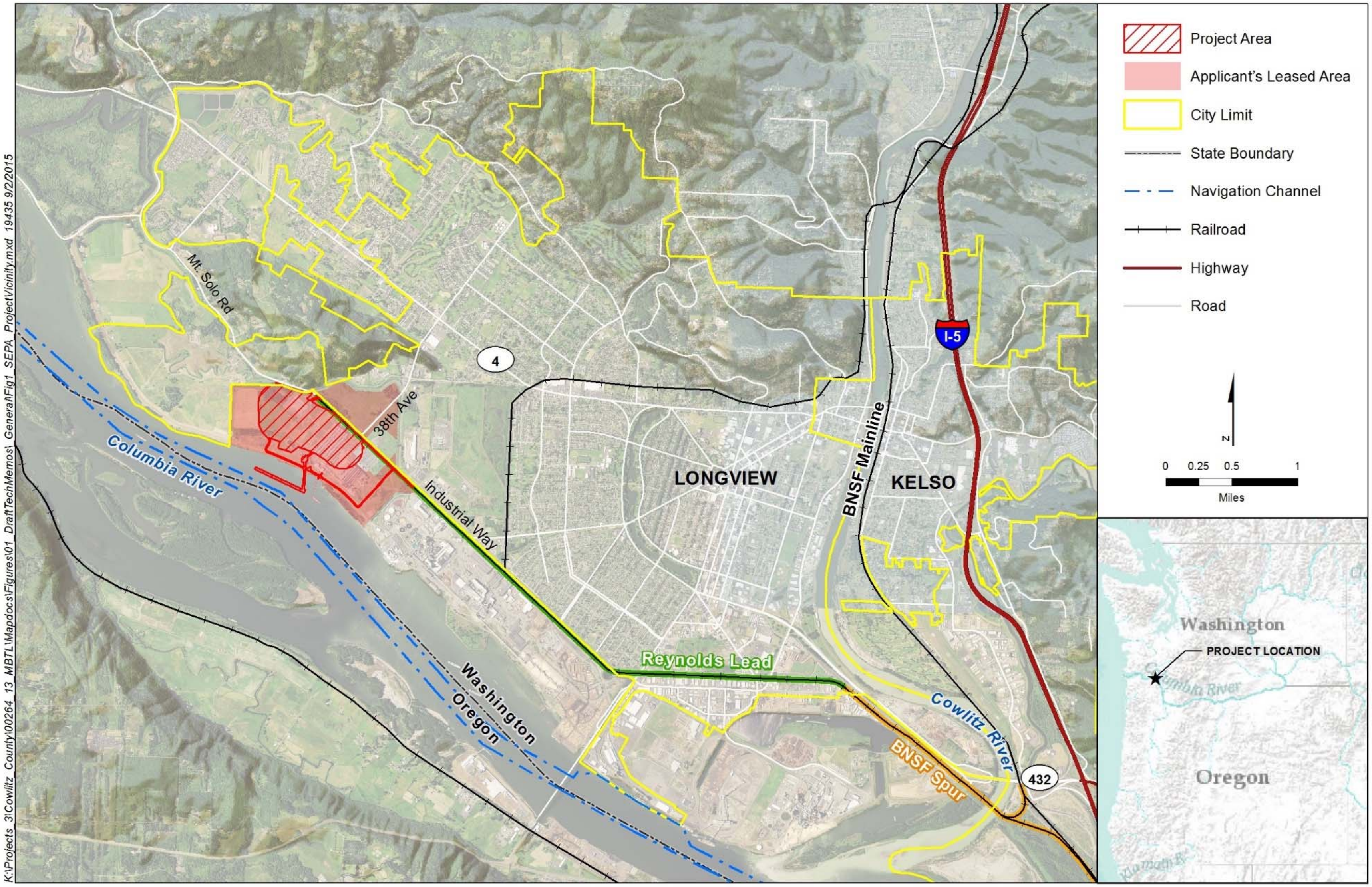
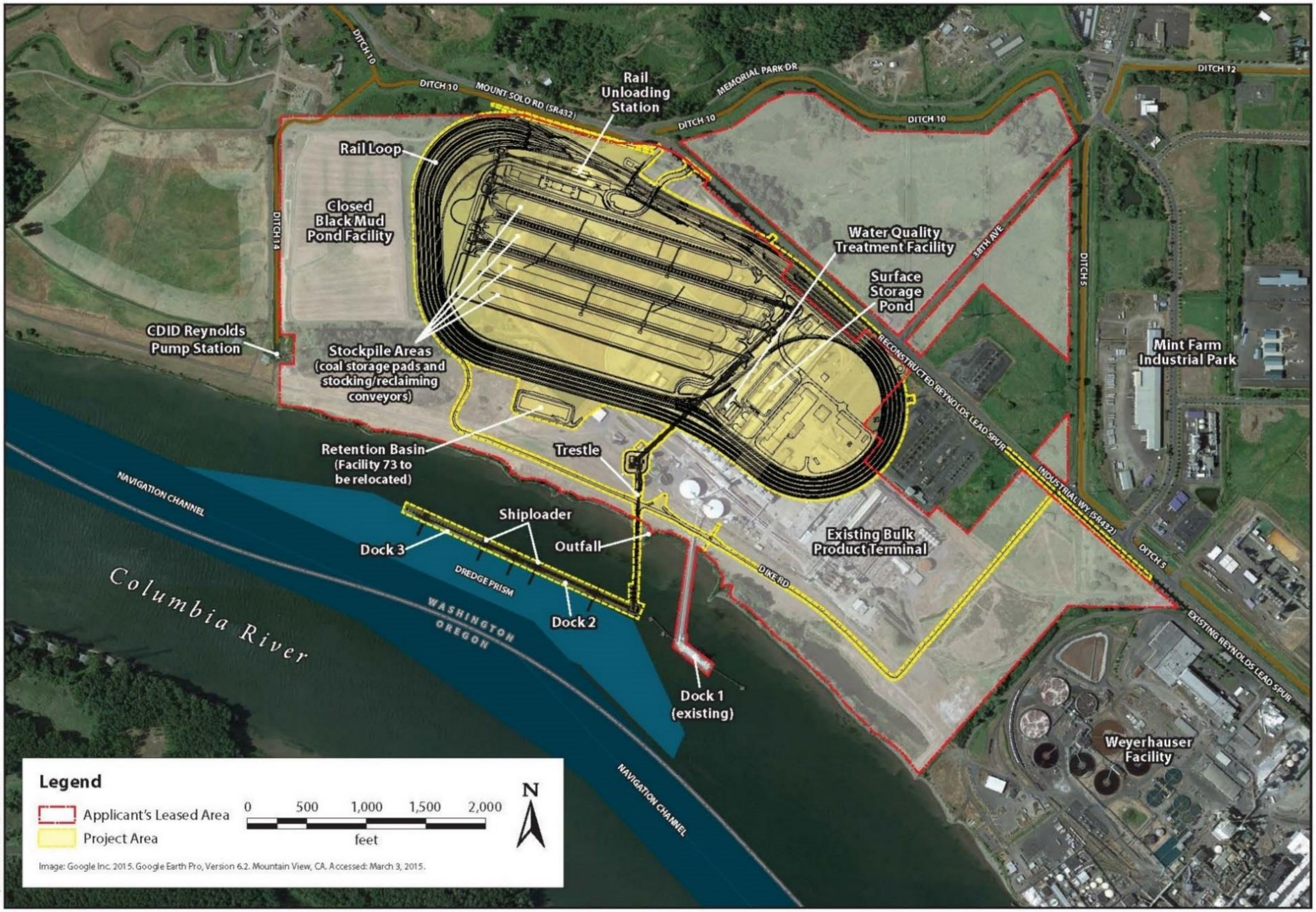


Figure 2. Proposed Action



1.1.2 No-Action Alternative

The Applicant plans to continue operating its existing bulk product terminal located adjacent to the project area. Ongoing operations would include storing and transporting alumina and small quantities of coal, and continued use of Dock 1. Maintenance of the existing bulk product terminal would continue, including maintenance dredging at the existing dock every 2 to 3 years. The Applicant plans to expand operations at the existing bulk product terminal, which could include increased storage and upland transfer of bulk products utilizing new and existing buildings. The Applicant would likely need to undertake demolition, construction, and other related activities to develop expanded bulk product terminal facilities.

