3.2 GEOLOGY, SOILS, AND SEISMICITY

The two predominant issues associated with geology and the project are 1) potential soil impacts due to construction and 2) potential impacts to the project from geologic hazards.

3.2.1 Affected Environment

The site is situated in an area that has been referred to as the Umatilla lowlands. This region is characterized by a relatively flat to gently rolling surface that gradually descends from the Blue Mountains southeast of the proposed power plant site to the Columbia River. The surface topography generally mimics the buried surface of the flood-basalt bedrock of the Umatilla Basin. The bedrock is known as the Columbia River Basalt Group (CRBG). Slopes are generally less than five percent.

3.2.1.1 Topography

A topographic relief map of the project area is presented in Figure 3.2.1.

<u>Proposed Power Plant Site</u>

The proposed power plant site is located approximately 1.0 kilometer (0.6 mile) west of the Cottonwood Bend in the Umatilla River at an elevation of approximately 164 meters (540 feet) above mean sea level (msl). The ground surface at the proposed power plant site is nearly flat with elevations varying about 0.6 meter (2.0 feet) from the northwest down to the southeast.

<u>Gas Pipeline Corridor</u>

Topography along the proposed alignment corridor for the gas pipeline ranges from gently sloping conditions at the southern end (located at the connection with the GTN natural gas pipeline) to generally flat conditions along the remainder of the alignment. Specifically, the GTN pipeline junction is situated on the eastern flank of Ward Butte approximately 180 meters (200 yards) west of the Butter Creek drainage at approximately 213 meters (700 feet) msl. The pipeline trends northward to near flat conditions north of the High Line Canal and drops to approximately 164 meters (540 feet) msl at the proposed power plant site.

<u>Transmission Line Corridor</u>

Topography along the proposed alignment corridor for the reconductored transmission line rises gently in a northward direction from the power plant site to an elevation 198 meters (650 feet) msl at the crest of Coyote Coulee. The transmission line then trends downhill and northward down moderate slopes to the eastward turn in the line located immediately south of Radar Road.

The transmission line alignment then trends eastward approximately 2.0 kilometers (1.2 miles) and climbs gentle to moderate slopes to the bend northward in the alignment at Powerline Road. The line then slopes gently down to its terminus at an elevation of approximately 91 meters (300 feet) msl near McNary Substation.

3.2.1.2 Geology

The proposed power plant and its supporting facilities are located within the Umatilla Basin, a broad lowland that is part of the Columbia Basin that extends across northeastern Oregon, southwestern Washington, and western Idaho. Figure 3.2.2 depicts the regional geology relevant to the proposed power plant site.

The flood-basalt bedrock of the Umatilla Basin is CRBG, a sequence of basalts which erupted from feeder dikes and vents in Northeastern Oregon and Southeastern Washington during Miocene time (between 6 and 17 million years ago). This basalt subsequently spread over an area of approximately 163,170 km^2 (63,000 mi^2) as it flowed westward to the Pacific Ocean. Total thickness of the bedrock basalt reaches over 4,575 meters (15,000 feet) in the Tri-Cities area to the north and tapers out in the Blue Mountains to the southeast of the proposed power plant site. Within the Umatilla Basin, the estimated thickness of the CRBG is 1,525 meters (5,000 feet).

During the eruptions of the flood-basalt and thereafter, extensive tectonic deformation of the layered bedrock resulted in broad bending and folding of the bedrock units. These tectonic processes created numerous synclines (downwarping of the sediments which creates broad structural basins in the project area), anticlines (upwarps which form the higher topographic features), and faults. Based on the predominant structural fabric, the Columbia Plateau has been subdivided into three informal structural subprovinces: Palouse Slope, Blue Mountains, and the Yakima Fold Belt. The proposed power plant is sited within the Yakima Fold Belt of the Columbia Plateau, an area characterized by narrow, asymmetrical anticlines spaced between 5 and 48 kilometers (3 and 30 miles) apart. The fault and fold structures in the general project area are shown on Figure 3.2.3.

Alluvial deposits consisting primarily of sand and gravel mantle the basalt bedrock throughout the Umatilla Basin. These deposits were placed during the late Pleistocene some 13,000 to 40,000 years ago. From approximately 13,500 to 15,000 years ago, glacial advance and retreat created ice dams in Northern Idaho. These dams formed ancient Lake Missoula, a glacial lake that covered a significant portion of what is now Western Montana. These ice dams eventually failed due to the rising water levels and released catastrophic floods that swept across southeastern Washington and along the Columbia River to the Pacific Ocean. As ancient Lake Missoula drained (in an estimated 24-48 hours per event), the region near the project area was repeatedly inundated. The Missoula Floods pooled in the Pasco Basin, then drained down the

Columbia River primarily through Wallula Gap, spreading out within the Umatilla Basin to form ancient Lake Condon. The force of the water completely stripped any existing overburden material and scoured the surface of the CRBG, forming scabland topography. Floodwaters reached an elevation of at least 351 meters (1,150 feet) in Lake Condon, creating a water depth of at least 122 meters (400 feet) near the proposed power plant site. This sequence took place dozens of times, depositing up to 45 meters (150 feet) of unconsolidated to poorly consolidated, crudely stratified sand and gravel alluvium with occasional boulders and silt lenses upon the basalt bedrock within the project area.

