

## 4.1 Geology and Soils

Geology and soils are resources with defining characteristics (such as soil structure, composition, or geologic formations) that are unique or valuable or support unique habitats. Geology and soils can also influence the potential for geologic hazards, such as landslides, earthquakes, seismic effects (e.g., surface fault ruptures, strong ground shaking, liquefaction, lifting and lowering of the surface, and tsunamis), and volcanic activity. Understanding the types of soils and the underlying geologic conditions is important in determining whether a project would be exposed to increased risks related to these conditions.

This section describes the geology and soils in the study areas. It then describes potential impacts on geology and soils that could result from construction and operation of the Proposed Action and under the No-Action Alternative, as well as the geologic conditions that exist in the study areas that could pose a risk to the project area. This section also presents proposed measures identified to mitigate impacts resulting from the Proposed Action.

### 4.1.1 Regulatory Setting

Laws and regulations relevant to geology and soils are summarized in Table 4.1-1.

**Table 4.1-1. Regulations, Statutes, and Guidelines for Geology and Soils**

<b>Regulation, Statute, Guideline</b>	<b>Description</b>
<b>Federal</b>	
Clean Water Act Section 402 Permit for Stormwater Discharges Associated with Construction Activities	Primarily deals with water quality but includes eroded soils potentially delivered offsite via runoff. Mandates that certain types of construction activities (and operations) comply with the EPA NPDES program. The EPA has designated Washington State Department of Ecology the nonfederal authority for the NPDES program in Washington State. Includes development of a stormwater pollution prevention plan.
<b>Local</b>	
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 (CCC 16.35)	Grading plan requirement and standards including the protection of water quality from adverse impacts of erosion and sedimentation.
Cowlitz County Building Code (CCC 16.05)	Cowlitz County has adopted the 2012 International Building and Residential Codes.
Notes: EPA = U.S. Environmental Protection Agency; NPDES = National Pollutant Discharge Elimination System; CCC = Cowlitz County Code	

## 4.1.2 Study Area

The study area for direct impacts on geology and soils is the project area.

The study area for indirect impacts on geology and soils is the project area and the broader geologic environment in the area surrounding the project area that could influence the project area. These broader geologic influences include earthquakes (seismicity) and their associated impacts (ground shaking), as well as tsunamis (large earthquake-generated waves that can affect coastal zones and could travel some distance up large rivers) or landslides that might reach the project area.

Figure 4.1-1 shows the study areas for the geology and soils analysis.

## 4.1.3 Methods

This section describes the sources of information and methods used to evaluate the potential impacts associated with the construction and operation of the Proposed Action and No-Action Alternative.