If the coal export terminal is not constructed, the Applicant would likely propose expansion of the bulk product terminal onto areas that would have been subject to construction and operation of the proposed coal export terminal. Additional bulk product transfer activities could involve products such as a calcined pet coke, coal tar pitch, cement, fly ash, and sand or gravel. Any new operations would be evaluated under applicable regulations. Upland areas of the project area are zoned Heavy Industrial and it is assumed future proposed industrial uses in these upland areas could be permitted. Any new construction would be limited to uses allowed under existing Cowlitz County development regulations.

1.2 Regulatory Setting

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

Table 1. Regulations, Statutes, and Guidance for Geology and Soils

Regulation, Statute, Guideline	Description
Federal	
National Environmental Policy Act (42 USC 4321 *et seq*.)	Requires the consideration of potential environmental impacts. NEPA implementation procedures are set forth in the President's Council on Environmental Quality's Regulations for Implementing NEPA (49 CFR 1105).
Clean Water Act Section 402 Permit for Stormwater Discharges Associated with Construction Activities	Primarily deals with water quality but includes eroded soil that is potentially delivered offsite via water runoff. Mandates that certain types of construction activity (and operations) comply with the EPA NPDES program. The EPA has delegated Ecology as the authority for the NPDES program in Washington State. Includes development of a stormwater pollution prevention plan.

Regulation, Statute, Guideline	Description
State	
Washington State Environmental Policy Act (RCW 43.21c)	SEPA directs state and local agencies to consider environmental impacts (cumulative, short-term, long-term, direct, and indirect), alternatives, and mitigation before committing to an action. SEPA gives agencies the authority to condition or deny a proposal based on the agency's adopted SEPA policies and environmental impacts identified in a SEPA document (RCW 43.21C.060, WAC 197-11-660).
Local	
Cowlitz County SEPA Regulations	Cowlitz County has adopted and incorporated rules pertaining to the integration of policies and procedures as required under SEPA (RCW 43.21C.120).
Cowlitz County Critical Areas Protection Ordinance (CCC 19.15)	Designates geologically hazardous areas (including seismic, volcanic, erosion, and landslide hazards) and defines performance standards and specific requirements for development within these areas.
Cowlitz County Grading (16.35)	Grading plan requirement and standards including the protection of water quality from adverse impacts of erosion and sedimentation.
Cowlitz County Building Code (16.05)	Cowlitz County has adopted the 2012 International Building and Residential Codes.

Notes: NEPA = National Environmental Policy Act; CFR = Code of Federal Regulations; USC = United States Code; RCW = Revised Code of Washington; SEPA = Washington State Environmental Policy Act; EPA = U.S. Environmental Protection Agency; NPDES = National Pollutant Discharge Elimination System; Ecology = Washington State Department of Ecology; CCC = Cowlitz County Code

1.3 Study Area

The study area for geology and soils is the project area. Additionally, the study area includes the broader geologic environment that can influence the project areas. These broader geologic influences include earthquakes (seismicity) and their associated impacts (e.g., ground shaking) as well as tsunamis (large earthquake-generated waves that can affect coastal zones and may extend some distance up large rivers) or off-site landslides that might reach the sites.

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 geology and soils.

2.1 Methods

This section describes the methods used to characterize the existing conditions and assess the potential impacts on geology and soils.

2.1.1 Data Sources

Information with respect to geology and soils was collected through review of information and reports provided by the Applicant, Washington State Department of Natural Resources Division of Geology and Earth Resources materials, U.S. Geological Survey (USGS) maps and reports, U.S. Department of Agriculture Natural Resources Conservation Service soil information, and geological and soil literature. Additionally, a site visit conducted on January 29, 2014 provided an overview of existing conditions at the project areas.

The following sources of information were used to evaluate the characteristics of geology and soils in the study area.

- USGS National Seismic Hazard Maps and associated report (U.S. Geologic Survey 2013).
- Cascadia Region Earthquake Workgroup (2013) report on the Cascadia Subduction Zone (CSZ) earthquakes.
- USGS reports on Washington State volcanic hazards (various).
- USGS reports on Columbia River liquefaction associated with CSZ earthquakes (various).
- Washington State Department of Natural Resources Division of Geology and Earth Resources geologic mapping and geologic hazards of the Longview area (various).
- Natural Resources Conservation Service soil mapping (2013).
- Geotechnical engineering reports and geotechnical engineering data reports prepared for the project area (GRI 2011, 2012).
- Professional workshop and refereed scientific journal materials on tsunamis in the Columbia River.
- Permit application and other materials prepared by the Applicant.
    - Washington State Joint Aquatic Resources Permit Application.
    - Cowlitz County Shoreline and Shoreline Conditional Use Application.
    - Applicant's Purpose and Need.
    - Geology and soil reports prepared for the project areas (URS Corporation 2014).

2.1.2 Impact Analysis

The analysis of impacts related to geology and soils considered the following elements.

- Regional and site characteristics (bedrock, unconsolidated sediment, and soil characteristics) and their influence on site or structure stability through soil erosion, landslides, and settling.
- Potential ground shaking and ground settling due to earthquakes and the stability of the underlying materials.
- The potential for impacts related to volcanic hazards and tsunamis.

2.2 Existing Conditions

The existing environmental conditions related to geology and soils in the study area are described below. Broader geologic context is provided as a foundation for the site-specific analysis.

2.2.1 Local and Site Geology

The project area for the Proposed Action is located on the north shore of the Columbia River approximately 5 miles downstream of the confluence of the Cowlitz and Columbia Rivers at approximately river mile 63 on the Columbia River. The project area is approximately 16 feet Columbia River Datum (CRD). The site is underlain by river and floodplain deposits and the surface is fairly level. Levees were constructed along the riverside of the project area (Figure 3) in approximately 1920, and the site has been industrialized since the 1940s (Anchor QEA 2011). The adjacent Columbia River navigation channel is approximately 43 feet deep at low tide (-43 feet CRD; National Oceanic and Atmospheric Administration Chart 18524) and from 28 to 42 feet deep at low tide at the location of the proposed docks (Dock 2 and Dock 3) (Millennium Bulk Terminals—Longview 2010). Although the project area is fairly level, steeper slopes descend into drainage ditches in the northern part of the project area and to the Columbia River on the south side of the project area and an on-site constructed pond. No unique geologic physical features occur at the project area.

While the physical attributes and location of the project area are dominated by their presence in the lower Columbia River valley, geologically they are within the broadly north to south–oriented physiographic-geologic province of the Puget Sound Lowland–Portland Basin–Willamette Valley lowland (Washington State Department of Natural Resources 2014a). In the Longview-Kelso area, this lowland area is quite narrow compared to the Puget Sound and Portland Basin–Willamette Valley portions to the north and south, respectively. The Longview-Kelso area is sometimes referred to locally as the Longview-Kelso basin (GRI 2012; URS Corporation 2014).

Figure 3. Levees Adjacent to the Proposed Action

The regional geology is dominated by events related to the eastward movement of the Juan de Fuca tectonic plate against the North American plate (Evarts et al. 2009; Parsons et al. 2005). The Juan de Fuca plate plunges (or forms a subduction zone) progressively deeper as it moves east beneath the North American plate. This movement compresses the rocks above it thereby producing both uplift and down dropping (troughs or basins). This area is also referred to as the CSZ. Additionally, as the Juan de Fuca plate melts at depth, the associated magma (lava) rises to the surface forming the Cascade volcanic range. Consequently, the three major geologic zones from west to east are the Coast Range forearc, the Puget Sound–Portland Basin–Willamette Basin forearc trough (encompassing the project area) and the Cascade Range volcanic arc (Evarts et al. 2009).