Since the cessation of the floods, natural processes such as water and wind have eroded and modified the surface topography, resulting in additional deposits of loess, silts, sands, and gravels throughout the proposed power plant site.

3.2.1.3 Soils

Soil types within the project area were identified using information provided by the National Resource Conservation Service (NRCS) soil survey for Umatilla County (USDA, 1988). Information about each soil series encountered was downloaded from the NRCS website or obtained from the soil survey. A total of 13 soil series were identified within the project area. The following is a list of the series identified within the project area that summarizes important characteristics of the soils. Maps depicting the areal extent of each soil unit relative to the project are presented in Figures 3.2.4, 3.2.5, and 3.2.6.

1b – Adkins fine sandy loam, 0 to 5 percent slopes

This deep, well-drained soil is on strath terraces of the Columbia River and formed as a result of wind deposition. It consists of a fine sandy loam that is generally used for irrigated crops or as rangeland, possesses a low shrink-swell potential, and is very susceptible to wind erosion. This soil type is encountered beneath a large portion of the proposed pipeline corridors and is considered prime farmland.

2b – Adkins fine sandy loam, gravelly substratum, 0 to 5 percent slopes

This deep, well-drained soil is on strath terraces of the Columbia River. It formed in gravelly alluvial deposits mantled by eolian sand and is encountered beneath the McNary Substation at the northernmost end of the transmission line alignment. This soil is very susceptible to being blown by wind during construction.

2c – Adkins fine sandy loam, gravelly substratum, 5 to 25 percent slopes

This deep, well drained soil is on strath terraces of the Columbia River. It formed in gravelly alluvial deposits mantled by eolian sand and is encountered uphill of the Umatilla River floodplain along the northwest flank of the Service Anticline (Umatilla Butte).

14b – Burbank loamy fine sand, 0 to 5 percent slopes

This deep, excessively drained soil is on strath terraces of the Columbia River. It formed in gravelly alluvial deposits mantled by eolian sand and is encountered on the northern slope of the Service Anticline and along a large portion of the transmission line alignment on Coyote Coulee.

70 – Pits, gravel

This map unit consists of excavated areas of rounded to subangular gravels, commonly mixed with sand or other soil material. Most of these areas are being mined for sand and gravel and support little vegetation. These commonly recognizable areas occur within other soil units that consist of soils that have a gravelly substratum.

74b – Quincy fine sand, 0 to 5 percent slopes

This deep, excessively drained soil is on strath terraces of the Columbia River. This soil is a weathering product of eolian sand.

75b – Quincy loamy fine sand, 0 to 5 percent slopes

This deep, excessively drained soil is on strath terraces of the Columbia River. This soil is a weathering product of eolian sand and is very similar to the Quincy fine sand.

75e – Quincy loamy fine sand, 5 to 25 percent slopes

This deep, excessively drained soil is on strath terraces of the Columbia River. This soil is a weathering product of eolian sand and is encountered along the steeper slopes of Coyote Coulee along the transmission line alignment.

76b – Quincy loamy fine sand, gravelly substratum, 0 to 5 percent slopes

This deep, excessively drained soil is on strath terraces of the Columbia River. It formed in gravelly alluvium mantled by eolian sand and is interbedded with Quincy fine sand and Burbank loamy fine sand along the transmission line alignment between the proposed power plant and the crest of Coyote Coulee. This soil has low clay content and is highly susceptible to wind erosion, particularly when excavated.

77c – Quincy loamy fine sand, eroded, 0 to 25 percent slopes

This deep, excessively drained soil is on strath terraces of the Columbia River. It formed in eolian sand and is most suitable as rangeland. This soil is found at the southernmost 900 meters (one half mile) of the proposed gas pipeline corridors and is highly susceptible to wind erosion, particularly when excavated.

95b – Taunton fine sandy loam, 1 to 7 percent slopes

This moderately deep, well drained soil is on strath terraces of the Columbia River, typically between 122 to 335 meters (400 to 1,100 feet) elevation. It formed in eolian sand deposited over cemented alluvium. This unit is encountered about 250 meters (820 feet) north and south of the

High Line Canal and in a small area near the proposed pipeline junction. This soil unit is best suited to irrigated crops but is limited by low natural fertility and moderate permeability.

126a – Xerofluvents, 0 to 3 percent slopes

These deep, somewhat poorly drained to excessively drained soils are encountered on the modern floodplain of the Umatilla River. They are derived from mixed alluvium. These soils flood frequently and are considered a poor construction material due to moderate strength and wetness.