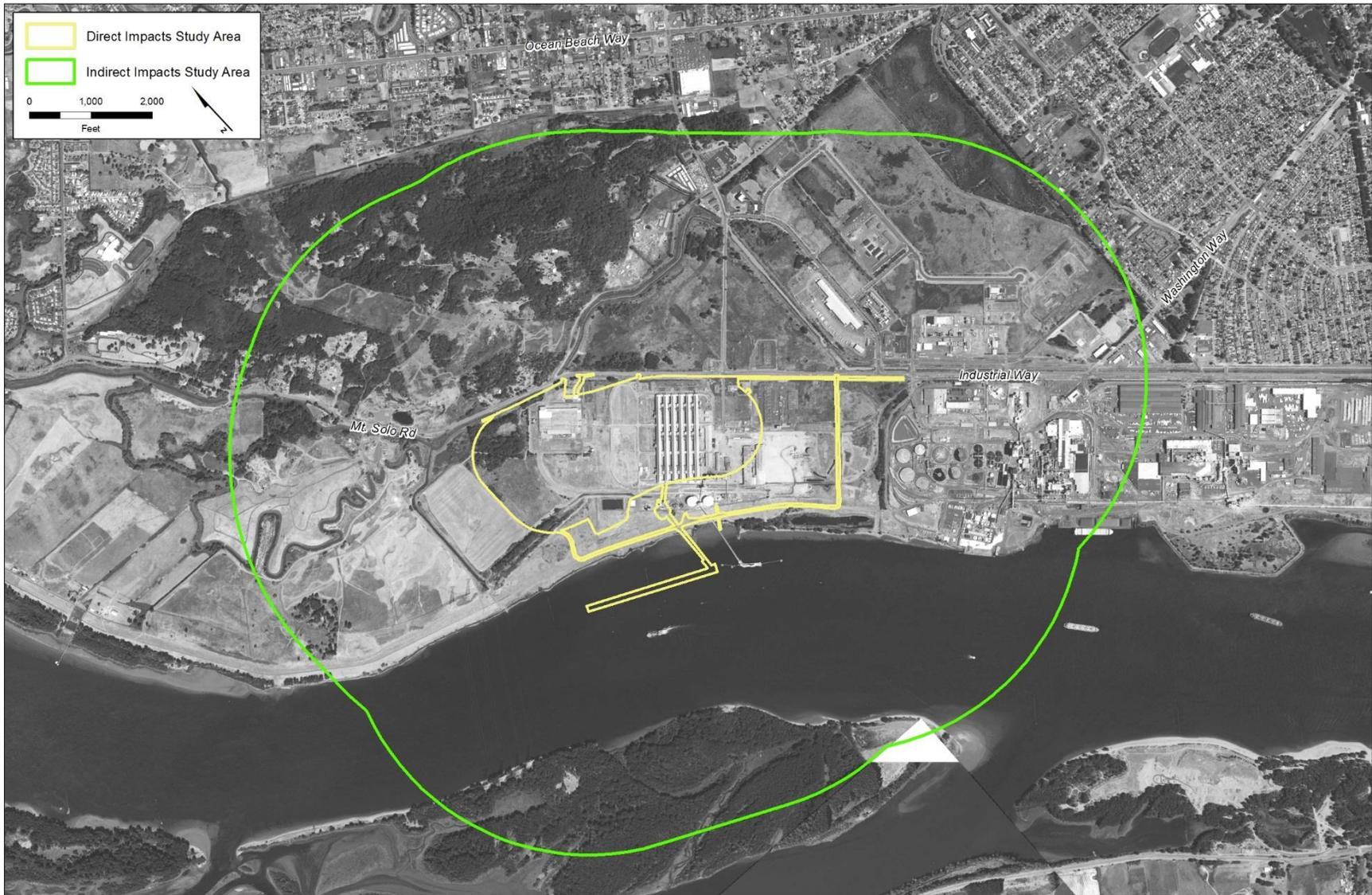
### 4.1.3.1 Information Sources

Information with respect to geology and soils was collected through review of information and reports provided by the Applicant as well as other sources of information and scientific literature, including 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 (NRCS) soil information, and geological and soil literature. Additionally, a site visit by a professional geologist conducted on January 29, 2014, provided an overview of existing conditions at the project area.

The following sources of information were used to identify the potential impacts of the Proposed Action and No-Action Alternative on geology and soils in the study area.

- USGS National Seismic Hazard Maps and associated report (U.S. Geological Survey 2013)
- Cascadia Region Earthquake Workgroup (2013) report on the Cascadia Subduction Zone earthquakes
- Washington State Department of Natural Resources Division of Geology and Earth Resources geologic mapping and geologic hazards of the Longview area (various)
- NRCS 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
- Geology and soil report prepared for the project area by the Applicant (URS Corporation 2014)

**Figure 4.1-1. Geology and Soils Study Areas**



### 4.1.3.2 Impact Analysis

The following methods were used to evaluate the potential impacts of the Proposed Action and No-Action Alternative on geology and soils.

The analysis of potential impacts related to geology and soils reviewed the following.

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

### 4.1.4 Existing Conditions

This section describes the existing environmental conditions in the study area related to geology and soils that could be affected by the construction and operation of the Proposed Action and No-Action Alternative. Broader geologic context is provided as a foundation for the site-specific analysis presented in the following section.

#### 4.1.4.1 Geology in the Project Area and Vicinity

The project area 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 in the Columbia River). Levees were constructed along the river side of the project area (Figure 4.1-2) around 1920, and the area has been used as an industrial site since the 1940s (Anchor QEA 2011). The project area is relatively level with some steep slopes that descend into drainage ditches on the northern part of the project area and to the Columbia River on the south side. Soils consist mostly of alluvium (i.e., river deposits of gravel, sand, and silt) as well as human-made sources of fill. The project area is at an elevation approximately 16 feet above sea level.

The adjacent Columbia River navigation channel is approximately 43 feet deep at low tide (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). No unique geologic physical features, such as unique geologic formations, rock outcroppings, cliffs, or soil formations, occur at the project area.