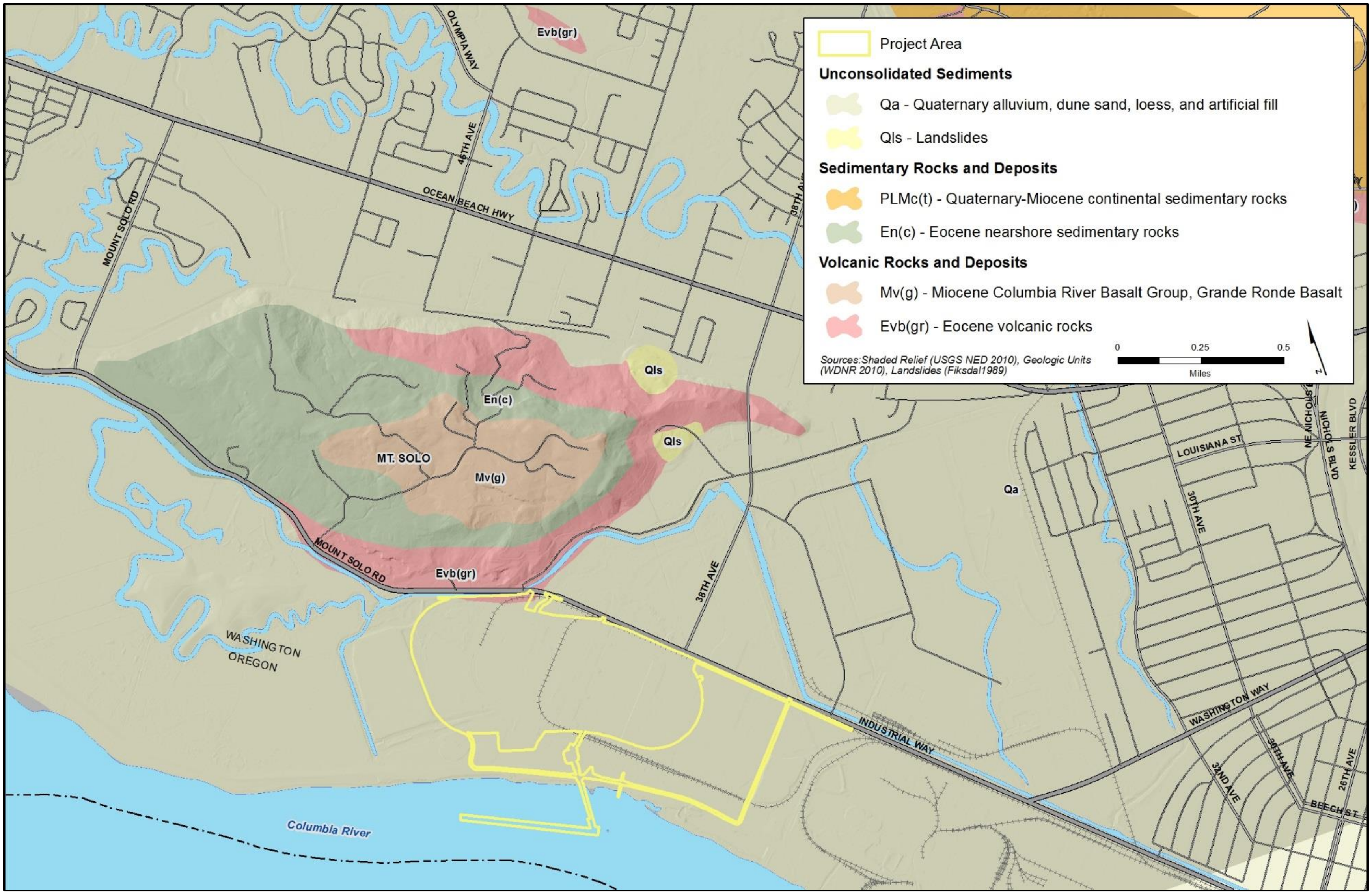
The project area is underlain by late Pleistocene and Holocene alluvial (river) deposits to a depth of more than 300 feet below sea level. However, bedrock is exposed at several places near the project area, including Mount Solo to the immediate north of the project area (Figure 4); Mount Coffin approximately 0.5 mile upstream of the project area (Washington State Department of Natural Resources2014b), and within the Columbia River where shallowly submerged bedrock has required excavation for channel maintenance at Longview just upstream of the Lewis and Clark Bridge (State Route 433) (Garmire 2012). Bedrock uplands also occur to the south across the Columbia River, to the northwest and north of the project area, and to the east of the project area across the Cowlitz River.

Three bedrock geologic units are exposed on Mount Solo (Figure 4). The bedrock at its central portion is mapped as Miocene age basalt (lava) flows of the Columbia River Basalt Group or Grande Ronde Basalt (Washington State Department of Natural Resources 2014b). This basalt is surrounded by Eocene age nearshore sedimentary rocks of sandstone and siltstone. The outermost bedrock is mapped as Eocene age volcanic rocks (basalt flows). At the study area scale landslides are also mapped along the slopes of Mount Solo (see *Landslides and Slope Stability*, below, for a more detailed discussion).

The low-lying area along the Columbia River is mapped as Quaternary alluvium, dune sand, loess (windblown silt), and artificial fill. Near the project area, the immediately underlying material is predominantly alluvium (i.e., river deposits of gravel, sand, and silt of Pleistocene to Holocene age) as well as artificial fill.

During Quaternary glaciations (between approximately 2 million to 10,000 years ago) sea level was more than 330 feet lower than present. During that time, the Columbia River incised to a similar depth of approximately 330 feet below current sea level at Longview (Baker et al. 2010; Peterson et al. 2013). Peterson et al. (2013: Figures 3 and 5) constructed cross-sections derived from boreholes in and near the project area. These cross-sections show, from the surface downward, about 20 feet of mud overlying sand or muddy sand/sandy mud from depths of approximately 20 feet to 160 feet, underlain in turn, by other sands, some muds, and Pleistocene gravel to a depth of approximately 330 feet (Peterson et al. 2013: Figure 5). The cross-section shows Mazama volcanic ash (derived from the explosion of Mount Mazama which created Crater Lake, Oregon) at approximately 45 to 60 feet below sea level. Mazama ash is approximately 7,700 years old (Peterson et al. 2013). Borings at the project area (GRI 2012:5) encountered volcanic ash between elevations -57.5 and -68 feet below mean sea level that ranged from 2 to 7 feet in thickness. Water wells at the project area reach almost 300 feet below ground depth, although there is a maximum reported depth of 410 feet (Anchor Environmental 2007: Figure 6-2; Anchor QEA 2013: Plate 4-2).

Figure 4. Local and Site Geology



In the late Pleistocene, a glacial dam forming massive Lake Missoula in Montana collapsed several times sending cataclysmic flows across the Columbia Plateau and down the Columbia River. In the Portland, Oregon, area these flows were more than 360 feet above present sea level and deposited sand banks at approximately 120 to 210 feet above present sea level (Peterson et al. 2013). These floods also deposited deep gravels and sands within the Columbia River valley. These deep gravels and sands underlie the project area at approximate depths of 120 feet and greater (Peterson et al. 2013: Figure 3). Regionally and locally, these deep floods also deposited fine-grained silts in the upper, slackwater parts of the flow. These floods extended up the Cowlitz River and deposited silts that are now found on the flanks of the adjacent hills at Castle Rock and near the confluence of the Cowlitz and Toutle Rivers (Chan et al. 2007).

Based on the elevations of the silts at Castle Rock and in the Toutle River valley (Chan et al. 2007), the Lake Missoula flood levels would have reached at least 175 to 200 feet above sea level in the Mount Solo vicinity and would have scoured it at least to these elevations. No fine-grained silt deposits associated with these floods are reported on Mount Solo (Wegmann 2006).

2.2.1.1 Subsurface Conditions

General subsurface conditions are described above under *Local and Site Geology*. Because the materials beneath the project area are derived from river and floodplain sedimentation (including the contemporary development of wetlands on these surfaces), geotechnical boreholes show sediments consisting of upper silty fill overlying loose to dense sands with varying silt and clay content, silts with sand content, and interbedded organic silt and peat (Anchor Environmental 2007; Anchor QEA 2011; GRI 2012; URS Corporation 2014). Based on geotechnical borings, groundwater begins at between 3 to 20 feet below the ground surface, so most sediments have varying amounts of water content (Anchor QEA 2011, 2013; GRI 2012; URS Corporation 2014). Field index properties done on geotechnical borings indicate that the surface and near-surface sediments are soft or loose (URS Corporation 2014). All of these properties indicate the potential for some amount of settlement under the loads (or weight) imposed by building and other structures. Consolidation tests indicate the potential for large settlement and the need for long periods for primary and secondary consolidation of these underlying materials (URS Corporation 2014). This consolidation would minimize the potential for settlement under constructed structure loading.

