CHAPTER 3. EARTH

3.1 HOW WERE EARTH RESOURCES IN THE STUDY AREAS EVALUATED?

This chapter describes earth resources in the combined study area (Alternatives 1, 2, and 3 as depicted on Figure 1-4 in Chapter 1) at a programmatic level. Geology and soils information was obtained from U.S. Geological Survey (USGS) data (including GEOMapNW)[1], and *critical areas* mapping was obtained from study area communities. No site visits were conducted at this stage, largely due to the vast geographical extent of the study area and the programmatic approach to the analysis. In addition to the USGS data, the following sources were reviewed to obtain the data presented in this chapter:

Earth Key Findings

Seismic and geotechnical hazards including ground shaking, liquefaction, landsliding, coal mines and other hazards are present throughout the area. Impacts under all alternatives would be minor with implementation of BMPs, geotechnical recommendations, regulatory requirements, and industry standards.

- Natural Resources Conservation Service's soil surveys for King County (NRCS, 2015);
- King County geographic information systems (GIS) web portal (King County, 2015); and
- Information from the Cascadia Region Earthquake Workgroup (City of Seattle, 2015).

3.2 WHAT ARE THE RELEVANT PLANS, POLICIES, AND REGULATIONS?

This section provides the relevant regulatory framework including plans, policies, and regulations related to geology and soil resources that would apply to the alternatives proposed in Chapter 2. The National Electric Safety Code (NESC) establishes basic provisions for safeguarding of persons from hazards arising from the installation, operation, or maintenance of (1) conductors and equipment in electric substations, and (2) overhead and underground electric supply and communication lines. The NESC is adopted by the state public utility commission (in Washington it is the Utilities and Transportation Commission or UTC), and utility providers must adhere to it. The NESC also includes work rules for the construction, maintenance, and operation of electric supply and communication lines and equipment. The standards are applicable to the systems and equipment operated by utilities, or similar systems and equipment, of an industrial establishment or complex under the

[1] Geologic mapping in the Pacific Northwest urban corridor is a cooperative effort among the USGS, Washington Division of Geology and Earth Resources, Oregon Department of Geology and Mineral Industries, University of Washington (GeoMapNW), Oregon State University, and Portland State University.

control of qualified persons. This standard consists of the introduction, definitions, *grounding rules*, list of referenced and bibliographic documents, and Parts 1, 2, 3, and 4 of the 2012 Edition of the National Electrical Safety Code (IEEE, 2012).

Grounding is a means to provide safety to electrical workers and any people who may come in contact with structures such as streetlights, mast arms, metal poles, and guy wires. The NESC provides rules on grounding components as a means to safeguard any person from injury that could be caused by electrical potential.

Washington State's Growth Management Act (GMA) requires all cities and counties to identify critical areas within their jurisdictions and to formulate development regulations to protect these areas (Chapter 36.70A RCW). Among the critical areas designated by the GMA are *geologic hazard areas*, which are areas susceptible to erosion, sliding, earthquake, or other geologic events. These hazards could affect the design, construction, and operation of the project and, if not considered appropriately, could pose a risk to public safety.

As required by the GMA, each city and most of the towns in the combined study area have codes regulating development in or near geologic hazard areas (including building codes). These codes and local policies require measures to address hazards such as slope instability, largely through avoidance by adhering to setbacks (unless a geotechnical slope stability investigation can demonstrate feasibility). Projects are not allowed to increase the potential for slope failure, and they must adhere to performance standards for construction in geologically hazardous areas. Other hazards, such as *liquefaction* and ground shaking, are addressed through implementation of building code standards that include seismic design measures. Feasibility is typically demonstrated through a site-specific geotechnical investigation that identifies underlying soil and bedrock properties, geotechnical hazards, and whether identified hazards can be overcome through application of geotechnical engineering recommendations.

The Washington State Building Code Council (SBCC) was created to advise the Legislature on building code issues and to develop the building codes used in Washington State. These codes help to ensure buildings and facilities constructed in the state are safe and healthy for building occupants, workers, and the public and provide regulations to address various geologic and soils conditions. The state building code is modeled on the 2012 International Building Code and is combined with Washington State amendments. The building code includes requirements for site preparation and foundations for aboveground improvements that represent new loadings (i.e., placement of new structures that require bearing more weight than previously).

Petroleum pipelines are regulated by the U.S. Department of Transportation under the Pipeline and Hazardous Materials Safety Administration (PHMSA). PHMSA's mission is to protect people and the environment from the risks of *hazardous materials* transportation by setting national policy, enforcing standards, and conducting research to prevent incidents. Pipeline safety regulations are contained in Code of Federal Regulations (CFR), Title 49 Parts 190 to 199. In the state of Washington, the UTC is responsible for developing and enforcing safety standards for natural gas and hazardous liquid pipelines located within the state.

Erosion hazards are typically addressed through drainage control requirements both during and after construction. Typically, local jurisdictions have clearing and grading requirements within the grading permit process to ensure that earth-disturbing construction activities are conducted in a manner that protects topsoil and minimizes the potential for erosion. Following the construction period, local drainage control requirements include design measures to ensure that stormwater runoff is managed in a way that also minimizes the potential for erosion.

3.3 WHAT EARTH RESOURCES AND GEOLOGIC HAZARDS ARE PRESENT IN THE COMBINED STUDY AREA?

3.3.1 Regional Geology and Topography

The combined study area is located in the central portion of the *Puget Sound basin*, an elongated, north-south trending depression in western Washington between the Olympic Mountain Range to the west and the Cascade Mountain Range to the east. The regional topography is characterized by a series of north-south trending ridges separated by deep troughs that are now known as Puget Sound, Elliott Bay, Lake Washington, and Lake Sammamish. Land elevations range from about zero up to approximately 3,000 feet above mean sea level at Tiger Mountain (National Geodetic Vertical Datum 29).

The regional topography was formed by the movement of glaciers over thousands of years. The glaciers were up to several thousand feet thick, and soils that were present beneath them are generally very hard and compacted as a result of the weight of the glaciers. More recently, erosional processes and landform changes resulting from human development have modified the regional topography. Geology in the region generally includes recent, surficial soils over a thick sequence of glacially consolidated soils and then bedrock. Subsurface conditions may vary greatly and unpredictably over short distances, and project planners frequently must contend with multiple geological concerns (e.g., expansive soils, artificial fills, corrosive soils, and liquefiable soils) for linear projects such as transmission lines.

3.3.2 Soils

The EIS Consultant Team reviewed soils data available from the Natural Resources Conservation Service (NRCS) Soil Survey Data (NRCS, 2015). The NRCS categorizes soils of similar composition into what are called soil series. Table 3-1 provides the soil series identified and their approximate portion of the combined study area.[2]

[2] Table 3-1 only provides soil series that were quantified above 0.2 percent because of the number of series that were identified in smaller percentages. The table also does not include the amount of surface water in the study area, which was calculated at approximately 5.5 percent.