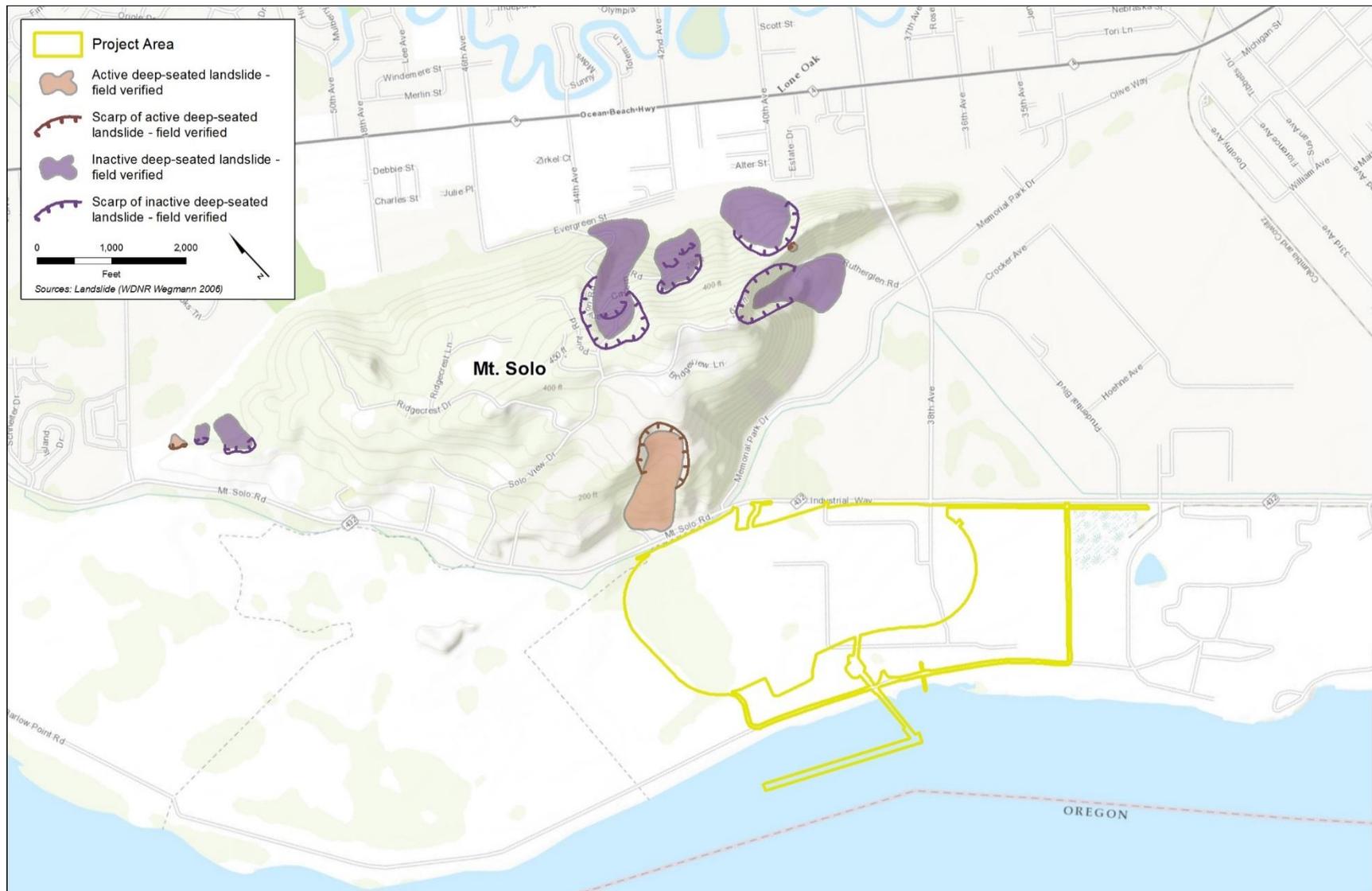
The study area exhibits attributes that are typical of the lower Columbia River valley. The regional geology is dominated by events related to the eastward movement of the Juan de Fuca tectonic plate against the North American plate (Everts et al. 2009; Parsons et al. 2005). As these plates shift, the Juan de Fuca plate descends below the North American plate and it liquefies at depth. The associated magma (lava) rises to the surface to form the volcanic Cascade mountain range.

Areas of exposed bedrock are present near the project area. These areas include Mount Solo to the immediate north of the project area (Figure 4.1-3) and Mount Coffin approximately 0.5 mile upstream of the project area (Washington State Department of Natural Resources 2014). The outermost bedrock on Mount Solo is mapped as volcanic rocks (basalt). At the study area scale, landslides are also mapped along the slopes of Mount Solo.

Figure 4.1-2. Levees in the Project Area and Vicinity



Figure 4.1-3. Landslides in the Project Area and Vicinity



## Subsurface Conditions

The soil material beneath the project area is derived from the interaction of the river and the floodplain during high flow events that deposit sediments consisting of sand, silt, and clay, as well as areas of peat (Anchor Environmental 2007; Anchor QEA 2011; GRI 2012; URS Corporation 2014). Groundwater is found between 3 and 20 feet below the ground surface, so sediments have varying amounts of water content (Anchor QEA 2011, 2013; GRI 2012; URS Corporation 2014). Geotechnical investigations indicate that the surface and near-surface sediments are soft or loose (URS Corporation 2014). These conditions indicate the potential for some settlement under the weight of certain project features, such as stockpile pads, buildings, and rail loops. Field tests indicate the potential for relatively significant settlement of these underlying materials over a long period of time (URS Corporation 2014).

Because of saturated sandy soil conditions that exist at the project area, liquefaction of soils could result from an earthquake. Geotechnical reports prepared for a previously proposed asphalt plant at the site identified the potential for post-earthquake liquefaction of soils to cause settlement of 7 to 16 inches (GeoEngineers 2007) and 12 to 16 inches (Shannon and Wilson 2008).