Because of saturated sandy conditions at depth, liquefaction could occur during and after an earthquake. Geotechnical reports prepared for a previously proposed asphalt plant on the site identifies the potential for post-earthquake liquefaction settlement of 7 to 16 inches (GeoEngineers, Inc. 2007) and 12 to 16 inches (Shannon and Wilson, Inc. 2008).

A variety of geotechnical data has been collected at the project area (Anchor QEA 2011, 2013). Anchor QEA (2011) also summarizes earlier geotechnical borings and appends those data reports and geotechnical reports. The Anchor QEA (2011, 2013) data have been collected to assist with project design, but a geotechnical analysis and report using these recent data have not been prepared.

2.2.1.2 Landslides and Slope Stability

No landslides are identified for the project area in local slope instability reports or on-site investigations (Figure 5) (Fiksdal 1989; Wegmann 2006; Anchor Environmental 2007; GRI 2011, 2012). The project area is also flat and therefore has a low likelihood of landslides. The City of Longview (2006) Comprehensive Plan identifies steep slopes that lead from the flat, low-lying surfaces of the alluvium into the adjacent Columbia River; however, there is no indication of excessive erosion along these banks. Much of the shoreline has been armored with large riprap and angular rock along the length of the levee near the project area and along the Columbia River. The levee and shoreline armoring disconnect the river from its floodplain and protect the levee system from erosion.

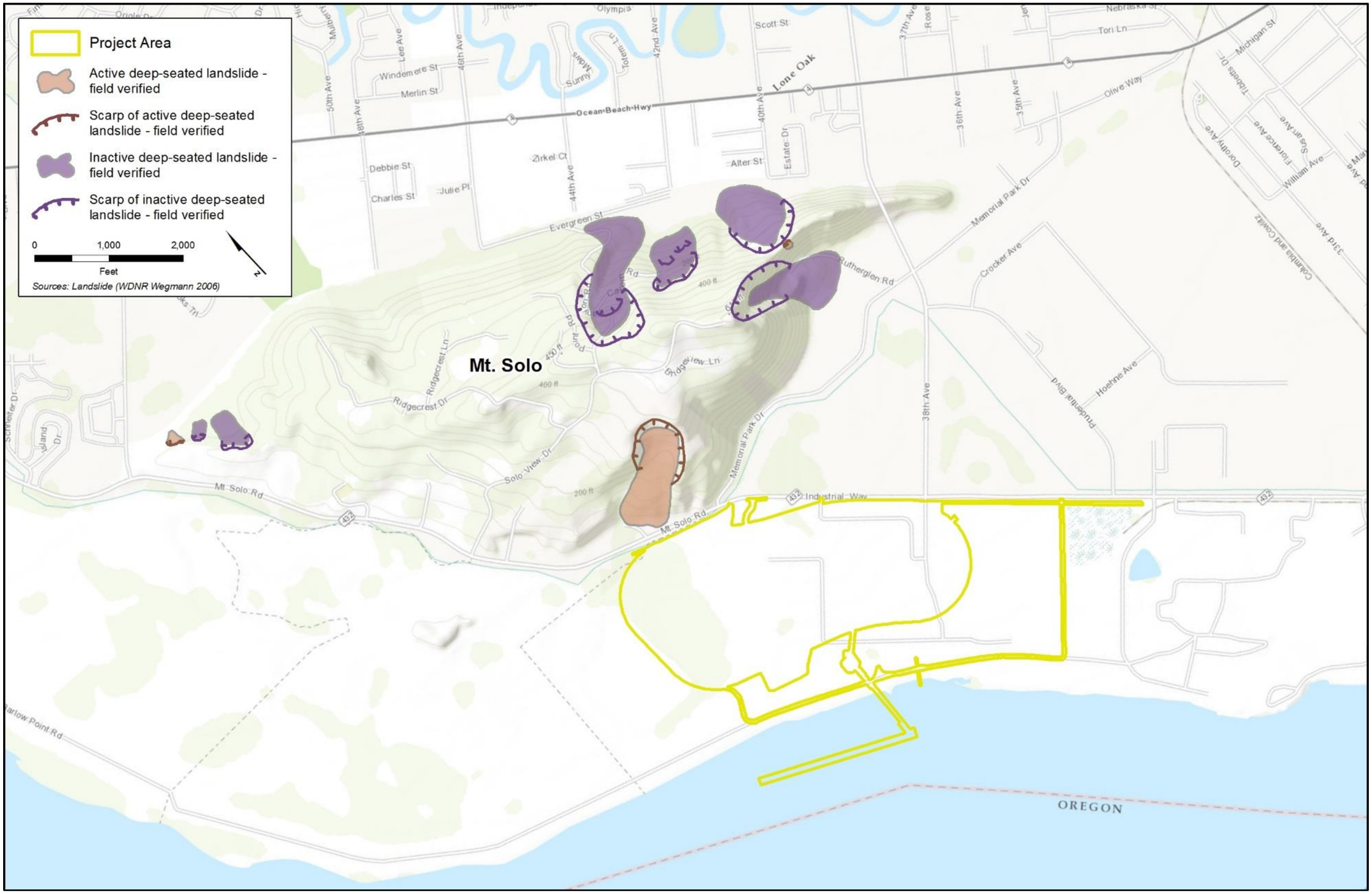
Landslides have been identified on Mount Solo. Fiksdal (1989) identified two landslide areas on easternmost Mount Solo, one on the north side and one on the south side (Figure 5). More detailed mapping by Wegmann (2006) identified multiple landslides around Mount Solo (Figure 5). Wegmann (2006) also identified whether the features were inactive or active. One active landslide is relevant to the project area. The approximately 16-acre active landslide is located on the south slope of Mount Solo (Figure 5), about 200 feet from the northwest corner of the project area. This landslide is formed in sedimentary bedrock overlain by basalt flows (Wegmann 2006). It is oriented toward the southwest. The landslide toe (bottom) is just west of the intersection of Industrial Way and Memorial Park Drive on the north side of the road. Its active nature is identified by the presence of ground cracks, exposed and disrupted soil, and disrupted trees (Wegmann 2006). Landslides may also be caused, or existing landslides may be reactivated, by strong ground shaking from earthquakes.

2.2.2 Seismicity

As described by URS Corporation (2014: Figures 2, 3, and 4) and by the Washington State Department of Natural Resources (2014b), Pacific Northwest earthquake origins are from one of four possible geologic events: interplate movement on the coastal CSZ, intraplate movement within the subducting Juan de Fuca tectonic plate that is sinking beneath the North American tectonic plate, shallow crustal movements within the North American tectonic plate, and movements beneath Cascade volcanoes (magma- or fault-related).

Although no great earthquakes (magnitude 8.0 to 9.0 or higher) have occurred on the CSZ during the historical record, reconstructions from the geologic record indicate that more than 10 great earthquakes have occurred in Oregon and Washington over the last 5,000 years (Cascadia Region Earthquake Workgroup 2013; URS Corporation 2014). Recurrence intervals for these earthquakes are approximately 250 to 900 years. These earthquakes result from fault rupture over most of the CSZ from northern California to southern British Columbia (Cascadia Region Earthquake Workgroup 2013) and cause substantial ground shaking and tsunamis. The last CSZ earthquake occurred in 1700 (Atwater 1994; Jacoby et al. 1997).