Table 3-1. Soils in Combined Study Area

Soil Series	Percent of Study Areas
Alderwood	44.7
Everett	10.7
Arents	8.0
Beausite	6.3
Ovall	3.4
Kitsap	2.7
Urban Land	2.6
Seattle Muck	2.2
Indianola	2.2
Bellingham	1.3
Neilton	1.0
Sammamish	0.9
Puyallup	0.9
Briscot	0.8
Ragnar	0.8
Norma	0.6
Pits	0.5
Puget	0.5
Earlmont	0.5
Mixed Alluvial Land	0.4
Pilchuck	0.4
Tukwila Muck	0.3
Riverwash	0.2
Shalcar Muck	0.2
Snohomish	0.2
Sultan	0.2

Source: NRCS, 2015.

As shown in Table 3-1, the Alderwood series makes up the soil in almost half of the combined study area. It consists of Alderwood gravelly sandy loam on zero to 8 percent slopes (1.4 percent), Alderwood gravelly sandy loam on 8 to 15 percent slopes (32.2 percent), Alderwood gravelly sandy loam on 15 to 30 percent slopes (5.8 percent), and Alderwood combined with Kitsap soils on very steep slopes (5.3 percent). The Alderwood series is derived from glacial drift or outwash and is moderately well drained. Erosion hazard (also discussed below) for the Alderwood series is slight on slopes of zero to 6 percent, slight to moderate on slopes of 6 to 15 percent, and severe to very severe on slopes greater than 15 percent. Slippage potential along the geologic contact between the till deposits and the underlying native deposits is moderate to severe on slopes greater than 15 percent (NRCS, 2015).

The Everett soils series is the next most prominent group of soils mapped in the combined study area. It consists of gravelly sandy loam on zero to 5 percent slopes (3.1 percent), gravelly sandy loam on 5 to 15 percent slopes (5.5 percent), gravelly sandy loam on 15 to 30 percent slopes (1.2 percent), and gravelly sandy loams mixed with Alderwood series soils (0.9 percent). Erosion hazard for Everett soils is slight on slopes of zero to 6 percent, slight to moderate on slopes of 6 to 15 percent, and severe to very severe on slopes greater than 15 percent (NRCS, 2015).

The Arents series is also fairly prominent and consists of till plains derived from basal till. Runoff on Arents soils is generally slow, and the erosion hazard is slight (NRCS, 2015).

3.3.3 Geologic Hazards

An important consideration for the construction and operation of the alternatives would be the potential to encounter geologic hazards, including steep slopes, erosion, landslides, seismic hazards, and other hazards such as soft soils.

3.3.3.1 Steep Slope Hazards

Steep slope hazards are generally characterized as areas where slopes are steeper than 15 percent or have shown evidence of past slope failure. The state legislature (WAC 365-190-120) defines landslide hazard areas as areas of historic failures, inclines of 15 percent or more containing a geologic contact or groundwater seepage, and bedrock slopes of greater than 40 percent. However, steep slope hazards can occur wherever the force of gravity becomes greater than either friction forces or the internal strength of the rock, soil, or sediment. Slope hazard areas are considered hazards because they are prone to landslides, either during periods of wet weather which reduces friction, as a result of human activities such as grading, or during seismic events. *Landslide hazard areas* are identified in Figure 3-1.

3.3.3.2 Erosion Hazards

Erosion hazards occur where soils may experience severe to very severe erosion from construction activities or through changes in surficial conditions that expose soils to new erosive forces. Erosive forces can come from precipitation, changes in drainage patterns, removal of vegetation, wind, or wave action. Certain types of soil, such as silts, are generally more prone to erosion hazards. The potential for erosion also increases as the slope steepness increases. Surficial soils and topographic maps can be used to identify areas that are particularly susceptible to erosion.

The NRCS rates soils based on an erosion factor "K," which indicates the susceptibility of a soil to *sheet* and *rill erosion* by water (NRCS, 2015). Factor K is one of six factors used to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic m atter and on soil structure and s*aturated hydraulic conductivity* (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. The Factor K values for the soils within the study areas range from 0.05 (Everett series on zero to 5 percent slopes) up to 0.43 (Earlmont series and Ellwell series on 30 to 60 percent slopes). Figure 3-1 illustrates areas of high erosion hazard mapped by local jurisdictions in accordance with the GMA.

Sheet erosion is the uniform removal of soil in thin layers by the forces of overland stormwater flow.

Rill erosion is the removal of soil by concentrated water running through little streamlets, or headcuts.

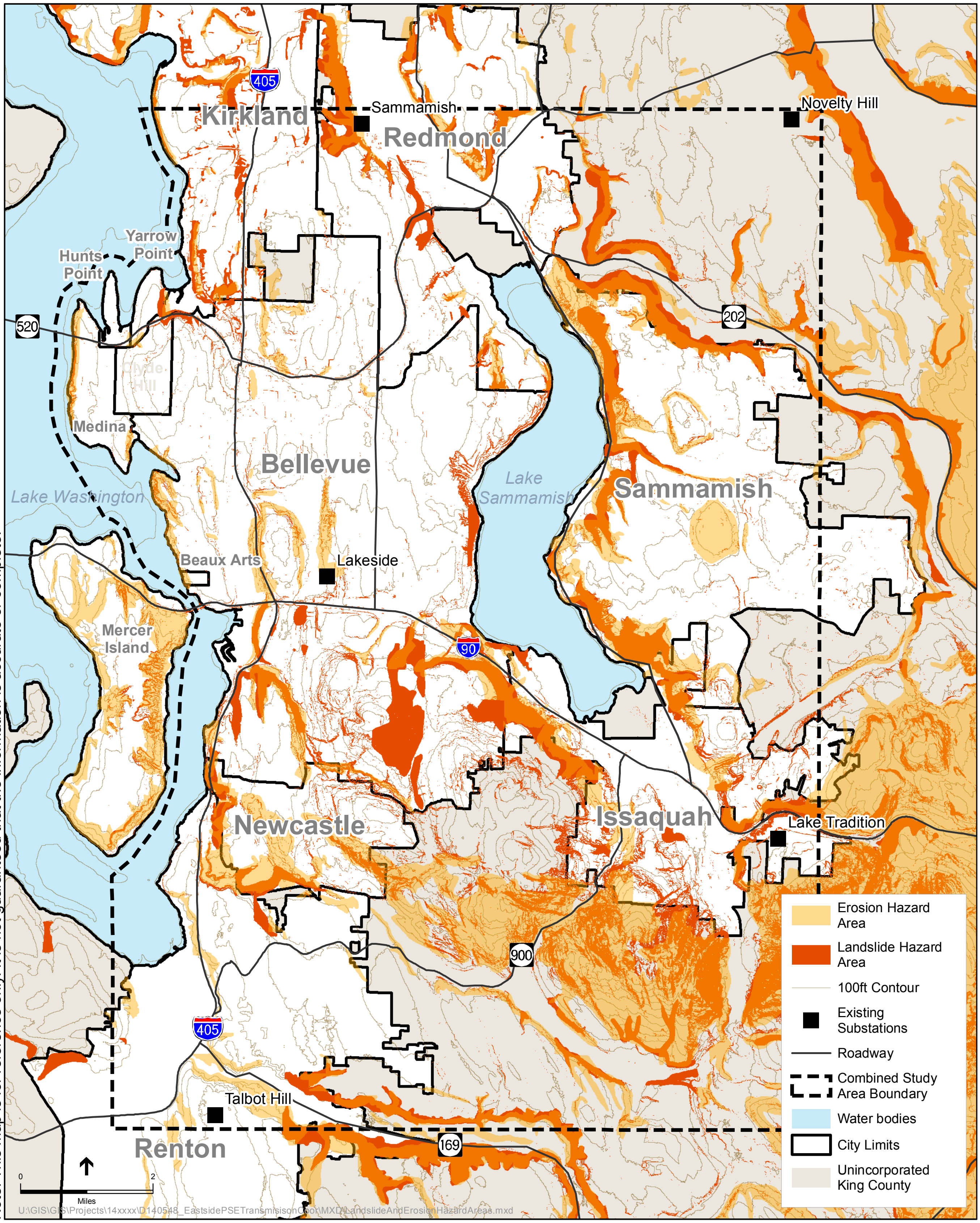
Saturated hydraulic conductivity is a property that describes the ease with which a fluid (usually water) can move through saturated media such as soil.