## Landslides and Slope Stability

Landslides were not identified as a potential risk for the Proposed Action in local slope instability reports or on-site investigations (Figure 4.1-3) (Fiksdal 1989; Wegmann 2006; Anchor Environmental 2007; GRI 2011, 2012). The project area for the Proposed Action is flat; therefore, there is a low likelihood of landslides occurring. Much of the shoreline of the Columbia River has been armored with riprap along the length of the levee adjacent to the Proposed Action. The riprap protects the levee from erosion, while the levee itself protects upland areas from flooding.

Landslides have been identified on Mount Solo. Fiksdal (1989) identified two landslide areas on the eastern flanks of Mount Solo, as well as one on the north side and another on the south side (Figure 4.1-3). More detailed mapping by Wegmann (2006) identified multiple landslides around Mount Solo. Wegmann (2006) also determined whether the features were inactive or active. One of the active landslides is on the south side of Mount Solo, meaning that it could affect the project area. This landslide is formed by the exposed bedrock that is discussed in Section 4.1.4.1, *Geology in the Project Area and Vicinity*. Landslides on Mount Solo could be caused by strong ground shaking from earthquakes or by saturated soil.

## Seismicity

Pacific Northwest earthquakes are caused by one of four possible geologic events: movements between the tectonic plates on the coastal Cascadia Subduction Zone (CSZ), subduction of the Juan de Fuca plate sinking beneath the North American tectonic plate, shallow crustal movements in the North American tectonic plate, and movements related to volcanic activity.

No great earthquakes (magnitude 8.0 to 9.0<sup>1</sup> or higher) have occurred on the CSZ during the historical record but reconstructions from the geologic record show that more than 10 great

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<sup>1</sup> The Richter scale is used to define the scale for earthquake magnitudes presented in this section.

earthquakes have occurred in Oregon and Washington over the last 5,000 years (Cascadia Region Earthquake Workgroup 2013; URS Corporation 2014). The interval in which these earthquakes reoccur is estimated at approximately 250 to 900 years with the last occurrence in 1700 (Atwater 1994; Jacoby et al. 1997).

Based on the historical record, plate movement due to the sinking of the Juan de Fuca plate under the North American plate is considered capable of causing earthquakes as large as magnitude 7.5 (URS Corporation 2014). These earthquakes generally do not have faults that reach ground level and the recurrence time is unknown. Earthquakes that were caused by this type of plate movement in Washington include the 1949 Olympia 7.1 magnitude, the 1965 Seattle 6.5 magnitude, and the 2001 Nisqually 6.8 magnitude. These earthquakes did not cause significant 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 earthquakes in the earth's crust occur over large areas. Based on data gathered and historical records in the Pacific Northwest, these earthquakes can be 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 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; Mount St. Helens is about 40 miles east of the project area. These earthquakes are associated with magma movement or volcanic faults within the Mount St. Helens seismic zone. The largest recorded earthquake beneath Cascade volcanoes was a magnitude 5.1 earthquake in 1981 (U.S. Geological Survey 2013).

### **Surface Fault Rupture**

No shallow crustal faults are active or potentially active within 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 faults are the Portland Hills and Frontal Fault–Lacamas Lake Faults that are about 40 miles to the southeast near Portland, Oregon (Wong et al. 2000; URS Corporation 2014). The Mount St. Helens Seismic Zone is a fault line about 45 miles to the east and offshore faults are about 60 miles to the west.

### **Strong Ground Shaking**

Between 1872 and 2014, earthquakes ranged in magnitude from 5.0 to 7.3 for all of Washington (URS Corporation 2014). Large earthquakes that would have affected the Longview area primarily took place in the Puget Sound area and Portland, Oregon. They range in magnitude from 5.0 to 7.1 (URS Corporation 2014). Large earthquakes would cause severe ground shaking in the Longview area including the project area.

The USGS National Seismic Hazard Maps determine earthquake ground motions for different seismic thresholds that are used for seismic requirements in building codes. These values come from evaluating all of the potential earthquakes (including their locations, depths, and likelihoods) that could affect an area. The maps display peak ground acceleration, the measure of the ground's acceleration from no motion at all to a peak motion during ground shaking. This acceleration causes

shaking and stress on structures. A peak ground acceleration in the range of 0.34 to 0.65 gravity (g) is regarded as severe shaking and could cause moderate to heavy damage to buildings or structures, depending on the duration of the event, the types of underlying materials, and the structural integrity of the affected buildings or structures (Petersen et al. 2014). The USGS map shows a peak ground acceleration in the study area of 0.4 to 0.5 g, which has a 2% chance of being exceeded in 50 years (Petersen et al. 2014).