127f – Xerollic Durorthids, 30 to 60 percent slopes

These soils consists of shallow to moderately deep, well drained soils on terrace scarps. These soils formed in loess over cemented alluvium and are encountered along the steepest faces of Coyote Coulee.

3.2.1.4 Seismicity

The seismicity of the Pacific Northwest is primarily driven by convergence between the Juan de Fuca and North American plates and has created a complex, seismically active convergent margin and volcanic arc in the Pacific Northwest (Ludwin *et al.*, 1991).

The chain of active volcanoes that result from plate subduction make up the Cascade Range, which extends roughly north-south through Oregon and stretches from northern California to British Columbia (Figure 3.2.7). Other major tectonic elements of the plate boundary include an active accretionary wedge complex in the offshore region east of the trench and a deformed Tertiary forearc basin that lies seaward of the volcanic arc. The present-day Coast Range and the Willamette Lowland-Puget Sound Basin stand where marine sediments and fragments of oceanic crust were accreted and later deformed during early Tertiary plate convergence and subduction (Unruh *et al.*, 1994). Northwestern Oregon sits on the Oregon Coastal forearc block whose boundaries extend from the Oregon-Washington border south to the Klamath Mountains. Behind the Oregon Coastal block and the Cascade volcanic arc, the Fold and Thrust Belt occupies a region that stretches from central Washington to central Oregon and encompasses the proposed power plant site.

Fold and Thrust Belt Seismotectonic Province

Most significant to the study area is the Fold and Thrust Belt, which contains portions of the Columbia Plateau physiographic province. This province is located in the intermontane region between the Cascades and the Rocky Mountains and is a broad plain mainly comprised of the Miocene Columbia River Basalt Group (CRBG). The Columbia Plateau can be further subdivided into the Blue Mountains and the Yakima Fold Belt (YFB) subprovinces, based on the predominant structural fabric.

The YFB runs through the central part of the Columbia Plateau while the Blue Mountains anticline defines the southeastern boundary of the study region. The proposed power plant site is located in the YFB, which is dominated by east-west and northwest-trending contraction structures that include anticlinal ridges, synclinal valleys, and reverse and transpressional faults. A regional-scale structure, the northwest-striking Olympic-Wallowa Lineament also traverses the region. The lineament is a zone of northwest-directed transpression (Mann and Meyer, 1993) that, in the vicinity of the YFB, consists of a diffuse zone of northwest-trending anticlines (Reidel *et al*., 1989).

The Columbia Plateau includes a number of tectonic basins, one of which is the Umatilla Basin where the proposed power plant site is located. Regional thickness patterns of CRBG and pre-CRBG sediments indicate that these basins have subsided and have been filled with basalts (Reidel *et al*., 1989). Formation of the folds within the YFB are estimated to have begun during the middle Miocene and still continue today. In general, anticlines within the YFB are asymmetrical with the exception of the Columbia Hills anticline. Distribution of seismicity appears to be mainly associated with the east-west-striking compressive faults and folds of the YFB (Geomatrix Consultants, 1995). Earthquakes within the Columbia Plateau typically exhibit reverse (compressive) focal mechanisms along east-west striking faults.

Historical Seismicity

Historically, north-central Oregon and south-central Washington has been characterized by a relatively low level of seismicity. In characterizing earthquake occurrence, historical earthquakes can generally be divided into pre-instrumental and instrumental periods. Prior to adequate seismographic coverage, the detection of earthquakes was generally based on direct observation and felt reports and were correlated with the Modified Mercalli Intensity (see Table 3.2.1) value for the event. These results are strongly dependent on population density and distribution. This part of the Pacific Northwest is typical of much of the western United States, and was sparsely populated in the 1800s. Therefore the detection of pre-instrumental earthquakes shows varying degrees of completeness. The pre-instrumental historical record is estimated to be complete for earthquakes of Richter local magnitude (M_L) 5 and larger since about 1850 for the Portland region (Bott and Wong, 1993). Seismograph stations were established in 1906 in Seattle and 1944 in Corvallis, but adequate seismographic coverage of small events ($M \leq 3.0$) did not begin in northwest Oregon until about 1980 when the University of Washington expanded its regional network. The historical record is complete for M_L 2.5 and greater only since 1980 (Bott and Wong, 1993).

An historical earthquake catalog of all known events within 80 km (50 miles) of the site for the period 1887 to 2000 was compiled from comprehensive databases. Historical earthquakes in excess of magnitude 2.0 are shown in Figures 3.2.8 and 3.2.9, respectively. Earthquakes which generated a maximum intensity of Modified Mercalli (MM) III or greater at the proposed power plant site are listed in Table 3.2.2. Only one earthquake of unspecified magnitude (M) 6.0 has occurred in the region, and it is located approximately 100 km (62 miles) from the site. Approximately five earthquakes in the catalog have magnitudes between M 5.0 to 5.9, all at distances of approximately 100 km (62 miles) from the proposed power plant site. The one exception is the 1893 Umatilla earthquake (see discussion below).