A **perched water table** occurs above the regional water table, in the vadose zone, when there is an impermeable layer of rock or sediment that can suspend the water there.

3.3.3.3 Landslide Hazards

Landslide hazard areas are mapped by local jurisdictions in accordance with the GMA. They include areas where there is evidence of past landslides, where the slope is 15 percent to 40 percent and the soils are underlain by silt or clay that can *perch* groundwater, or where the slope is steeper than 40 percent, regardless of soil type. This type of hazard is closely associated with the steep slope hazard. Landslide hazard areas identified within the combined study area are shown in Figure 3-1.

Note: This map is for reference only. It is not guaranteed that the information is accurate or complete.



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SOURCE: King County 2015; Sammamish 2015; Issaquah 2015; Bellevue 2015; Kirkland 2015; Redmond 2015; ESA 2015; WA Ecology 2014.
For more info visit www.energizeeastsideeis.org/map-landslide-erosion

Energize Eastside EIS 140548

Figure 3-1

Landslide and Erosion Hazard Areas

3.3.3.4 Seismic Hazards

The Puget Sound basin is located within a seismically active area dominated by the Cascadia *subduction zone*, which forms the boundary between two tectonic plates: the North American plate and the Juan de Fuca plate. The project vicinity has been subject to earthquakes in the historic past and will undoubtedly undergo shaking again in the future.

Subduction is the process when one tectonic plate moves under another and sinks into the mantle as the plates converge.

Crustal faults refer to the deformation caused by tectonic forces that are accumulated in the earth's crust (generally the upper 20 to 30 miles of the earth's surface).

Earthquakes in the Puget Sound region result from one of three sources: the Cascadia subduction zone off the coast of Washington, the deep intraslab subduction zone located approximately 20 to 40 miles below the Puget Sound area, or shallow *crustal faults*.

1. The Cascadia subduction zone shapes the geography of northern California, Oregon, Washington, and southern British Columbia, where the North American plate collides with a number of smaller plates. The largest of these is the Juan de Fuca plate, flanked by the Explorer plate to the north and the Gorda plate to the south. These smaller plates "subduct" (descend) beneath the North American plate as they converge along a 700-mile-long boundary. A large portion of the boundary between the subducting and overriding plates resists the convergent motion, until this part of the boundary releases the stored energy in an earthquake.

2. The closest active crustal source is the Seattle Fault Zone which runs roughly east-west in south Bellevue and roughly parallel to *Interstate 90* (see Figure 3-2). A fault is considered active when it has shown evidence of displacement within the last 11,000 years. An earthquake on the Seattle Fault poses the greatest risk to the Seattle urban region (City of Seattle, 2015).

3. Deep quakes are the most common large earthquakes that have occurred in the Puget Sound region. Quakes larger than magnitude 6.0 occurred in 1909, 1939, 1946, 1949, 1965, and 2001 (City of Seattle, 2015). However, shallow quakes are the type expected on the Seattle Fault Zone, which can create more damage than deep quakes because of the proximity to the epicenter. Damage from earthquakes depends on many factors including distance to epicenter, soil and bedrock properties, and duration of shaking.

Seismic hazards include the primary effects of earthquakes, such as ground displacement from fault rupture and ground shaking, as well as secondary effects including liquefaction, *settlement*, tsunamis, and *seiche waves*. These scenarios are defined below.

3.3.3.4.1 Earthquake-induced ground rupture

Defined as the physical displacement of surface deposits in response to an earthquake's seismic waves. The magnitude, characteristics, and nature of fault rupture can vary for different faults or even along different strands of the same fault. Strong ground shaking from a major earthquake can produce a range of intensities experienced at any one location.

Ground shaking may affect areas hundreds of miles distant from the earthquake's epicenter. The ground shaking can result in slope failure, settlement, soil liquefaction, tsunamis, or seiches, all of which pose a risk to the public. Areas considered to be of high seismic risk are depicted in Figure 3-2.