Ground shaking is also stronger in areas of soft soils or loose deposits such as sand and silt. The Site Class Map of Cowlitz County, Washington, shows the project area as site class E, which has the softest soil conditions and highest level of potential ground shaking (Palmer et al. 2004).

Cascadia Region Earthquake Workgroup (2013) notes that underwater landslides, which could disrupt the Columbia River navigation channel and adjacent industrial and commercial berthing areas, also pose a ground shaking and liquefaction hazard to the area.

### **Secondary Seismic Hazards: Liquefaction and Subsidence**

Liquefaction occurs when stress such as ground shaking causes saturated or partially saturated soil to lose its strength and act like a fluid. The project area has potential for liquefaction during ground shaking. The Liquefaction Susceptibility Map of Cowlitz County, Washington, shows the area as having high liquefaction potential (Palmer et al. 2004). The area is underlain by hundreds of feet of gravel, sand, silt, and organic layers. The sandy layers can liquefy during strong ground shaking and then could flow or lose stability, and no longer support the ground above them. The flowing layers could flow horizontally or vertically depending on the adjacent layers and whether the liquefying layer could exit the ground (e.g., by flowing out of an adjacent slope or river channel or coming out at the surface by forming one or more sand volcanos<sup>2</sup>).

The geologic record provides evidence of liquefaction potential along the Columbia River. Previous investigations at the site for a proposed asphalt plant resulted in similar estimates for settlement from liquefaction that range from 7 to 16 inches for a CSZ earthquake ranging from magnitudes 7.4 to 8.3, though this varies with location.

### **Volcanic Hazards**

The main volcanic hazard at Longview is from airborne fragments, ash fall, and lahars (volcanic mudflows) reaching, and continuing down, the Columbia River. Active volcanoes within the Cascade Range lie to the east of Longview, with the closest active volcano being Mount St. Helens about 40 miles to the east. The project area does not lie within the Cowlitz County designated volcanic flowage hazard zone 1 (within a 5-mile radius of volcanic activity). USGS estimates the annual chance of ash fall greater than 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).

Lahars originating from the south flank of Mount Rainier in the upper Cowlitz River are unlikely to reach the lower Cowlitz River (Cakir and Walsh 2012). Lahars have been documented upstream along the Sandy River draining from Mount Hood in Oregon (Pierson et al. 2009) at approximately 55 miles upstream of Longview. Lahars from Mount Adams could reach the Columbia River via the

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<sup>2</sup> A sand volcano is a cone of sand formed by the ejection of sand onto the surface from a central point. The cone looks similar to a volcano. The process is often associated with earthquake liquefaction and the ejection of fluidized sand that can occur in water-saturated sediments during an earthquake.

White Salmon River; its confluence is more than 100 river miles upstream of Longview. The Longview area is not within the Cowlitz County-designated volcanic flowage hazard zone 3, which would require an evacuation and emergency management plan.

### **Mine Hazard Areas**

Mine hazard areas in Cowlitz County are mainly associated with historical coal mining and areas affected by mine workings such as adits, tunnels, drifts, or airshafts. There is no bedrock with coal along the Columbia River in the Longview area.

### **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 (river mile 15, approximately 50 miles downstream of the project area) (Walsh et al. 2000; Washington State Department of Natural Resources 2010; Oregon Department of Geology and Mineral Industries 2012). 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).

### **Sea Level Rise**

Sea levels are rising. However, some areas of the Pacific Northwest are experiencing uplift; by contrast, areas around Puget Sound are subsiding and experiencing larger-than-average impacts from rising sea levels. Sea level rise in the Pacific Northwest is expected to be as little as 5 inches or less to more than 4 feet by the end of the century. The project area is approximately 60 miles inland from the mouth of the Columbia River, and sea level rise at the project area is expected to be minimal. Further, the project area is behind Columbia River levees of approximately 36 feet above sea level, and since this is higher than the potential sea level rise, there would not be any impacts on soils on the project area or an increased risk of erosion. Sea level rise is discussed further in Chapter 5, Section 5.8, *Greenhouse Gas Emissions and Climate Change*.

#### **4.1.4.2 Soils in the Project Area and Vicinity**

Cowlitz County soils have been mapped by NRCS (Natural Resources Conservation Service 2013). These soil units and some of their characteristics are shown in Table 4.1-2. Excluding water, five soil units are mapped at the project area (Figure 4.1-4). All of these soil units reflect the alluvial (river deposit) origin of the soil material and are relatively fine-grained.

