3.1 Earth

This section presents the existing conditions, potential impacts, and mitigation to the earth from the construction and operation of the Cherry Point Cogeneration Project (Cogeneration Project). More details on earth and natural hazards are provided in Appendix G.

3.1.1 Existing Conditions

The Cogeneration Project site is located in western Whatcom County, Washington, in the Whatcom Basin, west of the Cascade Mountain range. The Cogeneration Project site is relatively flat and the onsite geologic conditions are fairly uniform.

3.1.1.1 Geologic Conditions

Geologic conditions in the vicinity of the Cogeneration Project site have developed over millions of years. The discussion on existing conditions summarizes the geologic deposits and processes that created these conditions.

During major glaciation periods, retreats and advances of glaciers (called stades) resulted in the layering of differentiated sediments. Older sedimentary and crystalline rocks are exposed in the Cascade Range to the east, the Coast Range to the north, the Chuckanut Mountains to the southeast, the San Juan Islands to the southwest, and the Gulf Islands and Vancouver Island to the west. The sedimentary and crystalline rocks comprise the bedrock under the Cogeneration Project site. The surface geologic conditions at the site are primarily quaternary glacial and nonglacial unconsolidated sediments. These unconsolidated sediments were formed over the last 20,000 years during glacial episodes. The focus of the discussion will be on the unconsolidated sediments underlying the proposed Cogeneration Project site. Figure 3.1-1 is a generalized geologic surface map of the area surrounding the proposed Cogeneration Project site.

Igneous and metamorphic rocks present in mountains bordering the Whatcom Basin include the pre-Devonian-age granitic and hornblende-rich rocks of the Turtleback Complex exposed in only a few localities (Lummi Island) and a pre-Jurassic-age phyllite exposed in the Chuckanut Mountains to the southwest (Easterbrook, 1973 and 1976).

Sedimentary rocks include the Paleocene to Late Cretaceous-age Chuckanut Formation and the Eocene-age Huntingdon Formation. The Chuckanut Formation includes a thick sequence of sandstone, conglomerate, shale, and bituminous to sub-bituminous coal. The Chuckanut Formation makes up most of the Cascade foothills to the east and the Chuckanut Mountains to the southwest. The Huntingdon Formation was deposited unconformably on the Chuckanut Formation. The Huntingdon Formation consists of mostly sandstones and shales, similar to the Chuckanut Formation. Unconsolidated Quaternary deposits overlie the Chuckanut and Huntingdon Formations over much of the lowland areas (Easterbrook, 1973 and 1976).

Quaternary unconsolidated deposits were formed as a result of glacial stades as well as from at least two incursions of seawater during the Everson interstade (between stades). Drift deposits (sediments from melting glaciers) of the Vashon stade of the Fraser glaciation include the Vashon till and Esperance sand. These Vashon drift deposits are found at depth below the Everson interstade deposits and also exposed in sea cliffs along the Strait of Georgia shoreline. The Esperance sand is an outwash sand and gravel deposited from melt-water streams during the Vashon stade glacial advance. Vashon till was deposited as a lodgment till at the base of the advancing glacier and overlies the Esperance sand. The Vashon till is a compact mixture of pebbles and cobbles in a matrix of clay, silt, and sand. The Vashon till forms a massive layer that underlies much of the lowland area (Easterbrook, 1973 and 1976).

Deposits of the Everson interstade underlie much of the area around the proposed Cogeneration Project site. The Everson interstade deposits consist of two fossiliferous glaciomarine deposits separated by a fluvial sand. From bottom to top, these units include the Kulshan glaciomarine drift, the Deming sand, and the Bellingham glaciomarine drift (Armstrong and others, 1965; and Easterbrook, 1973 and 1976).

Deposits of stratified sand and gravel mantle the Bellingham drift in places and were likely the result of wave action reworking the surface of the Bellingham drift, resulting in the removal of most of the fine sediments. These sand and gravel deposits, where they occur, are 10 feet or less in thickness (Easterbrook, 1973 and 1976).

Sumas drift deposits fill most of the low-lying areas and valleys. These deposits include outwash sand and gravel, terrace deposits, and silt and clay of estuarine origin. These Sumas drift deposits do not occur beneath the area of the proposed Cogeneration Project site but do occur in the low-lying area to the north and in the valley of the Nooksack River to the east (Easterbrook, 1973 and 1976).