Figure 5. Landslides in the Project Vicinity



Based on the historical record, intraplate movements are considered capable of generating earthquakes as large as magnitude 7.5 (URS Corporation 2014). These earthquakes generally do not have faults that reach the ground surface and their recurrence interval is not known. Example intraplate earthquakes include the following: 1949 Olympia 7.1 magnitude, 1965 Seattle 6.5 magnitude and 2001 Nisqually 6.8 magnitude. These earthquakes did not cause substantial damage in the Longview area (Noson et al. 1988; Washington State Department of Natural Resources 2001; Washington State Seismic Safety Committee 2012; URS Corporation 2014).

Shallow crustal earthquakes are widespread geographically and based on geologic data and historical records in the Pacific Northwest, these movements are capable of producing earthquakes greater than magnitude 6.0 and perhaps as high as magnitude 7.0 to 7.5 (URS Corporation 2014). The 1872 North Cascade (Lake Chelan, Washington, area) magnitude 6.5 to 7.0 earthquake is considered the largest historical shallow crustal earthquake (Bakun et al. 2002; URS Corporation 2014). Shallow crustal faults in southwestern Washington and northwestern Oregon have the potential to generate magnitude 6.0 and greater earthquakes (Wong et al. 2000; Lidke et al. 2003; Personius et al. 2003; URS Corporation 2014).

Volcanic earthquakes occur beneath the Cascade volcanoes, which are approximately 30 miles or greater to the east of the project area. These earthquakes can be associated with the movement of magma or from faults such as that within the Mount St. Helens seismic zone (which may also be considered shallow crustal earthquakes). The largest recorded earthquake beneath Cascade volcanoes was a magnitude 5.1 earthquake in 1981 (U.S. Geological Survey 2013).

2.2.2.1 Surface Fault Rupture

No recognized crustal faults are active or potentially active in the immediate vicinity of the project area (Lidke et al. 2003; Personius et al. 2003; Barnett et al. 2009; Czajkowski and Bowman 2014.). The closest Holocene age (the last 10,000 years) faults are the Portland Hills and Frontal Fault–Lacamas Lake Faults approximately 40 miles to the southeast near Portland, Oregon (Wong et al. 2000; URS Corporation 2014), and the Mount St. Helens Seismic Zone to the east and offshore faults to the west, both of which are approximately 60 miles away.

2.2.2.2 Strong Ground Shaking

URS Corporation (2014: Table 1) compiled a list of the largest known earthquakes felt in Washington derived from Noson et al. (1988) and from the Pacific Northwest Seismic Network (www.pnsn.org/ and www.pnsn.org/earthquakes/historic-catalog). Between 1872 and 2014, these earthquakes ranged in instrumental magnitude from 7.3 to 5.0 for all of Washington (URS Corporation 2014: Table 1). Large earthquakes that would have affected the Longview area occur primarily in the Puget Sound area and Portland, Oregon, vicinity. They range in instrumental magnitude from 5.0 to 7.1 (URS Corporation 2014: Table 1). Large or CSZ earthquakes would cause severe ground shaking in the Longview area including the project area.

Earthquake magnitude provides a specific measure with which to compare the energy released by different events. However, earthquake magnitude does not provide a direct measure of shaking at a given site because that movement decreases with distance from the earthquake site. The distance from the earthquake also includes the depth within the Earth at which the earthquake actually occurred. For example, ground shaking from the 2001 Nisqually earthquake (magnitude 6.8) was not particularly violent since it occurred at 30 miles depth. The location directly above it was 30 miles away (Palmer et al. 2004).

The USGS National Seismic Hazard Maps determine earthquake ground motions for various probability levels that are applied in seismic provisions of building codes. These values are derived by evaluating all the potential earthquakes (along with their locations, depths, and probabilities) that could affect an area. The maps show probabilistic peak ground motion as peak ground acceleration (PGA) expressed as a multiplier of the force of gravity (g). That is, the ground and overlying structures are accelerated from no motion at all to a peak motion value. This acceleration causes shaking and stress on structures. The USGS (2014) map depicting 2% probability of PGA exceedance over 50 years shows the Longview area within the 0.4 to 0.5 g contour (Petersen et al. 2014). A PGA in the range of 0.34 to 0.65 g is perceived as severe shaking and could cause moderate to heavy damage, depending on the duration of the event, the types of underlying materials, and the structural integrity of affected buildings or structures (Petersen et al. 2014).

Ground shaking is also stronger in areas of soft soils or unconsolidated deposits such as sand and silt. The Site Class Map of Cowlitz County, Washington, characterizes the project area as site class E, which has the softest soil conditions and highest level of potential ground shaking (Palmer et al. 2004). As noted by the Cascadia Region Earthquake Workgroup (2013:11), one ground shaking–liquefaction hazard is underwater landslides that could disrupt Columbia River shipping channels.

One component of geotechnical analysis reports is to integrate the regional data with detailed, site-specific data to calculate ground shaking and other effects (such as liquefaction, see next section) for a particular location and type of construction. These reports use the regional earthquake and PGA data from the USGS National Seismic Hazard Maps and integrate it with bedrock, surficial sediment properties, and groundwater conditions derived from site-specific boreholes. Laboratory data on the characteristics of borehole samples and calculations are then used to derive the site-specific ground shaking, liquefaction and other parameters.

2.2.2.3 Secondary Seismic Hazards: Liquefaction and Subsidence

Liquefaction occurs when a saturated or partially saturated soil loses its strength and acts like a fluid due to applied stress such as earthquake shaking. The project area is subject to liquefaction and subsidence during ground shaking. The Liquefaction Susceptibility Map of Cowlitz County, Washington, characterizes the area as having high liquefaction susceptibility (Palmer et al. 2004). As noted above, the area is underlain by hundreds of feet of gravel, sand, silt, and organic layers. The sandy layers can liquefy during strong ground shaking. When liquefied these layers can flow like a liquid and/or lose consistency and no longer support the ground above them. The layers may flow laterally or be injected vertically, depending on the strength and weakness of adjacent layers or whether the liquefying layer can exit the ground (e.g., by flowing out of an adjacent slope or into a river channel). If close to the surface, the flowing materials may be ejected at the surface (vent) forming one or more sand volcanoes. The loss of support for overlying layers may also result in them subsiding and moving laterally. These changes continue until the liquefied layer deliquefies.

The geologic record provides evidence of liquefaction susceptibility along the Columbia River. One of the data sets that provided information on the 1700 CSZ great earthquake was surface venting of liquefied layers. Several of these layers were dated by tree-ring analyses of trees affected by the sediment ejection or trees that began growing on the new ground (Atwater 1994; Jacoby et al. 1997). Atwater (1994) record such liquefaction events at Marsh, Brush, Price, Hunting, and Wallace

Islands within the lower Columbia River. The Wallace Island site is between river miles 47.5 and 50 approximately 13 miles from the project area.

One geotechnical investigation at the project area indicated that post-liquefaction settlement varies with location and earthquake magnitude but is estimated at 7 to 16 inches for a CSZ earthquake of magnitude 7.4 and a PGA of 0.24 g (GeoEngineers, Inc. 2007). Another geotechnical investigation estimated similar liquefaction-induced settlement of 12 to 16 inches for a magnitude 8.3 CSZ earthquake with a PGA of 0.26 g (Shannon and Wilson, Inc. 2008). These estimates were for a previously proposed asphalt plant at the site.

2.2.3 Volcanic Hazards

The primary volcanic hazard at Longview is from airborne fragments, ash fall, and lahars (volcanic mudflows) reaching, and continuing down, the Columbia River.

2.2.3.1 Volcanic Eruption and Ash Fall

Active volcanoes occur within the Cascade Range to the east of Longview. The active volcanoes nearest the area are Mount St. Helens (approximately 40 miles to the east), Mount Adams (approximately 70 miles to the east), and Mount Hood (approximately 80 miles to the southeast). The project area is not within the Cowlitz County–designated volcanic flowage hazard zone 1 (i.e., within a 5-mile radius of volcanic activity).

As noted by URS Corporation (2014), ash fall of more than 0.4 to 2 inches would disrupt transportation and operation of certain facilities. USGS estimates the annual probability of ash fall exceeding 4 inches at Longview to be between 0.01 and 0.02% or between 1 in 10,000 to 1 in 5,000 (Wolfe and Pierson 1995).