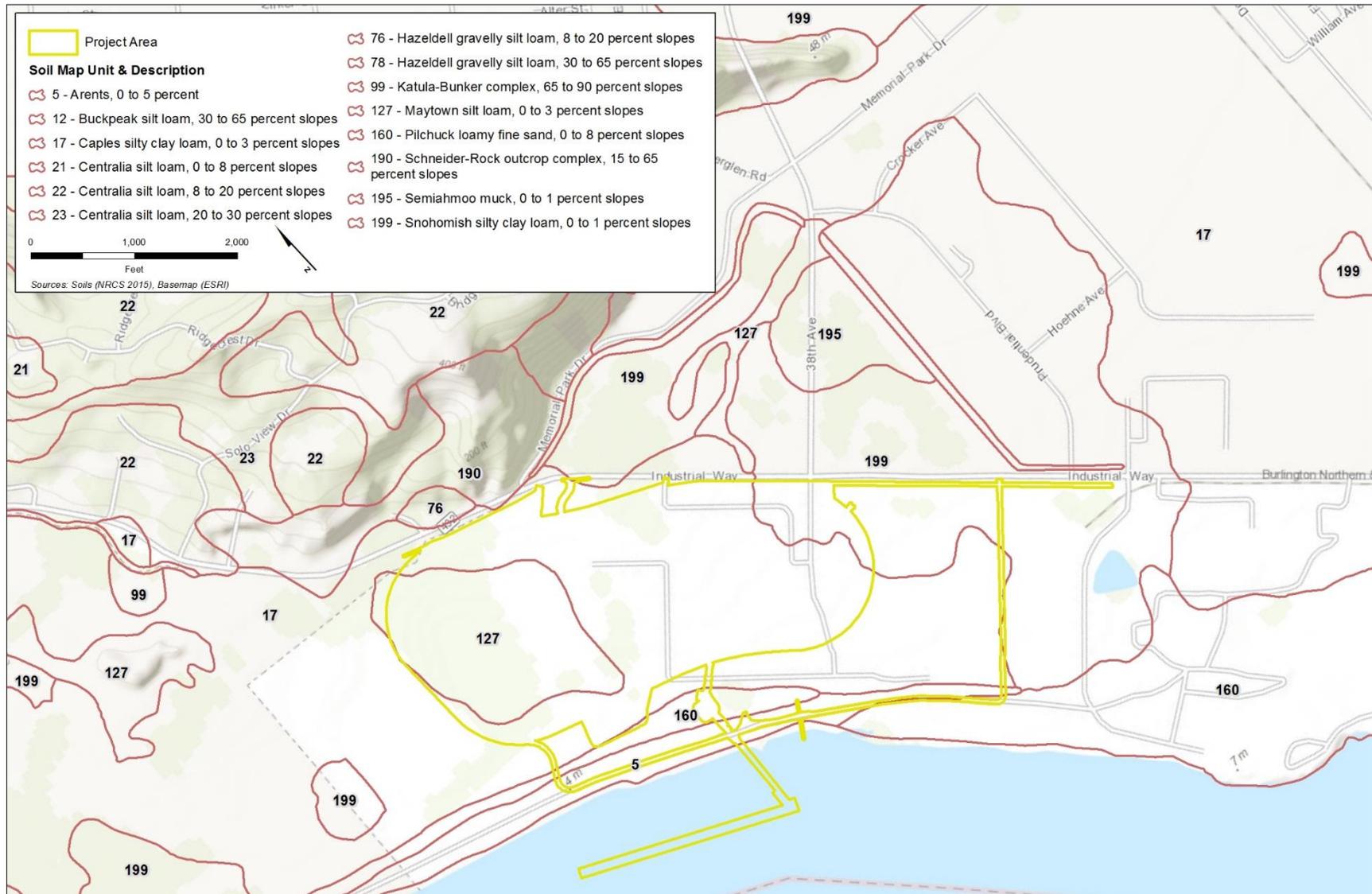
The erosion hazard is considered slight for all of the soils in the study area. The K factor<sup>3</sup> indicates a soil's vulnerability to erosion. The higher the soil's K factor, the higher its erosion potential. Based on the K factor, the Caples silty clay loam (Map Unit Number 17), the Maytown silt 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 in regards to their potential for corrosion of concrete. Several engineering measures address concrete and steel corrosion, such as improving drainage and replacing native soil with fill (Washington State Department of Transportation 2014).

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<sup>3</sup> K factor is a soil erodibility factor which represents both susceptibility of soil to erosion and the rate of runoff.

Figure 4.1-4. Soil Types in the Project Area and Vicinity



A soil's linear extensibility is the measure of its potential to expand during wetting and to contract during drying. The more a soil expands the more potential it has to affect overlying materials such as structure foundations. 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). The values in Table 4.1-2 are provided as a percent expansion and a descriptive classification (class).

The above discussion relates to the naturally occurring soils at the project area. However, the project area has been an industrial site since the 1940s and has had various amounts of surface disturbance and fill material (sand, silt, mixed silt and sand, large gravel, and crushed rock [Anchor QEA 2011; GRI 2011, 2012]) placement. Due to the industrial use, site-specific surface soil materials could vary from NRCS mapping. Data reports for the project area indicate varying areas of fill materials, particularly under existing structures.