Based on the historical record, the proposed project is an area of diffuse seismicity with a few areas of concentrated seismicity. Eastern Oregon is much less active than the Portland region, which is the most seismically active area in Oregon. Most events in eastern Oregon do not appear to be associated with known faults, indicating the presence of many faults which do not have surface expression or faults which are unmapped. Most earthquakes in Oregon and Washington have focal depths of 15 to 20 km (nine to 12 miles) or less, though focal depths deepen in western Oregon-Washington to about 25 to 30 km (16 to 19 miles) (Ludwin *et al.*, 1991). Regional focal mechanisms indicate that the project area lies within a compressional regime characterized by a mostly north-south maximum compression, resulting in reverse/thrust, strike-slip, or oblique faulting (Ludwin *et al.*, 1991).

Significant Earthquakes

Significant earthquakes and earthquakes greater than M 4.0 in the region are shown on Table 3.2.2. The four largest events are further discussed below.

1872 North Cascades Earthquake

On December 15, 1872, a large earthquake occurred in the wilderness of central Washington with an approximate M_L 7.4. The exact source of the earthquake is unknown, though it was felt throughout the Pacific Northwest. Because there were few inhabitants in the region, the only reported damage was to a few log buildings. Extensive landslides occurred throughout the Cascades and along the Columbia River, including a massive landslide at Ribbon Cliff, which blocked the river for several hours. Ground fissures occurred at the eastern end of Lake Chelan, while at Chelan Falls a geyser spouted water as high as nine meters for several days (Stover and Coffman, 1993). The event generated an approximate maximum intensity of MM III-IV near the site (Malone and Bor, 1979) (Figure 3.2.10).

1893 Umatilla Earthquake

On March 3, 1893, a moderate earthquake occurred near Umatilla. The exact location and source of the earthquake are unknown. Studies have shown that the earthquake had a shallow depth, was felt over a relatively small area, and had a maximum intensity of MM V (Squier Associates, 1994).

1936 Milton-Freewater Earthquake

On July 16, 1936, at 07:07:49 Greenwich Mean Time (GMT), an earthquake with an estimated M_L 6.1 occurred near the town of Milton-Freewater on the Oregon-Washington border (Mann and Meyer, 1993). This was the largest and most significant earthquake in northeastern Oregon. The maximum intensity was MM VII+, and it was felt over an area of 275,000 km^2 (106,178 ft^2). The main shock was preceded by two felt foreshocks and was followed by numerous aftershocks. The main shock produced the strongest shaking and caused damage in and around the towns of Milton-Freewater, Umapine, and Stateline, Oregon and Walla Walla, Washington. Ground cracks as large as one to two meters (three to seven feet) wide reportedly occurred west of Milton-Freewater. At the site the intensity was approximately MM V (Figure 3.2.11). This is probably the strongest ground shaking that the site has been subjected to in historical times. A MM V roughly corresponds to a peak horizontal acceleration of 0.18 to 0.34g based on Wald *et al.* (1999).

1976 Deshutes Valley Earthquake

On April 13, 1976, at 00:47:15 GMT, an earthquake of estimated M_L 4.8 occurred near the town of Maupin in north-central Oregon. The maximum intensity was MM V-VI along the Deschutes River Valley, and it was felt over an area of 35,000 km^2 (13,514 mi^2). A composite focal mechanism of the main shock suggests that the earthquake occurred on a west-northwest-striking reverse fault (Wong and Bott, 1995). At the site, the intensity was approximately MM II-IV (Figure 3.2.12).

Seismic Source Zones

All reported Quaternary-aged seismic source zones within the project area have been examined. These are tabulated below in Table 3.2.3 at the end of this section and are depicted in Figure 3.2.13.

Anticipated Level of Ground Shaking

Significant potential earthquake sources located within the project area have been investigated for seismic risk to the proposed power plant. Specific areas considered in this analysis are depicted in Figure 3.2.14. The analysis yields expected level of ground shaking in terms of peak ground acceleration under the Maximum Credible Earthquake (MCE) generated at each source. These are reported at the end of this section in Table 3.2.4.

3.2.2 Environmental Consequences and Mitigation Measures

Impacts associated with geology include impacts on soils native to the project area and impacts to the proposed power plant due to geologic hazards. Potential impacts and mitigation measures for each of these issues are addressed below.

Impact 3.2.1 Local soils could be adversely affected by construction of all elements of the proposed project

Soil Erosion from Surface Water Runoff

Assessment of Impact As shown in Tables 3.2.5 and 3.2.6, the majority of the soils in the project area occur on slopes of less than 5 percent. The runoff potential and water erosion hazard for these soils are low and slight, respectively. Approximately 98 percent of the total project area includes soils with a slight water erosion hazard. In addition, the region typically receives less than 10 inches of rain annually. Approximately 60 percent of the annual precipitation occurs from November through March.