3.3.3.4.2 Liquefaction

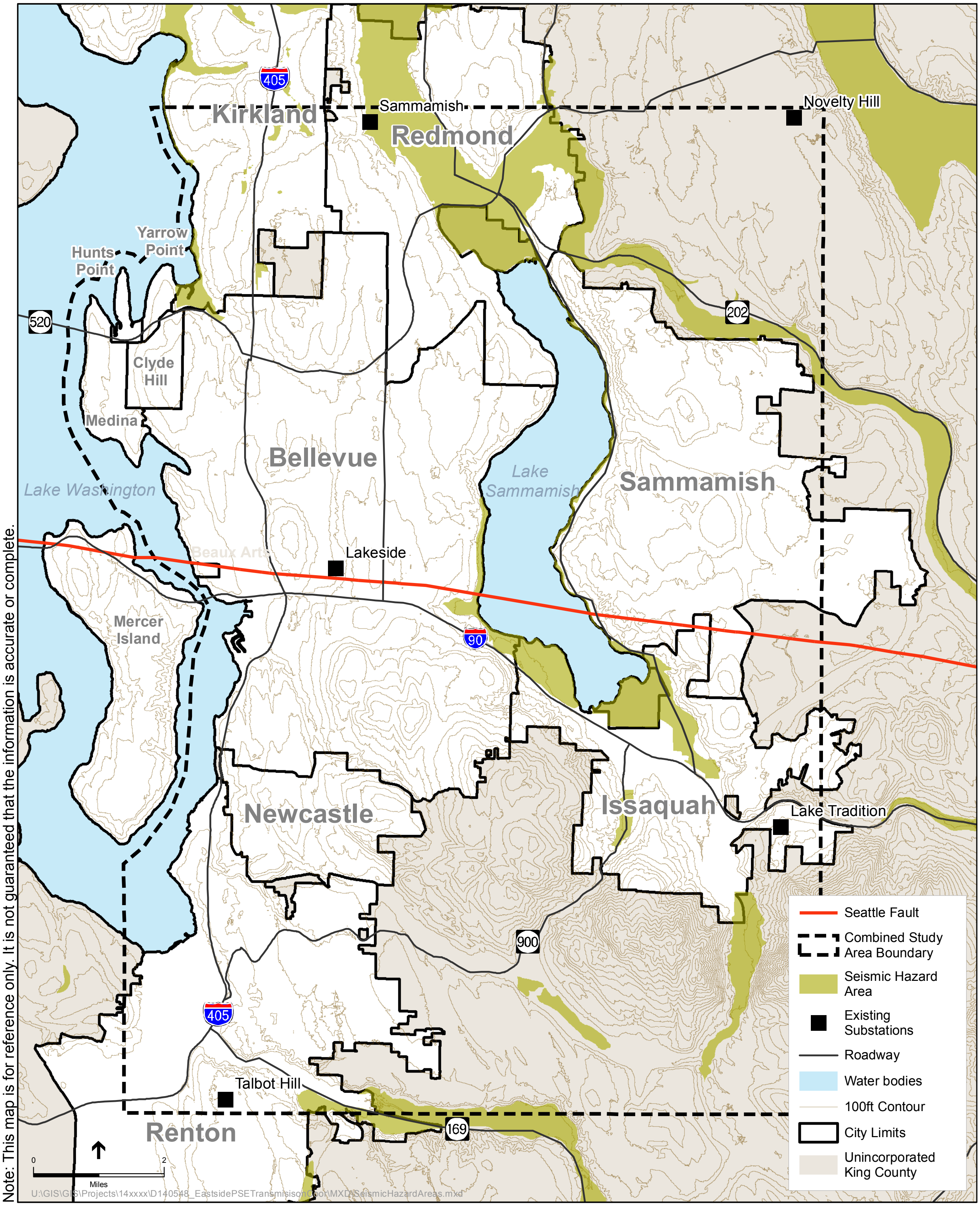
Of particular concern because it has often been the cause of damage to structures during past earthquakes. Liquefaction occurs where soils are primarily loose and granular in consistency and located below the water table. Saturated loose soils that are found within 50 feet of the ground surface are considered at most risk of liquefaction. The consequences of liquefaction include loss in the strength and settlement of the soil. The loss of strength can result in lateral spreading, bearing failures, or flotation of buried utility vaults and pipes. Seismic hazard areas identified in Figure 3-2 are those areas where the foundation soils are considered to be subject to liquefaction or lateral spreading during an earthquake (but could also be susceptible to seismically induced settlement). Typically, these soils are found in low-lying areas near bodies of water, such as along the larger streams and around lakes where is a high probability of loose saturated alluvial soils. In the combined study area, areas such as lowland lakeside areas of the northern and southern tips of Lake Sammamish, as well as the floodplains of the Cedar River and Evans Creek, contain areas considered susceptible to liquefaction.

3.3.3.4.3 Tsunamis or seiches

Possible secondary effects from seismic events. Tsunamis, often incorrectly described as tidal waves, are sea waves usually caused by displacement of the ocean floor. Typically generated by seismic or volcanic activity or by underwater landslides, a tsunami consists of a series of high-energy waves that radiate outward like pond ripples from the area in which the generating event occurred. For the Puget Sound region, either a large subduction zone quake off the coast or along the Seattle Fault could produce a tsunami. However, while a tsunami generated by a distant or Cascadia subduction earthquake could result in much damage to the coast, the impact in King County would not be as great. In the case of a subduction zone quake, a tsunami would travel from the coast through the Strait of Juan de Fuca into Puget Sound, and then south to Seattle. As a result, primary concerns lie with a tsunami or seiche generated by a land movement originating on the Seattle Fault (King County, 2009). A tsunami from the Seattle Fault could create tsunamic waves affecting areas of the shoreline along Elliott Bay which is outside of the study area.

3.3.3.4.4 Seiche waves

Consist of a series of standing waves in an enclosed or partially enclosed body of water caused by earthquake shaking, similar to what could be described as sloshing action. Seiche waves can affect harbors, bays, lakes, rivers, and canals. Both Puget Sound and Lake Washington could experience a seiche as they did in 1891, 1949, and 1964 as well as on Lake Sammamish. A seiche could affect a larger area than a tsunami because of King County's extensive shoreline (King County, 2009). The "sloshing" effect of a seiche could cause damage to facilities close to the water.



SOURCE: King County 2015; Kirkland 2015; Redmond 2015; Bellevue 2015(fault line); ESA 2015; WA Ecology 2014.

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Figure 3-2

Seismic Hazard Areas

3.3.3.1 Other Hazards

Soft soil conditions or soils that cannot support new improvements can also be a form of geologic hazard, causing subsidence or settlement over the short or long term. Soft soils can consist of undocumented fill materials or natural soils that have not been subject to overburden forces and thus have low strengths and are compressible. Other hazards could include coal mining areas and tunnels such as those present in southern Bellevue and Newcastle. Without appropriate design consideration, soft soils can lead to embankment failures during construction or long-term settlement after construction if left unaddressed. The presence of soft soils or soils that are not suitable to support new loadings (i.e., placement of buildings or towers) can only be determined on a site-specific basis through observation and laboratory testing of subsurface materials.

3.4 WHAT GEOLOGIC RISKS ARE PRESENT FOR EXISTING ELECTRICAL INFRASTRUCTURE?

PSE is not aware of any past major geological incidents affecting power facilities on the Eastside. Following the Nisqually Earthquake in 2001, PSE reported 200,000 customers without power due to tripped circuit breakers immediately after the earthquake, which was restored to all but 8,000 customers by the end of the day (Nisqually Earthquake Clearinghouse Group, 2001). Systemwide, there have been no structure failures of steel transmission poles due to geologic hazards, and failures of wood poles have been rare, involving extenuating circumstances like placement in a bog or being impacted by a landslide in a remote mountain setting (Strauch, personal communication, 2016).