2.2.3.2 Lahars and Sedimentation

Lahars associated with the 1980 Mount St. Helens eruption flowed down the Toutle River to the Cowlitz River and reached the Columbia River at approximately the Lewis and Clark Bridge (SR 433) (Haini 1983). Lahars derived from the south flank of Mount Rainier in the upper Cowlitz River are unlikely to reach the lower Cowlitz River (Cakir and Walsh 2012). The Longview vicinity is not within the Cowlitz County–designated volcanic flowage hazard zone 3, which requires an evacuation and emergency management plan. That requirement only applies to areas upstream of the North Fork Toutle River sediment retention structure.

Upstream on the Columbia River, lahars have been documented along the Sandy River draining from Mount Hood in Oregon (Pierson et al. 2009). These sites are approximately 55 miles upstream of Longview. Lahars from Mount Adams could reach the Columbia River via the White Salmon River; its confluence with the Columbia River is more than 100 river miles upstream from Longview.

2.2.4 Mine Hazard Areas

Mine hazard areas in Cowlitz County are primarily associated with historical coal mining and areas underlain by or affected by the mine workings such as adits, tunnels, drifts, or airshafts. No bedrock with coal occurs along the Columbia River near Longview. The nearest historical coal mines are in the Coal Creek drainage approximately 7 miles northwest of Mount Solo and 5 miles northeast of Mount Solo on the east side of the Cowlitz River (Culver 1919; Vonheeder 1977). Based on a review of topographic maps and geologic reports (Culver 1919; Vonheeder 1977; Norman et al. 2001), no other mines have been documented near Mount Solo or the adjacent Columbia River deposits. Consequently, the issue is not discussed further.

2.2.5 Tsunamis

Washington and Oregon tsunamis could result from CSZ earthquakes along their coastline or similar major earthquakes in areas such as southern Alaska, Japan, or Indonesia. Tsunami hazard and evacuation maps for Washington and Oregon only extend up the Columbia River to a point just east of Astoria, Oregon (approximately 50 miles downstream of the project area at river mile 15) (Walsh et al. 2000; Washington State Department of Natural Resources 2010; Oregon Department of Geology and Mineral Industries 2012). Therefore, these maps are not applicable to the Longview area.

Based on previous work, Tolkova (2013) reviewed five documented historical tsunamis and their penetration up the Columbia River (August 23, 1872; November 4, 1952; May 23, 1960; March 28, 1964 [great Alaskan tsunami]; and March 11, 2011 [East Japan tsunami]). Instrumentally recorded tsunamis reach as far as Portland, Oregon, although with relatively small magnitude (i.e., wave height and energy). For example, the 1964 great Alaskan tsunami had a 0.3-meter (approximately 1-foot) height at Beaver (river mile 53). The 2011 East Japan tsunami registered a wave height between 0.001 to 0.004 meters (approximately 0.04 inches to 0.16 inches) at Longview (river mile 65.7). Tsunami wave height and penetration also vary with tide level with less height and penetration during a falling tide and greater wave height and penetration during rising tides (Tolkova 2013).

Evaluation of tsunami penetration up the Columbia River occurred at a Workshop on Tsunami Hydrodynamics in a Large River held at Oregon State University, Corvallis, in 2011 (http://isec.nacse.org/workshop/2011_orst/) and subsequently summarized by Yeh et al. (2012). These evaluations indicate that as a tsunami enters the river valley it is transformed into a long period (i.e., longer time between wave peaks), small amplitude (i.e., small height) wave (Yeh et al. 2012; Tolkova 2013). Modeling indicates that although the wave would advance to Portland at approximately river mile 107, its height would be quickly reduced upon entering the river because of energy dissipation (Yeh et al. 2012). For example, a numerical simulation indicated that a tsunami height of 5.6 meters (18 feet) at the Columbia River mouth would decrease to 1.5 meters (4.9 feet) at river mile 18 (Astoria), to 0.2 meter (0.65 foot or less than 8 inches) at Longview (river mile 65.7), and to 0.04 meter (0.13 foot or approximately 5 inches) at river mile 107 (Portland) (Yeh et al. 2012).

2.2.6 Sea Level Rise

Future sea level change in the vicinity of the Columbia River mouth is expected to be between -3 centimeters and +48 centimeters (approximately -1.2 inches and +18.9 inches) by 2050 and 10 to 143 centimeters (approximately 4 inches to 56 inches) by 2100 (National Research Council 2012). The range of values is based on consideration of several influences on sea level rise including tectonism (incorporation of tectonic uplift is the reason for the -3 centimeter value noted above) (National Research Council 2012). Considering the low gradient of the lower Columbia River, the maximum expected rise at Longview would be similar to the coastal sea level rise projections at the mouth of the Columbia River. The project area is behind Columbia River levees of approximately 36 feet CRD, as noted in the SEPA Surface Water and Floodplains Technical Report (ICF 2017a), and since this is higher than the potential sea level rise, there would not be any impacts on soils on the project area or increased risk of erosion. Consequently, the issue is not discussed further.

2.2.7 Soils

Cowlitz County soils have been mapped by the Natural Resource Conservation Service[1]. Figure 6 shows the naturally occurring soils mapped at the project area. Excluding water, five soil units are mapped at the project area. These soil units and some of their relevant characteristics are presented in Table 2. All of these soil units reflect the alluvial (river deposit) origin of the soil parent material and are relatively fine-grained. The soil textures range from gravelly sandy loam (Arents, Map Unit Number 5), to loamy fine sand, to silt loam, to silty clay loam. These soils map units also reflect the low-gradient nature of these river deposits with map unit slopes from 0 to 8%. These map units reflect the soil characteristics throughout each soil's range in Washington (and Oregon) and the slopes along this landscape position, which are very flat (near zero), except adjacent to drainage ditches, ponds, and the Columbia River.

The project area is dominated by Caples silt loam (Map Unit Number 17) and the Maytown silt loam (Map Unit Number 127) (Figure 6; Table 2). A small area is mapped as Snohomish silty clay loam. The Pilchuck loamy fine sand (Map Unit Number 160) and the Arents (Map Unit Number 5) map units are narrow and parallel the Columbia River shoreline. With respect to the project area boundary, these soils are only encountered along the narrow trestle extension that leads to the dock within the Columbia River.