The construction contractor would be required to adopt standard practices for control of soil erosion and sediment runoff at construction sites. These practices would include:

- Revegetation of disturbed areas
- Use of temporary erosion and sediment control measures such as silt fence, straw bales, mulch, and slope breakers and maintenance of these features throughout construction and restoration;
- Installation of permanent erosion control measures, as necessary, during construction, cleanup and restoration.

As a result of natural conditions at the construction sites and the practices that would be adopted by the contractor, surface water runoff at the proposed project would not have a significant adverse impact on soils.

Recommended Mitigation Measures Soil erosion as a result of precipitation and runoff could be eliminated by constructing the proposed project between April and October. It is recommended that, consistent with the objective to have the proposed power plant project commercially operable in August 2003, all ground-disturbing activities should be conducted within the drier months, to the extent practicable.

Soil Erosion from Wind

Assessment of Impact As shown in Tables 3.2.5 and 3.2.6, the wind erosion hazard for the soils in the project area ranges from moderate to very high. Approximately 15 percent of the total project area has a moderate wind erosion hazard. Seventy-six percent of the total project has a high wind erosion hazard, and about 7 percent of the total project area has a very high wind erosion hazard. Wind erosion is influenced by the climate, vegetative cover, soil texture, soil moisture, length of the unprotected soil surface, topography, and frequency of soil disturbances. The October to November and January to April time periods are the most critical for wind erosion. However, high winds can be expected year round within the region.

The construction contractor would be required to adopt standard practices for control of soil erosion and sediment runoff at construction sites. These practices would include:

- Making reasonable efforts to reduce the area of soil disturbance;
- Removing vegetation only as necessary;
- Minimizing the amount of traffic over unprotected soils or confining equipment use to specific areas;
- Application of water or mulch, as necessary, for emergency wind erosion control during construction;
- Revegetation of construction areas.

As a result of the practices that would be adopted by the contractor, wind erosion at the proposed project would not have a significant adverse impact on soils.

<u>Recommended Mitigation Measures</u> Soil erosion as a result of wind could be reduced by constructing the proposed project between April and October. It is recommended that, consistent with the objective to have the proposed power plant project commercially operable in August 2003, all ground-disturbing activities should be conducted within these months, to the extent practicable.

<u>Reduced Agricultural Yield</u>

<u>Assessment of Impact</u> Construction of the pipeline would require grading, excavations, trenching and backfilling. The mixing of topsoil with less productive subsoil horizons during these activities could lower the soil productivity. It is expected that any adverse effects of the proposed project would be reduced to insignificance by the measures described below:

- Stripping and segregation of topsoil from over the trench and from the trench spoil storage. The construction contractor would strip the topsoil layer to a maximum depth of 30 centimeters (12 inches), or, where topsoil depth is less than 30 centimeters (12 inches), topsoil would be stripped to a depth where the topsoil color changes to the color of the underlying soil horizon or to where an otherwise distinct underlying soil horizon is encountered.

- Storing of stripped topsoil separately and not allowing it to mix with trench spoil, cut-and-fill materials, rock, construction debris, excavated materials or other subsoil.

In the worst case, approximately 67 percent of the project area has soils with a stony or rocky subsoil. Grading, excavation, trenching and backfilling may result in the additional incorporation of stones into the topsoil. Shallow bedrock (less than 60 inches [152 centimeters] depth) was not identified in any of the soils in the project area (Tables 3.2.5 and 3.2.6). Measures used to minimize the introduction of rock into the topsoil would include:

- Segregation of topsoil from the trench spoil.
- Removal of excess rock from at least the top 30 centimeters (12 inches) of the soil to the extent practical in agricultural and residential areas.
- Removal of rock as necessary so the size, density and distribution of rock on the construction area would be similar to adjacent areas not disturbed by construction.

Recommended Mitigation Measures No measures beyond those included in the proposed project are recommended.

Spread of Noxious Weeds and Soil-Borne Plant Disease

Assessment of Impact The spread of noxious weeds and soil-borne plant disease is a potential problem in agricultural areas. Seed or soil may adhere to construction equipment and be spread from one construction area to another, resulting in the establishment of noxious weed seed and soil-borne plant disease in previously uninfected areas. Straw bales and mulch may also contain noxious weed seed, and the weeds may become established in construction areas where the straw is used for erosion and sediment control.

The construction contractor would adhere to the following practices to reduce the spread of noxious weeds or soil-borne plant disease:

- Thorough cleaning of construction equipment by Contractors with high-pressure washing equipment prior to moving to the job site.
- Consultation with the Oregon Department of Agriculture and other appropriate agencies to identify the presence of noxious weeds in the project area.
- Use of straw bales and straw from fields where the harvested seed has been certified as Oregon certified seed.
- Consultation with appropriate agencies to determine if soil-borne plant diseases of agronomic significance have been identified in the project area.