Although it is possible that the Cascadia subduction zone could move in a way that causes a series of large earthquakes (each measuring magnitude 8.0 to 8.5) over a period of years, the earthquake that many scientists and emergency planners anticipate is modeled on the zone’s last major quake in 1700 that caused ruptures from end to end, causing one great earthquake measuring magnitude 9.0 (CREW, 2013). The shaking that results from this type of abrupt shifting of the earth’s crust would be felt throughout the Pacific Northwest, causing shaking for 4 to 6 minutes. In general, the intensity and destructiveness of the shaking will be greater at locations closer to the plate interface, with coastal areas experiencing the highest intensities and the level of shaking diminishing farther inland. Distance, however, is not the only factor: local geologic conditions, including soil type, can increase or decrease the intensity of the shaking and produce a range of secondary effects, including landslides and liquefaction (the latter occurs when certain types of soil lose cohesion and behave like a liquid). Widespread power outages are expected throughout the Pacific Northwest, including the combined study area, from downed power lines or damage to substations as a result of an earthquake. Slope failure, soil erosion, etc. could also impact electrical infrastructure by causing downed power lines or other damage to infrastructure that would interrupt service.

3.5 HOW WERE POTENTIAL EARTH IMPACTS ASSESSED?

Geology and soil considerations important to the Energize Eastside Project include general topography, underlying geological characteristics and properties, and soil characteristics, as well as seismic and other related geologic hazards. These considerations affect the type of construction methods used for the project and, if not adequately considered during project design, could affect the long-term safety of the proposed improvements. Regional geology and seismicity would not change as a result of the project, but they would have an important influence on how the project is designed and constructed.

Potential impacts were determined by identifying the range of geologic hazard areas and soil types present within the study area associated with each alternative.

Minor - If implementation of regulatory requirements and project design would address potential adverse impacts such that there would be little likelihood of adverse or even noticeable effects. While some damage might be anticipated during a seismic event, provided that there is protection of human health and limited disruption to power supply capabilities, impacts would be considered minor.

Moderate - If implementation of regulatory requirements and project design would address most potential adverse impacts, but some reasonable potential for adverse or substantive effects would remain such that risks to human health or structural improvements would remain above acceptable levels[3].

Significant – Even with implementation of regulatory requirements and design measures, if substantive damage, injury, death, or widespread or long-term interruption of power supply would likely occur, then impacts would be considered significant. With regard to seismic hazards, these impacts would be considered significant even if the probability is remote.

3.6 WHAT ARE THE LIKELY CONSTRUCTION IMPACTS RELATED TO EARTH?

Construction activities involve varying degrees of earthwork, including grading, excavation, and stockpiling of soils. Soils formerly protected by vegetation or covered by asphalt or concrete can become exposed to winds and water flows that can result in soil erosion or loss of topsoil. As detailed in Chapter 5, projects that disturb more than 1 acre would be required to obtain a General Construction Permit through the *National Pollutant Discharge Elimination System* (NPDES) program. Such projects must include construction *best management practices* (BMPs), as detailed in a *Stormwater Pollution Prevention Plan*

[3] The use of "acceptable levels of risk" is used here to acknowledge that eliminating all risk from geotechnical hazards such as seismic groundshaking and landslides is technically not feasible, and due to the inherit uncertainties regarding the timing and severity of natural disasters, some risk will inevitably remain. However, the basis for regulatory requirements including those set by the National Electric Safety Code (NESC), Federal Energy Regulatory Commission (FERC), and the North American Electric Reliability Corporation (NERC) requirements take into account a variety of risk factors that are protective of human health.

(SWPPP). These BMPs are developed on a project-specific basis and may vary depending on the activities involved. Typical examples of construction BMPs could include installation of silt fences, use of straw bales, or application of soil stabilization measures that are designed to minimize the potential for erosion to occur on exposed areas. In general, these water quality BMPs are effective in minimizing erosion and loss of topsoil such that additional protection measures are not necessary, and with implementation the BMPs would result in a minor impact for all construction activities.

3.6.1 Construction Impacts Considered

Construction activities common to all action alternatives have the potential to cause a number of short-term impacts on the environment related to geology and soils, including the following:

3.6.1.1 Erosion Hazards

Clearing of protective vegetation, fill placement, and spoils removal or stockpiling during construction allows rainfall and runoff to erode soil particles. The severity of potential erosion depends on the quantity of vegetation removed, site topography, rainfall, types of soils, and the volume and configuration of soils stockpiled. BMPs that could help minimize erosion hazards include, but are not limited to, the following:

- Maintaining vegetation cover and providing adequate surface water runoff systems;
- Constructing silt fences downslope of all exposed soil and using plastic covers over exposed earth; and
- Using temporary erosion control blankets and mulching to minimize erosion prior to vegetation establishment.

3.6.1.2 Slope Instability and Landslide Hazards

Construction of the proposed infrastructure could involve grade changes, cuts and fills, and installation of bridge and retaining wall structures in areas susceptible to landsliding or slumping of hillsides. Geotechnical evaluations and slope stability analysis, where necessary, would be completed to limit the risk of impacts resulting from constructing in landslide hazard areas. Construction in landslide hazard areas is more likely to occur under Alternatives 1 and 3 than Alternative 2.

All grading and cut-and-fill activities would be done in accordance with a grading plan that would be developed following a final geotechnical evaluation for the proposed improvements. Construction specifications would include quality assurance programs that prohibit construction in oversteepened slopes in accordance with local and state building code requirements.

3.6.1.3 Seismic Hazards

An earthquake could occur during construction, resulting in embankment slope failures, liquefaction, ground settlement, or equipment destabilization. The risk of seismic hazards to construction is considered low because of the relatively low probability that an earthquake would coincide with the actual limited construction period. If a large earthquake were to occur, the major risk would be to the ongoing construction activities although injury to workers is also possible. Work schedules would likely be delayed as efforts are made to repair damaged components of the work. Damage to exposed cuts or fills could disrupt utilities or nearby structures.

3.6.1.4 Construction-Induced Vibrations

The use of heavy equipment during construction causes ground vibrations. The level of vibrations depends on the type of heavy equipment, distance from the source, and ability of the soil to transmit vibrations. The main concern for construction vibration is potential damage to structures. Most construction processes do not generate high enough vibration levels to approach damage criteria because ground vibrations tend to dissipate quickly with distance. The major sources of construction vibration include impact pile driving, augered piling, vibratory rollers, and horizontal directional drilling.