**Table 4.1-2. Soils and Soil Properties in the Project Area**

Map Unit Number <sup>a</sup>	Soil Map Unit Name	Drainage Class	K Factor <sup>b</sup>	Erosion Hazard	Corrosion of Concrete <sup>c</sup>	Corrosion of Uncoated Steel <sup>d</sup>	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:

- <sup>a</sup> 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.
- <sup>b</sup> The potential for concrete corrosion increases decreasing water and soil acidity and increases in sodium, magnesium sulfate, and sodium chloride.
- <sup>c</sup> The potential for corrosion of uncoated steel increases with soil water saturation, greater water acidity and conductivity.

Source: Natural Resources Conservation Service 2013

N/A = not applicable

## 4.1.5 Impacts

This section describes the potential direct and indirect impacts related to geology and soils that would result from construction and operation of the Proposed Action and the No-Action Alternative.

### 4.1.5.1 Proposed Action

This section describes the potential impacts that could occur in the study area<sup>4</sup> as a result of construction and operation of the Proposed Action.

Construction activities could affect geology and soils directly through ground disturbance associated with construction of the coal export terminal and preloading of the coal stockpile areas. Operational activities could affect geology and soils indirectly through exposure of people and structures to potential effects from catastrophic events

#### Construction—Direct Impacts

Construction-related activities associated with the Proposed Action could result in direct impacts as described below. As explained in Chapter 2, *Project Objectives, Proposed Action, and Alternatives*, construction-related activities include demolishing existing structures and preparing the site, constructing the rail loop and dock, and constructing supporting infrastructure (i.e., conveyors and transfer towers).

#### Enlarge Land, 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 depositing sediments 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 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 involve ground-disturbing activities such as grading, railroad construction, excavating for foundations, and road construction that would affect about 190 acres of land. Approximately 2.1 million cubic yards of material would be imported for compressing soils on site, as well as about 130,000 cubic yards of ballast rock for rail-related structures and infrastructure. 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 4.1.4.2, *Soils in the Project Area and Vicinity*, and shown in Table 4.1-2, although the soils in the project vicinity have a moderate to high potential for erosion, the on-site soils have a slight erosion hazard mainly due to the site's flat, low gradient. Bare soil could be exposed for varying periods of time due to construction activities over several years. This could lead to potential soil erosion due to rainfall or wind. Soil erosion would have the potential for off-site transport of eroded soil materials to waterways such as the Columbia River and adjacent ditches. Wind erosion potential would be limited—because of the precipitation levels that occur at the site and proposed dust suppression during construction to control wind erosion—but could occur during summer dry periods. Dust from coal stockpiles is addressed in Chapter 5, Section 5.6, *Air Quality*. When build-out is complete, the project area would be approximately 90% impervious surfaces, which would reduce soil erosion potential to near zero.

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<sup>4</sup> Acreages presented in the impacts analysis were calculated using geographic information system (GIS) technology, thus, specific acreage of impacts are an estimate of area based on the best available information.

As described in Chapter 2, Section 2.2.3, *Proposed Facilities, Construction, and Operations*, 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). Potential impacts of disposal of dredge material on water quality and surface waters are addressed in Section 4.2, *Surface Water and Floodplains*, and Section 4.5, *Water Quality*.

### **Affect Project Structures from Soil Materials Underlying the Site**

As discussed in Section 4.1.4.2, *Soils in the Project Area and Vicinity*, and shown in Table 4.1-2, 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. Impacts related to corrosion of project-related structures and infrastructure would be avoided through standard engineering and construction methods. Washington State Department of Transportation (2014) uses a variety of standard engineering measures to address concrete and steel corrosion such as improving drainage and replacing native soil with fill. Such standard engineering measures would be employed by the Applicant to ensure potential soil related corrosion would not occur.

The sediments beneath the project area are relatively fine-grained and water-saturated, and the water table is near the ground surface. These characteristics make the sediments vulnerable to compaction from the weight of overlying materials and structures. This vulnerability is mainly a concern for the coal stockpile areas on the project area due to the coal's weight. Thus, preloading and installing wick drains is required to expel the groundwater and consolidate soils beneath the stockpile areas prior to operations. Compaction would be less of a 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 importing material to compact the underlying soil to improve its load-bearing capacity. Approximately 2.1 million cubic yards of material would be imported into the coal stockpile areas in stages over a period of up to 7 years. Preloading would provide soil compaction to avoid potential impacts associated with soil settlement during operations.

### **Construction—Indirect Impacts**

Construction of the Proposed Action would not result in indirect impacts on geology and soils because construction impacts would be immediate and would be limited to the project area. Therefore, no construction impacts would occur later in time or farther removed in distance from the direct impacts on the project area as discussed previously.