As a result of these measures, the proposed project would not contribute to the spread of noxious weeds.

Recommended Mitigation Measures No measures beyond those included in the proposed project are recommended

Impact 3.2.2 The proposed project could be adversely affected by geologic hazards

Soil Hazards

Assessment of Impact Soil hazards in this context are those that lead to excessive post-construction movements (either settlement or swelling) that impede the safe operation of the proposed power plant. Excessive settlement is typically associated with organic-rich soils, loose uncemented silts and sands, or highly plastic silts and clays. Furthermore, excessive settlement can arise from the improper specification, placement, and compaction of backfill. Conversely, highly plastic soils can exhibit extreme swelling characteristics with moderate increases in moisture content.

Based on the studies performed by URS, the proposed project does not encounter significant deposits of organic-rich soils, loose uncemented silts and sands, or highly plastic silts and clays. Therefore, soil-related hazards do not pose a significant risk to the safe construction and operation of the project.

A detailed geotechnical investigation would be conducted during the design of the proposed power plant project. Information gained during the geotechnical investigation would be used to select an appropriate foundation system for the proposed power plant project.

Recommended Mitigation Measures No measures beyond those included in the proposed project are recommended

Landslides

Assessment of Impact Assessment of landslide hazards was performed by interpreting aerial photograph and evaluating field reconnaissance. The project terrain is marked with relatively flat topography with no evidence of previous landslide activity. Therefore, the risk of landslides to the safe construction and operation of the proposed power plant is low.

Recommended Mitigation Measures None are recommended.

Impacts from Seismic Activity

Potential impacts from seismic activity include volcanic eruptions, strong ground shaking, seismically induced landsliding, liquefaction of subsurface soils, surface rupture by the earthquake, and subsidence. These are discussed further below.

Volcanic Activity

Assessment of Impact There are no active volcanoes, Quaternary lava flows, or cinder cones within the project vicinity. The chain of active volcanoes that result from plate subduction makes up the Cascade Range, which extends roughly north-south through Oregon and stretches from northern California to British Columbia. Presently, the High Cascade Range in southwestern Washington and northwestern Oregon is dominated by late Pleistocene stratovolcanoes, such as Mount St. Helens (located ~240 km from site), Mount Adams (~180 km), Mount Rainier (~230 km), and Mount Hood (~200 km), all of which are considered to be potentially active and have erupted in the last few hundred years. Specific hazards related to volcanic activity include lava or debris flows and ash falls (also known as tephra). The site is located too far from known volcanoes to be at risk from lava or debris flows. Historic ash falls have impacted the site during prior eruptions of Mt. Mazama (Crater Lake) and Glacier Peak. However, the amount of ash likely to fall at the site from future eruptions will not be sufficient to cause structural damage. Air filters leading to the combustion turbines or on-site diesel generators would likely require replacement/cleaning subsequent to an ash fall. Overall, the risk to the safe operation of the proposed power plant from volcanic eruption is low.

Recommended Mitigation Measures None are recommended.

Ground-shaking

Assessment of Impact The project area is subject to periodic ground-shaking from earthquakes. The intensity of the shaking is dependent upon three factors: the magnitude of the earthquake, the distance between the earthquake epicenter and site, and the response of the onsite soils to the motions induced by the earthquake. It is expected that a maximum credible earthquake (MCE) on the Service Anticline would produce accelerations at the proposed power plant ranging from about 0.3 to 0.4 g, depending on fault rupture length of the Service Anticline. This level of ground shaking exceeds Peak Ground Acceleration (PGA) values specified in the Oregon Structural Specialty Code. However, MCE ground motions are overly conservative as a design basis for these types of facilities. To this end, the proposed power plant would be designed using model codes or site-specific seismic studies that account for the expected level of ground shaking on a probabilistic basis. This is the approach commonly used for power plants, buildings, bridges, hospitals, chemical plants, and other facilities. As such, ground-shaking hazards would be mitigated through proper design and construction and would pose no significant risk to human safety during the construction and operation of the proposed power plant.

Recommended Mitigation Measures No measures beyond those included in the proposed project are recommended.

Seismically Induced Landslide

Assessment of Impact The absence of steep topography precludes the development of seismically induced landslides that would affect the proposed power plant. Therefore, the risk to public safety from seismically induced landslides is low.

Recommended Mitigation Measures None are recommended.

Liquefaction and Related Phenomena

Assessment of Impact The absence of loose, granular, and saturated soils near the ground surface precludes widespread liquefaction that would affect the proposed power plant site. Therefore, the risk to public safety from seismically induced liquefaction and related phenomena (settlement, lateral spreading, or flow) is low.