3.6.1.5 Olympic Pipeline

In addition to the aforementioned hazards, portions of the existing 115 kV overhead easement corridor are shared with the Olympic Pipe Line Company (OPLC) which operates two steel pipelines that transport petroleum products. The pipelines are 16 inches and 20 inches in diameter and buried approximately 3 to 4 feet below the ground surface. Construction of new transmission lines in the vicinity of the petroleum pipelines or other earthwork activities in or near these pipelines could represent potential hazards from inadvertent contact, causing excessive ground vibrations, or result in damage from erosion. Although a significant adverse impact could occur during construction near petroleum pipelines, these potential hazards do not constitute a probable impact due to existing regulations and practices in place for pipeline safety. OPLC has stringent construction requirements in the area of its pipelines and would continue close coordination with PSE for all construction activities located adjacent to these pipelines. Therefore, no potentially significant adverse impacts related to work near pipelines are expected under any of the alternatives. See also Chapter 8 for a discussion of potential rupture hazards.

3.6.2 No Action Alternative

Under the No Action Alternative, PSE's existing maintenance activities and programs would continue. No utility lines or facilities would be built; therefore, no construction impacts related to geologic and seismic hazards are anticipated.

3.6.3 Alternative 1: New Substation and 230 kV Transmission Lines

Impacts are described according to the major components associated with Alternative 1. The substation impacts are described first, followed by transmission line options.

The expansion of the substations or construction of a new substation would require clearing and grading to prepare the area for foundations to support the new transformer. The new transformer would also require supporting equipment that would be placed on a concrete pad in accordance with regulatory requirements and industry standards. All construction activities for the expansion of the substations would be done in accordance with identified BMPs to minimize erosion, resulting in minor effects.

The transmission lines considered under this alternative fall under four different options, and they all involve some disturbance of surface soils or submerged soils. Disturbance of site soils would be necessary for clearing and grading to prepare foundation pads, as well as potentially a staging area and equipment access depending on the location of the transmission line.

3.6.3.1 Option A: New Overhead Transmission Lines

Under this option, a minimum of 18 miles of new overhead transmission lines would be constructed. Most construction would occur within existing easements but could also occur in new locations that might need more extensive grading and clearing activities. As noted above, construction activities would be conducted in accordance with BMPs outlined in the SWPPP prepared for the NPDES construction permitting. These erosion control BMPs would cover all construction activities and provide protection of any disturbed soils. Implementation of these BMPs would ensure that the potential for erosion during construction is minimized such that impacts would be minor.

In addition, prior to construction, geotechnical evaluations would be completed to identify and limit potential impacts resulting from constructing in landslide hazard areas. Construction specifications would include quality assurance programs that prohibit construction in oversteepened slopes in accordance with local and state building code requirements.

3.6.3.2 Option B: Existing Seattle City Light 230 kV Transmission Corridor

This option includes rebuilding both of the Seattle City Light SnoKing-Maple Valley 230 kV transmission lines and constructing a new transmission substation. This option would result in less disturbed area and a reduced potential for erosion and other hazards compared to Alternative 1, Option A. Implementation of required BMPs in accordance with NPDES Construction General Permit requirements would be effective in ensuring that the erosion potential is minor.

3.6.3.3 Option C: Underground Transmission Lines

Placement of the new transmission lines underground would require the most disturbance of surface soils and have the greatest potential for erosion compared to the other options. This is because of the amount of earthwork required to create trenches and potentially the need for imported fill in cases where the natural soils are not suitable for reuse. Adherence to the NPDES Construction General Permit would be effective in reducing the erosion potential to the point it would be considered minor.

3.6.3.4 Option D: Underwater Transmission Lines

Depending on the underlying conditions present, the installation of underwater transmission lines could be completed using trenchless methods, such as horizontal directional drilling, or trenching methods using special vessels to dredge the trenches. Trenchless methods would disturb soils at the entry and exit points (where the splicing *vaults* would be located landside) to enable the horizontal drilling equipment to reach desired depths. Ultimately, trenchless methods would result in less disturbance than conventional methods, and BMPs would also be required at the entry and exit points to ensure that erosion potential is minimized. Underwater dredging using conventional methods would result in localized disruption of sediments during construction, however, they would likely be reused to bury the line (water quality impacts associated with *turbidity* are discussed in the Chapter 5). Nonetheless, both trenchless and conventional methods would require implementation of BMPs for all landside disturbances, ensuring that erosion potential is minimized and impacts reduced to minor levels consistent with applicable in-water permit requirements.

3.6.4 Alternative 2: Integrated Resource Approach

Potential construction impacts under Alternative 2 would be much more limited than Alternative 1 because less construction of new infrastructure would be necessary. Clearing and grading would be necessary for the battery storage site and peak generator plants. Depending on location, this could include replacing major gas mains to increase natural gas supply capacity. Construction BMPs would be implemented to address potential erosion impacts. Earthwork activities would be done in accordance with design plans supervised by a state-licensed geotechnical engineer, and thus potential impacts would be minor.

3.6.5 Alternative 3: New 115 kV Lines and Transformers

Alternative 3 would replace or co-locate over 60 miles of new 115 kV transmission and distribution lines. The lines would be constructed overhead and would generally have similar potential construction impacts to Alternative 1 although the amount of construction would be greater. By covering a greater area there would likely be more probability of encountering critical areas such as steep slopes or unstable soils. As noted above for Alternative 1, geotechnical evaluations would identify and limit potential impacts resulting from constructing in landslide hazard areas. Construction specifications would prohibit construction in oversteepened slopes in accordance with local and state building code requirements.

During construction, erosion control BMPs would be implemented during all earthwork activities to address potential erosion impacts. Earthwork activities would be done in accordance with design plans supervised by a state-licensed geotechnical engineer.

Therefore, with implementation of required erosion control BMPs and other applicable permit requirements, construction impacts would be minor.

3.7 HOW COULD OPERATION OF THE PROJECT AFFECT EARTH RESOURCES?

3.7.1 Operation Impacts Considered

All of the alternatives would rely on an electrical system that crosses seismic and other geologic hazard areas. In general, Alternative 2 would have a more limited geographic coverage than Alternatives 1 and 3, but facility footprints for energy storage and peak generation plant components could be large (similar in size to a substation). The study areas cover relatively large geographical areas that contain a range of geologic conditions and potential hazard areas, from flat lowland areas of the floodplains to upland areas with steep topography. In general, potential impacts would likely include the following:

3.7.1.1 Erosion Hazards

Clearing of protective vegetation or asphalt/concrete, fill placement, and spoils removal or stockpiling during construction allows exposed soils to be susceptible to the erosive effects of wind and water. However, once the project is constructed, revegetation or replacement with asphalt or concrete would reduce the potential for erosion. As noted above, the project would be required to adhere to the NPDES Construction General Permit. This permit includes postconstruction BMP requirements to ensure that drainage is managed during project operation to protect soils from erosion.