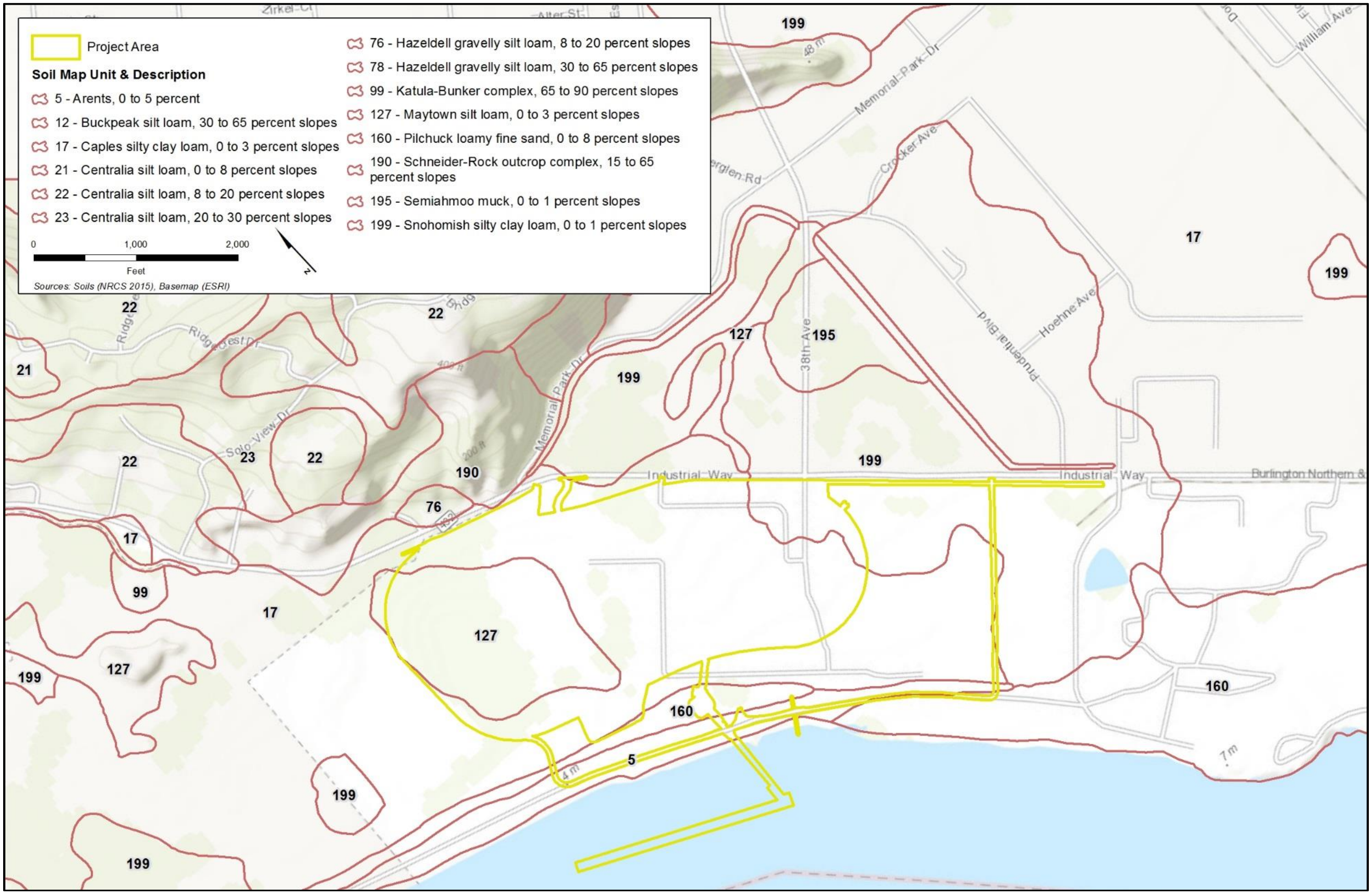
The erosion hazard is characterized as slight for all soils reflecting the low landscape gradient. The K factor indicates a soils susceptibility to sheet and rill erosion. The higher the soil's K factor the higher its erosion potential. Based on the K factor, the Caples silty clay loam (Map Unit Number 17), the Maytown silt loam (Map Unit 127), and Snohomish silty clay loam (Map Unit Number 199) have a higher erosion hazard under bare soil conditions. These soils have a low susceptibility to wind erosion.

The site soils are all moderate with respect to their potential for corrosion of concrete. Their uncoated steel corrosion potential ranges from low (Pilchuck loam fine sand), to moderate (Arents), to high (Caples silty clay loam, Maytown silt loam, and Snohomish silty clay loam). Several standard engineering measures address concrete and steel corrosion such as improving drainage and replacing native soil with fill (Washington State Department of Transportation 2014).

A soil's linear extensibility is a measure of its potential to expand during wetting and, conversely, to contract during drying. The more a soil expands the more potential it has to affect overlying materials such as structure foundations. The values in Table 2 are provided as a percent expansion and a descriptive classification (class). The soil expansion classes for the project area range from low (Arents, Pilchuck loamy fine sand), to moderate (Maytown silt loam, Snohomish silty clay loam), to high (Caples silty clay loam).

[1] http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Figure 6. Soil Types in the Project Vicinity



The above discussion addresses the naturally occurring soils at the project area. The project area has been an industrial site since the 1940s and has had various amounts of surface disturbance (grading, digging for new foundations, asphalt road placement with underlying gravel base) and fill material placement. Consequently, site-specific surface soil materials may vary from the Natural Resource Conservation Service mapping. Geotechnical data reports for the project area indicate varying distributions of fill materials particularly under existing structures. This fill material includes sand, silt, mixed silt and sand, large gravel, and crushed rock (Anchor QEA 2011; GRI 2011, 2012).

Table 2. Soils and Soil Properties at the Project Area

Map Unit Number[a]	Soil Map Unit Name	Drainage Class	K Factor[b]	Erosion Hazard	Corrosion of Concrete[c]	Corrosion of Uncoated Steel[d]	Linear Extensibility /Class
5	Arents, 0 to 5% slopes	Moderately well drained	0.28	Slight	Moderate	Moderate	1.5%/Low
17	Caples silty clay loam, 0 to 3% slopes	Somewhat poorly drained	0.43	Slight	Moderate	High	7.0%/High
127	Maytown silt loam, 0 to 3% slopes	Moderately well drained	0.49	Slight	Moderate	High	3.6%/ Moderate
160	Pilchuck loamy fine sand, 0 to 8% slope	Not defined	0.20	Slight	Moderate	Low	1.5%/Low
199	Snohomish silty clay loam, 0 to 1% slopes	Poorly drained	0.37	Slight	Moderate	High	4.5%/ Moderate
263	Water	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

[a] Soil Map Units are shown on Figure 6.

[b] Higher K factor values indicate greater potential for erosion: K factor values below 0.13 have low erosion potential; values 0.13 to 0.26 have medium erosion potential; values greater than 0.26 have high erosion potential.

[b] The potential for concrete corrosion increases decreasing water and soil acidity and increases in sodium, magnesium sulfate, and sodium chloride.

[c] The potential for corrosion of uncoated steel increases with soil water saturation, greater water acidity and conductivity.

Source: Natural Resource Conservation Service 2013

N/A = not applicable

Chapter 3
Impacts

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

Construction impacts include potential impacts such as soil erosion that could be delivered off site to streams adversely affecting water quality. Operational impacts include the potential adverse impacts of the geological and soil environment on the project. Examples of these impacts are earthquakes, landslides, or tsunamis that could damage the export terminal after its construction. Seismic-related impacts are important primarily after project construction. Therefore, these impacts are discussed under Section 3.1.3, *Operations: Direct Impacts*.

3.1 Proposed Action

The following construction activities could affect geology and soils.

- Ground disturbance associated with construction of the export terminal
- Preloading of the coal stockpile areas

The following operations activities could affect geology and soils.

- Exposure of people and structures to potential effects from catastrophic events

3.1.1 Construction: Direct Impacts

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

Result in Land Enlargement, Affect a Unique Physical Feature, or Cause Substantial Soil Erosion

Construction of the Proposed Action would not result in the enlargement of land area by placing fill in the Columbia River or by causing sedimentation in the Columbia River. There are no unique physical features at the project area that would be affected by the Proposed Action. Although steep slopes locally occur along drainage ditches and the Columbia River banks, there are no indications of instability and project activities are not expected to cause instability at these locations.

Construction of the Proposed Action would affect approximately 190 acres of land and involve such ground-disturbing activities as grading, railroad construction, excavation for foundations, and road construction. Additionally, approximately 2.1 million cubic yards of material would be imported and used for preloading, or compressing soils onsite for the stockpile areas, as well as approximately 130,000 cubic yards of ballast rock for rail infrastructure and rail-related structures. Approximately 2.5 million cubic yards of material would be moved around the project area during the compression of on-site soils.

As discussed in Section 2.2.7, *Soils,* and shown in Table 2, although the soils in the project area have a moderate to high potential for erosion (i.e., moderate to high K factor), the on-site soils have a slight erosion hazard, primarily because of the site's flat gradient. However, since construction would occur over a period of several years, large areas of bare soil could be exposed for varying periods. Soil erosion could occur during periods of rainfall and would have the potential for off-site transport of eroded soil materials to waterways such as the Columbia River and adjacent ditches. Additionally, imported preload and rail ballast materials would be obtained from a commercial supplier. Wind erosion potential is limited because of the precipitation levels that occur at the site, and proposed dust suppression during construction to control wind erosion of, but could occur during summer dry periods. Dust from coal stockpiles is addressed in the SEPA Air Quality Technical Report (ICF 2017b). When build out is complete, the project area would be approximately 90% impervious surfaces, which would reduce soil erosion potential to near zero.