Recommended Mitigation Measures None are recommended.

Surface Fault Rupture

Assessment of Impact No known faults traverse the proposed power plant site. Therefore, risk to the safe operation of the proposed power plant from seismically induced surface fault rupture is low.

Recommended Mitigation Measures None are recommended.

Subsidence

Assessment of Impact Faults identified within the proximity of the proposed power plant site are not expected to generate tectonic subsidence. As such, risk to the safe operation of the proposed power plant from seismically induced subsidence is low.

Recommended Mitigation Measures None are recommended.

3.2.3 Cumulative Impacts

The proposed project would have minimal effects on geology, soils and seismicity. The proposed power plant would be located on a flat site. The associated natural gas, water and reclaimed water pipelines and electric power transmission lines would be located in gently sloping areas. Other existing or proposed power generation projects in the vicinity of the proposed project are similarly located in areas with low geologic hazard. The proposed project would not be especially vulnerable to geologic hazards and thus would not increase the overall or cumulative vulnerability of the project area to geologic hazards.

Land with soils suitable for agriculture is often consumed by urban development. Cumulatively, the loss of agricultural land as a result of urban development could result in reduced agricultural productivity. The proposed power plant would be located on a 31-hectare (77-acre) parcel of land surrounded by freeways, other roads and industrial facilities. Umatilla County has zoned the parcel for industrial and commercial use and does not intend it to be used for agricultural purposes. The proposed power plant site was formerly used as a gravel yard and currently is sparsely vegetated. Other existing or proposed power generation projects in the vicinity of the proposed project are similarly located in areas that are zoned for industrial use.

Although, local governments have decided that industrial use is the best use of certain lands previously used for agriculture, the proposed power plant would contribute to the progressive industrialization of the Umatilla/Hermiston area and the cumulative loss of lands with soils suitable for agricultural use.

Portions of the natural gas pipeline and the reclaimed water would traverse lands used for agriculture. Topsoil would be removed during construction of the pipelines and replaced after pipe installation. The agricultural productivity of the land would be unaffected. Thus, the pipelines would not contribute to a cumulative loss of land with soil suitable for agricultural use.

Table 3.2.1:
Modified Mercalli Intensity Scale

Intensity	Modified Mercalli Intensity Scale of 1931[1]
I	Not felt except by a very few under especially favorable conditions.
II	Felt by only a very few persons at rest, especially on upper floors of buildings; delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake; standing motor cars may rock slightly; vibration like passing of truck; duration estimated.
IV	During the day felt indoors by many, outdoors by few; at night some awakened; dishes, windows, doors disturbed; walls make cracking sound; sensation like heavy truck striking building; standing motor cars rocked noticeably.
V	Felt by nearly everyone, many awakened; some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned; disturbances of trees, piles, and other tall objects sometimes noticed.
VI	Felt by all, many frightened and run outdoors; some heavy furniture moved; a few instances of fallen plaster or damaged chimneys; damage slight.
VII	Everybody runs outdoors; damage negligible in buildings of good design and construction, slight to moderate in well-built, ordinary structures, considerable in poorly built or badly designed structures; some chimneys broken; noticed by persons driving motor cars.
VIII	Damage slight in specially designed structures, considerable in ordinary substantial buildings, with partial collapse, great in poorly built structures; panel walls thrown out of frame structures; fall of chimneys, factory stacks, columns, monuments, walls; heavy furniture overturned; sand and mud ejected in small amounts; changes in well water; persons driving in motor cars disturbed.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse; buildings shifted off foundations; ground cracked conspicuously; underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked; rails bent; landslides considerable from river banks and steep slopes shifted sand and mud; water splashed over banks.
XI	Few, if any (masonry) structures standing; bridges destroyed; broad fissures in ground; underground pipelines completely out of service; earth slumps and land sips in soft ground; rails bent greatly.
XII	Damage total; practically all works of construction are damaged greatly or destroyed; waves seen on ground surface; lines of sight and level are distorted; objects thrown into air.

[1] From Kramer (1996)

Table 3.2.2:
Significant Historical Earthquakes Which Have or May Have Generated MM III or Greater Intensities at the Site

Date	Origin Time (GMT)	Latitude (degrees)	Longitude (degrees)	Magnitude	Estimated MM Intensity
1872 Dec 15	0:00:00	48.600	-121.400	M_L 7.4	VII+ (III-IV at site)
1892 Mar 5	5:00:00	46.600	-120.500	M_I 5.1	VI*
1893 Mar 5	0:00:00	45.900	-119.333	M_I 5.0	VI*
1918 Nov 1	17:00:00	46.700	-119.500	M_I 5.0	VI*
1921 Sep 14	11:00:00	46.100	-118.250	M_I 5.0	VI*
1924 Jan 5	22:00:00	45.830	-119.250	M_I 5.0	V*
1936 Jul 16	7:07:49	46.208	-118.233	M_L 6.1	VII (V at site)
1951 Jan 7	22:45:00	45.900	-119.200	M_I 4.3	V*
1964 Jan 15	23:06:36	45.900	-120.000	m_b 4.2	Unknown*
1976 Apr 13	0:47:15	45.076	-120.859	M_L 4.8	V-VI (II-IV at site)

* No isoseismal map is known to exist for these earthquakes, but given their location and maximum intensity or instrumental magnitude, it is possible these earthquakes generated MM III at the site.