### **Operations—Direct Impacts**

Operation of the Proposed Action would result in the following direct impacts. Operations-related activities are described in Chapter 2, *Project Objectives, Proposed Action, and Alternatives*.

## **Expose People or Structures to Potential Effects Involving Catastrophic Events**

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 (liquefaction), landslides, and tsunamis. Thus, potential effects from these types of catastrophic events were evaluated.

### **Earthquake Faults**

There are no known earthquake faults in the study area that reach the ground surface. Therefore, no ground surface ruptures could directly damage structures or buildings in the study area.

### **Ground Shaking**

The project area and surrounding 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 peak ground acceleration 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. As per the Cowlitz County Critical Areas Protection Ordinance (Cowlitz County Code 19.15), construction of the Proposed Action would be required to comply with International Building Code 16.05 and Cowlitz County Grading Ordinance 16.35, as applicable. Additionally, a geotechnical report would be prepared as part of the Proposed Action and would inform project design and construction techniques, which would likely reduce potential impacts associated with ground shaking.

### **Seismic-Related Ground Failure (Liquefaction)**

The study area could be subject to liquefaction during strong ground shaking. Palmer et al. (2004) characterizes the area as having high liquefaction susceptibility. An investigation of the area that was conducted for a previously proposed asphalt plant indicated that settlement after liquefaction would vary with earthquake location and earthquake magnitude. The investigations concluded that ground settling due to post-liquefaction settlement could damage the proposed structures and buildings. The Proposed Action would comply with the adopted International Building Code (per Cowlitz County Code 16.05 and 16.35 Grading Ordinance). Preloading 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 likely 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 further reduce potential impacts based on the potential susceptibility of liquefaction.

### **Landslides**

There are no existing landslides in the study area. Strong ground shaking associated with earthquakes would have minimal potential to cause new landslides in the study area, because the area 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 side of Mount Solo, but it is approximately 250 feet from the edge of the estimated greatest extent of the landslide, more than the 50 feet required by the Cowlitz County Critical Areas Ordinance 19.15 for landslide hazards. However, as with all landslides, periods of prolonged and intense rainfall (including multiyear periods) or earthquake-caused ground shaking could trigger this landslide. However, because the project area is approximately 200 feet beyond the minimum distance required by the Cowlitz County Critical Areas Ordinance (CCC 19.15) and it is physically isolated from the landslide, the Proposed Action would not increase the risk that a landslide would occur.

### **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. 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 project-area structures or operations, including ships at the docks.

## **Operations—Indirect Impacts**

Operation of the Proposed Action would not result in any indirect impacts on geology or soils because operations would not result in any further changes to soils or geology that may occur later in time of further removed in distance than the direct impacts.

### **4.1.5.2 No-Action Alternative**

Under the No-Action Alternative, the Applicant would not construct the coal export terminal and ongoing operations in the project area would continue and additional storage and transfer activities might occur using existing buildings and structures and impacts on geology and soils related to the Proposed Action would not occur. The Applicant would continue with current and future increased operations in the project area. The project area for the Proposed Action could be developed for other industrial uses including an expanded bulk product terminal or other industrial uses. However, no activities that would require a U.S. Army Corps of Engineers permit or shoreline permit would occur as part of the No-Action Alternative. New construction, demolition, or related activities to develop the project area into an expanded bulk terminal could occur on previously developed upland portions of the area.

## **4.1.6 Required Permits**

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

- **Fill and Grade Permits/Building Permits—Cowlitz County.** Fill and grade permits and building permits would be required from Cowlitz County to ensure that final design and construction follow the County and engineering requirements.
- **Critical Areas Permit—Cowlitz County.** The Proposed Action would require a Critical Areas Permit to address compliance with Cowlitz County's Critical Areas Ordinance related to the presence and protection of Critical Aquifer Recharge Areas located on site.

- **Construction Stormwater Permit—Washington State Department of Ecology.** A Construction Stormwater Permit would be required from the Washington State Department of Ecology to address erosion control and water quality during construction.
- **Industrial Stormwater Permit—Washington State Department of Ecology.** An industrial Stormwater Permit would be required from the Washington State Department of 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. Best management practices 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.
- A site-specific preloading plan would be developed prior to initiating construction of the Proposed Action by the geotechnical engineer working with the 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- 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 resulted in changes to the surface conditions (i.e., soil settlement, structural damage).
- 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 facility 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.

#### 4.1.7 Proposed Mitigation Measures

No impacts on geology and soils from construction and operation of the Proposed Action have been identified that would require mitigation. Nor have impacts on the Proposed Action from geologic events been identified that would require mitigation. Thus, no mitigation measures are proposed for geology and soils.

## **4.1.8 Unavoidable and Significant Adverse Environmental Impacts**

Compliance with laws and required plans described above would reduce impacts on geology and soils. There would be no expected unavoidable and significant adverse environmental impacts on geology and soils in the study area related to the Proposed Action.