Dredging related to the construction of Docks 2 and 3 would be managed under the Section 401 Water Quality Certification. This could involve approval of flow-lane disposal of dredge material, which would avoid impacts on uplands. The Applicant could, if approved, also dispose of dredge materials in upland portions of the project area for preloading the stockpile area. Placement of this dredge material in the stockpile area would compact the underlying soil (see *Affect Project Structures from Soil Materials Underlying the Site*, below, for more information). This in-water activity is discussed in the SEPA Water Quality Technical Report (ICF 2017c) and SEPA Surface Water and Floodplains Technical Report (ICF 2017a).

Affect Project Structures from Soil Materials Underlying the Site

As discussed in Section 2.2.7, *Soils*, and shown in Table 2, the on-site soils have moderate potential to corrode concrete, low to high potential to corrode steel, and have an expansion-contraction (wet-dry) class of low to high. A variety of standard engineering measures address concrete and steel corrosion such as improving drainage and replacing native soil with fill (Washington State Department of Transportation 2014).

The sediments underlying the project area are relatively fine-grained and water-saturated, and the water table is near the ground surface. These characteristics make the sediments susceptible to compaction from the weight of overlying materials and structures. This susceptibility is primarily of concern for the coal stockpile areas on the project area, because the coal's weight would cause compaction of the underlying sediment (estimated at approximately 8 to 10 feet), which would result in relatively substantial settlement of these underlying sediments. Compaction would be a lesser concern for other project components, because they involve much less weight.

Compaction and settlement of underlying sediments in the coal stockpile areas are addressed in the project design through preloading. Preloading involves import of material to compact the underlying soil to improve their load-bearing capacity. Approximately 2.1 million cubic yards of material would be imported into the coal stockpile areas (Millennium Bulk Terminals–Longview 2013) in stages over a period of up to 7 years.

3.1.2 Construction: Indirect Impacts

Construction of the Proposed Action would not result in indirect impacts on geology and soil because construction impacts are immediate and no construction impacts would occur later in time or farther removed in distance than the direct impacts.

3.1.3 Operations: Direct Impacts

Operation of the Proposed Action could expose people or structures to potential effects involving catastrophic events such as; rupture of a known earthquake fault, strong seismic ground shaking, seismic-related ground failure (i.e., liquefaction), landslides, and tsunamis. Thus, potential effects from these types of catastrophic events were evaluated.

3.1.3.1 Surface Faults

No known earthquake faults at the project area reach the ground surface. Therefore, no ground surface ruptures could directly damage structures or buildings at the project area.

3.1.3.2 Ground Shaking

The Longview area, including the project area, could be subject to strong ground shaking from earthquakes. The USGS National Seismic Hazard Map shows that there is a 2% probability of an earthquake with a PGA of 0.4 g to 0.5 g, occurring over 50 years (Petersen et al. 2014). As a generalization, this means that in any 50-year period, there is a 2% chance that an earthquake could occur that would result in severe shaking. This amount of shaking could directly damage proposed structures and buildings including those with human occupancy (one maintenance building and one administration building).

3.1.3.3 Seismic-Related Ground Failure, Including Liquefaction

The project area could be subject to liquefaction during strong ground shaking. Palmer et al. (2004) characterize the area as having high liquefaction susceptibility. Geotechnical investigation of the area for a previously proposed asphalt plant indicated that post-liquefaction settlement varies with earthquake location and earthquake magnitude but is estimated at 7 to 16 inches for a magnitude 7.4 CSZ earthquake with a PGA of 0.24 g (GeoEngineers, Inc. 2007). Shannon and Wilson, Inc. (2008) estimated similar liquefaction-induced settlement of 12 to 16 inches for a magnitude 8.3 CSZ earthquake with a PGA of 0.26 g for the previously proposed asphalt plant. Ground settling of this amount could damage proposed structures and buildings. These previous geotechnical studies used the earthquake magnitudes and PGAs recognized at the time of their preparation and did not address coal stockpiles. The Proposed Action would comply with the adopted International Building Code (per Cowlitz County Code [CCC] 16.05) and Cowlitz County Grading Ordinance (CCC 16.35). Preloading of the stockpile area would expel groundwater and consolidate soils in the immediate vicinity of the coal stockpile areas, which would reduce the susceptibility of the soils to liquefaction. This would also be likely to reduce the potential for damage to proposed structures that occur in the immediate vicinity of the preloading area. Preparation of a geotechnical report would identify the specific soil conditions pre- and post-project construction, and would inform project design and construction techniques to reduce potential impacts based on the risk of liquefaction.

3.1.3.4 Landslides

There are no existing landslides at the project area. Strong ground shaking associated with earthquakes would have minimal potential to cause new landslides at the project area, because the site is level and there is only about 40 feet of elevation difference between the site surface and the adjacent Columbia River bottom.

The project area is near the active deep-seated landslide on the south flank of Mount Solo, but it is located more than 50 feet from the its edge, which is the minimum distance required by the Cowlitz County Critical Areas Ordinance for landslide hazards. Additionally, because the project is at the toe (bottom) of the landslide, and is physically isolated from it, no actions taken at the project area would increase the risk that the landslide would be reactivated. However, as with all landslides, periods of prolonged and intense rainfall (including multiyear periods) or earthquake-caused ground shaking could activate this landslide. The extent to which any such movement would be translated to the toe of the slide or the extent to which the toe might extend to the southwest towards the project area is uncertain.

3.1.3.5 Tsunamis

Large earthquakes in the Pacific Ocean or on the CSZ could cause a tsunami, which could affect the coastal zone of Washington and Oregon. Large tsunamis have been detected as far up the Columbia River as Portland, Oregon, as described in Section 2.2.5, *Tsunamis*. Modeling calculations found that an 18-foot-high tsunami at the Columbia River mouth decreased to less than 8 inches at Longview (Yeh et al. 2012). Tsunami levels at the project area would be similar and would not affect the project area structures or operation including ships at the docks.

3.1.4 Operations: Indirect Impacts

No indirect impacts on geology or soils have been identified.

3.2 No-Action Alternative

Under the No-Action Alternative, the Applicant would not construct the export terminal. Ongoing operations in the project area would continue and additional storage and transfer activities might occur on the using existing buildings. However, these activities would not require new permits and would not affect the geology and soils in the project area beyond their current conditions.

Chapter 4
Required Permits

The Proposed Action would require the following permits related to geology and soils.

- A fill and grade permit and/or a building permit would be required from Cowlitz County to ensure that final design and construction follow the County and engineering requirements.
- Cowlitz County Critical Areas permit to address compliance with the County's Critical Areas Ordinance related to the presence and protection of Critical Aquifer Recharge Areas located on site.
- A Construction Stormwater Permit would be required from Washington State Department of Ecology (Ecology) to address erosion control and water quality during construction.
- An Industrial Stormwater Permit would be required from Ecology to address erosion control and water quality during operations. The permit and Stormwater Pollution Prevention Plan control adverse impacts through the application of best management practices. These are defined as schedules of activities, prohibitions of practices, maintenance procedures, and structural and managerial practices that, when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts on waters of Washington State. The types of best management practices are source control, treatment, and flow control.

The following permit requirements would be required for construction of the Proposed Action.

- A qualified geologist or engineer would monitor the fill placement during construction and conduct appropriate field tests to verify proper compaction of the fill soils.
- Preliminary plans have identified the need to preload the site for construction. A site-specific preloading plan would be developed prior to initiating construction by the project geotechnical engineer working with the project civil and structural engineers. The plan would include measures to maintain proper site drainage, collection, and treatment of water generated, volumes, and sources of fill sources, and staging of fills, setbacks from existing structures. The plan would also consider the short-term and long-term impacts on adjacent structures and features, including but not limited to railroads, existing streets and utility connections, utilities, drainage features, landfills, existing hazardous materials, and buildings.
- Visual inspection would be conducted following abnormal seismic activity. These inspections would document whether the seismic activity has resulted in significant changes to the surface conditions.
- Best management practices would minimize the potential for erosion. A stormwater pollution prevention plan would be required and implemented. Clearing, excavation, and grading would be limited to the areas necessary for construction, and would not be completed far in advance of terminal construction.
- BMP C107: Construction Road/Parking Area Stabilization. Roads, parking areas, and other on-site vehicle transportation routes would be stabilized to reduce erosion caused by construction traffic or runoff.

Chapter 5
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