GMT	Greenwich Mean Time
M_L	Richter Local
M_I	Intensity-based
m_b	Body-wave

Table 3.2.3:
Significant Quaternary Faults in the Site Region

Fault	Style	Rupture Length (km)	M_{max} (M_w)	Dip	Closest Distance to Project Site (km)	Data Sources
Service Anticline	S-S/R	10 42	6.2 7	Fold	5	Foundation Sciences, 1980; Squier Associates, 1994
Columbia Hills Anticline	R	170	7.7	Fold	22	Geomatrix, 1995; Geomatrix, 1996; Wong et al., 2000b
Rattlesnake-Wallula Trend (RAW) - REVERSE	R	50	7.1	45°NE	46	Geomatrix, 1995; Geomatrix, 1996; Wong et al., 2000b
Rattlesnake-Wallula Trend (RAW) - STRIKE SLIP	S-S	115	7.5	90°	46	West et al., 1996; Geomatrix, 1996; F.H. Swan, pers. omm., 2000; S.P. Reidel, pers. commun., 2000; Wong et al., 2000b
Wallula	S-S	44	7	90°	51	Squier Associates, 1994;
Horse Heaven Hills	R	48	7	45°NE	57	Geomatrix, 1988; Geomatrix, 1990; Wong et al., 2000b
Arlington - Shutler Buttes fault zone	S-S	70	7.2	90°	66	Geomatrix, 1995; Geomatrix, 1996; Wong et al., 2000b
Columbia Hills Anticline fault	R	72	7.2	45°N W	86	Geomatrix, 1995; Geomatrix, 1996; Wong et al., 2000b
Umtanum Ridge	R	141	7.6	45°S	95	Geomatrix, 1995; Wong et al., 2000b
Oak Flat - Luna Buttes zone	S-S	40	6.9	90°	95	Geomatrix, 1995; Wong et al., 2000b
Hite	S-S	60	7.1	90°	99	Geomatrix, 1995;
Toppenish Ridge (Satus Peak segment)	R	30	6.8	45°S	101	Geomatrix, 1988; Geomatrix, 1990; Wong et al., 2000b
Walla Walla Basin	S-S?	12	6.3	70°SW	104	Squier Associates, 1994; Tolan and Reidel, 1989
West Grande Ronde Valley	N	17	6.5	70°NE	107	Geomatrix, 1995
Manastash Ridge	R	40	6.9	45°S	118	Geomatrix, 1988; Wong et al., 2000b

Fault	Style	Rupture Length (km)	M_{max} (M_w)	Dip	Closest Distance to Project Site (km)	Data Sources
Saddle Mountains (Saddle Gap segment)	R	28	6.8	40°S	121	Geomatrix, 1988; Wong et al., 2000b
East Grande Ronde Valley	N	15	6.4	70°SW	126	Geomatrix, 1995
Saddle Mountains (Smyrna Bench segment)	R	16	6.4	40°S	128	Geomatrix, 1990; Geomatrix, 1996; Wong et al., 2000b
Tampico	S-S	16.5	6.5	90°	136	Geomatrix, 1988; Wong et al., 2000b
Frenchman Hills (West Canal segment)	R	30	6.8	40°S	139	Geomatrix, 1995; Wong et al., 2000b
Cowiche Mountain	R	50	7.1	45°N	140	Geomatrix, 1990; Wong et al., 2000b
Wallowa	N	40	6.9	70° NE	151	Geomatrix, 1995

S-S = Strike-slip fault
R = Reverse fault
N = Normal fault

Table 3.2.4:
MCE Median (50th Percentile) Peak Horizontal Accelerations on Soil

Seismic Source	MCE (M_w)	Distance to Project (km)	Peak Horizontal Acceleration (g's)				
			Abrahamson & Silva (1997)	Boore et al. (1997)	Campbell (1997)	Sadigh et al. (1997)	Average PGA
Service Anticline	7	5.0	0.43	0.45	0.47	0.42	0.44
Wallula Fault	7	51.0	0.09	0.10	0.09	0.08	0.09
Columbia Hills Anticline	7.7	22.0	0.26	0.32	0.34	0.33	0.31
Rattlesnake-Wallula Trend	7.5	46.0	0.12	0.14	0.15	0.13	0.13
Rattlesnake-Wallula Trend	7.1	46.0	0.12	0.13	0.10	0.13	0.12