3.7.1.2 Slope Instability and Landslide Hazards

Proposed improvements would consist primarily of new or expanded substations or development of storage or generation facilities, as well as construction of new transmission lines that would have a relatively limited footprint. These facilities would be in developed areas and would be subject to building codes that require geotechnical investigations and an evaluation of slope stability where necessary.

In addition, transmission poles and towers constructed under Alternatives 1 and 3 would adhere to construction standards as outlined in National Electric Safety Code (NESC), Federal Energy Regulatory Commission (FERC), and North American Electric Reliability Corporation (NERC) requirements including foundation designs to ensure long-term stability. Also, the American Society of Civil Engineers (ASCE) produces Manual No. 74 that provides Guidelines for Electrical Transmission Line Structural Loading, including standards for reliability-based design to prevent cascading types of failures.

3.7.1.3 Seismic Hazards

Seismic activity is likely to occur during the life of the proposed improvements[4] and could be substantial, resulting in significant damage, power outages, injury, and death, if the facilities are not designed appropriately. Catastrophic failures of circuit breakers, transformer bushings, and disconnect switches at substations or downed power lines can result in widespread power outages. For the substation expansions under Alternatives 1 and 3, prior to the issuance of grading permits, PSE would be required to retain a Washington-licensed geotechnical engineer to design the project facilities to withstand probable seismically induced ground shaking at each location. All grading and construction would adhere to the specifications, procedures, and site conditions contained in the final design plans, which would be fully compliant with the seismic recommendations of the Washington State Building Code and any local building code amendments. The required measures would encompass site preparation and foundation specifications.

[4] In general, the design life of improvements is considered to be very roughly 50 years.

The final structural design would comply with NESC 2012 as adopted by the UTC, which also includes seismic standards. For the transmission lines, NESC 2012 states that the structural requirements necessary for wind/ice loadings are more stringent than seismic requirements and sufficient to resist anticipated earthquake ground motions. In addition, according to ASCE Manual No. 74, “transmission structures need not be designed for ground-induced vibrations caused by earthquake motion because historically, transmission structures have performed well under earthquake events, and transmission structure loadings caused by wind/ice combinations and broken wire forces exceed earthquake loads.” Nonetheless, load comparisons would be performed between a seismic event and extreme weather conditions to ensure that the appropriate structural design would be able to withstand either of these conditions.

3.7.1.4 Liquefaction

Liquefaction of soils during an earthquake could result in vertical and lateral displacements of structures, embankments, and paved areas, potentially resulting in substantial damage or injury and system outages. The liquefaction potential of each project site would be confirmed during the design stage as required by law. Design of structures to resist seismic forces and secondary effects such as liquefaction would be required.

3.7.1.5 Unstable or Unsuitable Soils

Existing soils that cannot support proposed improvements, cannot be reused as structural fill or landscape material, or could cause corrosion of subsurface improvements could be a source of damage to new facilities. Geotechnical investigations would identify underlying materials and their engineering properties including the presence of unique geotechnical conditions such as areas with shallow soils over bedrock or the presence of former coal mining tunnels. Soils unsuitable for use as structural fill, such as expansive soils or compressible soils, would be replaced such that foundation soils would be able to meet building code specifications.

See also Chapter 8 for discussion of other potential health effects such as seismic safety related to the proposed improvements.

3.7.2 No Action Alternative

Under the No Action Alternative, PSE’s existing maintenance activities and programs would continue. No utility line or facility construction is likely and there would be no additional loss of vegetation or disturbance to animals from new permanent structures. However, there will be continued loss or disturbance of vegetation as a result of PSE’s Transmission Vegetation Management Program; trees would be trimmed, managed with herbicides or removed under existing transmission lines to limit vegetation to low-growing height species.

The types of conservation measures PSE expects to implement to achieve its goals would occur on customers’ properties. No permanent impacts are likely from operation since new infrastructure would be minimal and not require substantial clearing or result in other habitat impacts.

Under the No Action Alternative, PSE would use Corrective Action Plans instead of building new infrastructure to address risk in the near term. With no new improvements, there would be no operational impacts related to geologic and seismic hazards. However, it is possible that PSE would implement new technologies and there would be continued maintenance activities. These would likely represent very minor physical improvements that would have negligible potential geologic and seismic hazard impacts.

3.7.3 Alternative 1: New Substation and 230 kV Transmission Lines

Following construction, the new facilities could be subject to or contribute to impacts from erosion, slope instability, seismic hazards, liquefaction, unstable soils, and ground vibrations. However, with proper facility design measures in accordance with regulatory requirements discussed earlier and appropriate maintenance, the potential for these impacts would be minor for the substation and as described for each transmission line option below.

3.7.3.1 Option A: New Overhead Transmission Lines

Under this option, a minimum of 18 miles of new overhead transmission lines would be constructed. As noted above, the transmission lines would be constructed in accordance with the standards outlined by NESC, FERC, NERC, and ASCE Manual No. 74. In areas of common utility corridors, coordination with other utility providers would be conducted as appropriate. Site-specific geotechnical investigations would be required to define the underlying engineering properties and identify any geotechnical hazards that may be present. Geotechnical engineering methods, such as use of engineered fill or foundation design, would be used to ensure that the effects of any identified hazards are minimized and impacts during operation would be minor.

3.7.3.2 Option B: Existing Seattle City Light 230 kV Transmission Corridor

This option includes rebuilding the Seattle City Light SnoKing-Maple Valley 230 kV transmission line and constructing a new transmission substation. The three potential sites for the new substation, referred to as Vernell, Westminister, and Lakeside, are all located within areas that are not identified as landslide or seismic hazard areas but are within areas considered an erosion hazard (Figure 3-1). Of note, the Lakeside substation is located relatively close to the Seattle Fault trace and therefore could potentially be subject to higher ground shaking hazards. However, site-specific geotechnical investigations would identify any geologic or seismic hazards such as unstable soils, liquefaction, landslides, or others and provide geotechnical engineering recommendations to minimize any adverse effects. Impacts would be minor with implementation of geotechnical recommendations in accordance with regulatory requirements.

3.7.3.3 Option C: Underground Transmission Lines

Placement of the new transmission lines underground removes many of the geotechnical considerations for safe design such as structural loading and seismic ground shaking. In general, buried improvements perform well during a seismic event, although they can be subject to damage from liquefiable soils, if present. Sand boils or lateral spreading, both related to liquefaction, can cause substantial damage in underground improvements if not designed appropriately. However, as mentioned above, all improvements including underground transmission lines would require geotechnical investigations to determine the geotechnical engineering properties of site-specific materials prior to construction. Engineering approaches such as treatment of liquefiable soils or replacement with engineered fills can reduce these potential impacts such that they would be considered minor.

3.7.3.4 Option D: Underwater Transmission Lines

Once completed, underwater transmission lines would generally be expected to perform very well in an earthquake event, although they could be susceptible to liquefaction hazards if not designed appropriately. However, with incorporation of geotechnical recommendations in accordance with regulatory requirements, potential impacts would be reduced to minor levels.

3.7.4 Alternative 2: Integrated Resource Approach

Alternative 2 includes energy efficiency methods, end-user strategies, and small-scale distributed generation improvements (gas turbines, anaerobic digesters, and others) that would require less new construction than Alternatives 1 or 3. There would still be some relatively large-scale facilities such as the battery storage and peak generation plants and any future improvements after the end of the 10-year target period when additional solutions are required to address future growth. These facilities would have seismic considerations similar to substation expansion under Alternative 1. As a result, operational impacts would generally be the same as Alternative 1. Conformance with industry standards and regulatory requirements, including building code requirements enforced by local jurisdictions and the UTC, would ensure that geotechnical and seismic hazards are identified and design plans developed to minimize adverse effects from these hazards to minor levels.

3.7.4.1 Energy Efficiency Component

Energy efficiency strategies would not involve much new construction. Impacts related to earth resources would be negligible.

3.7.4.2 Demand Response Component

Demand response is an end-use strategy that pertains more to customer usage patterns and requires little construction of new infrastructure. Impacts related to earth resources would be negligible.

3.7.4.3 Distributed Generation Component

On-site energy generation could involve the construction of gas turbines, anaerobic digesters, reciprocating engines (e.g., diesel generators), microturbines, and fuel cells. In general, these on-site facilities would entail relatively small footprints. Similar to Alternative 1, new facilities would require compliance with existing regulatory requirements. As a result, there would be little likelihood for these improvements to result in adverse effects related to earth resources, and the potential impacts would be considered minor.

3.7.4.4 Energy Storage Component

Energy storage units would consist of relatively large battery sites constructed on sites approximately 6 acres in size (Strategen, 2015). The battery sites would receive geotechnical evaluations to identify any site-specific hazards and geotechnical recommendations to ensure that the new improvements can withstand the anticipated new loadings (i.e., weight of the batteries and *appurtenances*). Incorporation of geotechnical recommendations including site preparation methods and foundation design would ensure that any identified geologic hazards are minimized, resulting in minor impacts.

3.7.4.5 Peak Generation Plant Component

Simple-cycle gas-fired generators would be installed at existing substations within the Eastside and would require substation expansion at each location. Similar to energy storage sites, but at a much smaller scale (footprint is 2,000 square feet); generator sites would receive geotechnical evaluations to identify any site-specific hazards and recommendations to ensure that the new improvements can withstand the anticipated new loadings (i.e., weight of the batteries and appurtenances). Incorporation of geotechnical recommendations including site preparation methods and foundation design would ensure that any identified geologic hazards are minimized, resulting in minor impacts.

3.7.5 Alternative 3: New 115 kV Lines and Transformers

Alternative 3 involves the most new construction and covers the widest area of the alternatives considered. These new improvements would likely encounter a range of geotechnical and seismic hazards that would be identified in site-specific geotechnical investigations. Similarly, the proposed transmission line from Lake Tradition to Berrydale would also encounter a range of geotechnical and seismic hazards such as the seismic hazard areas (liquefaction) associated with the Cedar River floodplain.

As noted in Chapter 2, five substations would require complete rebuilds and expansion for this alternative including Sammamish, Lakeside, Talbot Hill, Clyde Hill, and Hazelwood. The Sammamish and Hazelwood substations are adjacent to a mapped landslide hazard area. The Lakeside and Hazelwood substations are adjacent to mapped erosion hazards. In addition, the Lakeside substation is relatively close to the Seattle Fault. The remaining two substations, Talbot Hill and Clyde Hill, are not within or near any identified hazard areas.

The location of these substations relative to hazard areas does not necessarily preclude the feasibility of developing the improvements in a way that minimizes any hazards that may be present. With incorporation of regulatory requirements such as NESC 2012 and NERC/FERC standards and requirements, the proposed improvements would be designed and constructed to minimize hazards such as seismic ground shaking, liquefaction, and unstable soils. As a result, the potential impacts would be minor.

3.8 WHAT MITIGATION MEASURES ARE AVAILABLE FOR POTENTIAL IMPACTS TO EARTH RESOURCES?

3.8.1 Construction Measures

Use of the following measures during construction would reduce or minimize the potential for erosion, slope failure, unsuitable soils, or settling impacts for all alternatives that involve earthwork:

- Avoid construction on steep slopes, known and potential landslide zones, and areas with organic or liquefiable soils, where feasible.
- Use appropriate shoring during construction.
- Use erosion and runoff control measures, including retention of vegetation, replanting, ground cover, etc.
- Comply with relevant state and local critical areas codes and other applicable requirements.
- Dispose of soils at approved disposal sites.
- Coordinate with other utility providers, as appropriate, to determine how best to avoid or minimize any impacts. PSE would work with other utility service providers during design of the project to coordinate the placement of new facilities and ensure protection of other utilities.
- Conduct settlement and vibration monitoring, as applicable, during construction to identify potential adverse conditions to critical structures and local facilities.

If site-specific earth impacts are identified during future review of individual projects, additional measures to reduce or minimize those impacts may be identified.

3.8.2 Operation Measures

Use of the following measures during operation would reduce or minimize the potential for erosion, slope failure, unsuitable soils, or settling impacts for all alternatives that involve earthwork:

- Monitor all improvements for changes in conditions such as cracking foundations, slumping slopes, or loss of vegetative cover.
- Implement inspection and maintenance programs for all improvements to ensure consistent performance and stability.
- Comply with relevant state and local critical areas codes.

If changes are identified during future inspection and monitoring of conditions, additional measures to reduce or minimize those impacts may be identified.

3.9 ARE THERE ANY CUMULATIVE IMPACTS TO EARTH RESOURCES AND CAN THEY BE MITIGATED?

Although the entire region is a seismically active area, geologic and soil conditions vary widely within a relatively short distance. Other projects in the area would also be required to adhere to the same Washington state and local building codes as the Energize Eastside Project, which would reduce the risk to people and property in the region. While future seismic events cannot be predicted, adherence to federal, state, and local programs, requirements, and policies pertaining to building safety and construction would limit the potential for injury or damage. Therefore, the Energize Eastside Project, combined with past, present, and other foreseeable development in the area, would not result in a cumulatively significant impact by exposing people or structures to risks related to geologic hazards, soils, or seismic conditions.

3.10 ARE THERE ANY SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS TO EARTH RESOURCES?

While damage and potential injury or death from a significant seismic event is never completely avoidable, the probability is substantially reduced when new improvements are constructed in accordance with current seismic standards and building code requirements that incorporate the most recent scientifically based design standards. As a result, there would be no probable significant adverse impacts related to earth resources under any of the alternatives analyzed.