Recent alluvial deposits occur in the Nooksack River floodplain to the east. Beach deposits occur along the Strait of Georgia and Bellingham Bay at the base of the sea cliffs and form sand spits created by long shore currents (Sandy Point and Semiahmoo Spit). Peat deposits occur in low-lying areas and depressions in floodplains, Sumas outwash plains, and on the Bellingham drift (Easterbrook, 1973 and 1976).

Based on cross-sections developed from available literature (Easterbrook, 1976) and borehole logs (Ecology, 2001 and Remediation Technologies Inc., 1993), the stratigraphy for the proposed Cogeneration Project site was developed and is illustrated on Figure 3.1-2. The stratigraphic layers are summarized below.

Quaternary Deposits:

- *Sand and Gravel overlying the Bellingham Drift (Qbg):* A thin mantle consisting primarily of sand, from well sorted sand to silty sand. This unit is interpreted to be wave-reworked material from the Bellingham drift. This unit ranges up to 10 feet thick and may or may not be present at the proposed Cogeneration Project site.

- *Bellingham Drift (Qb):* The Bellingham glaciomarine drift consists of a fossiliferous blue-gray, unsorted, and unstratified pebbly sandy silt and pebbly clay. The Bellingham drift may be 70 to 80 feet thick below the proposed Cogeneration Project site. The Bellingham drift includes an upper weathered zone as much as 23 feet thick.
- *Deming Sand (Qd):* The Deming sand consists of brown, stratified, well-sorted, medium to coarse sand with some layers of silt, clay, and gravel. The Deming sand may be 30 to 40 feet thick below the proposed Cogeneration Project site. The Deming sand appears to be discontinuous or pinches out to the east and northeast.
- *Kulshan Drift (Qk):* The Kulshan glaciomarine drift consists of a fossiliferous blue-gray, unsorted, and unstratified mixture of silt, clay, sand, and pebbles. The thickness of the Kulshan drift at the proposed Cogeneration Project site is unknown. In some cases, this unit was not distinguishable in the well logs. In these cases, the Kulshan drift was lumped into the undifferentiated sedimentary deposits (*Qu*).
- *Undifferentiated sedimentary deposits (Qu):* These are unconsolidated sedimentary deposits that were not separated or were not distinguishable on the well logs. The unconsolidated sedimentary deposits may include the Kulshan drift (*Qk*), Vashon till (*Qvt*), Esperance sand (*Qve*), and other glacial and nonglacial sediments below the Bellingham drift.

Pre-Quaternary Layers:

- *Undifferentiated sedimentary rock (TMu):* Tertiary-Mesozoic sedimentary rocks (bedrock) were encountered in wells to the north and northeast of the proposed Cogeneration Project site. These rocks were encountered at 210 and 256 feet below ground surface to the north and northeast. One well to the west that was drilled to a depth of 650 feet below ground surface did not encounter bedrock. These sedimentary rocks are likely Chuckanut or Huntingdon Formation with structures similar to their exposures to the southeast. Wells in the area around the Cogeneration Project and Refinery did not encounter bedrock to depths of 600 feet.

3.1.1.2 Surficial Soils

The soils at the proposed Cogeneration Project site and vicinity are described in the literature as having no erosion hazard (Goldin, 1992). The distribution of soil types in the vicinity of the Cogeneration Project site is shown on Figure 3.1-3. The general soil type that encompasses most of the proposed Cogeneration Project site and vicinity is the Birchbay-Whitehorn unit. Permeability in the Birchbay-Whitehorn soils is low to moderate. Elements of the Whatcom-Labounty unit and the Kickerville-Barneston-

Everett unit are also present in the vicinity. Hydric soils exist at the Cogeneration Project site and are discussed in more detail in Section 3.4.

3.1.1.3 Topography and Unique Physical Features

The topography of the proposed Cogeneration Project site is depicted on Figure 3.1-4. Existing slopes range from 0.5% to 1%. Because of the flat topography, no significant topographic modifications will be required to prepare the site. No modifications to drainage patterns will occur, as described in Section 3.3.

No unique physical features are present in the vicinity of the proposed Cogeneration Project site. The site and surrounding areas are typical of areas found throughout western Whatcom County.

3.1.1.4 Present-day Regional Tectonic Setting

Northwestern Washington State is located along the western margin of the North American tectonic plate, near the boundary of the Juan de Fuca plate. The Juan de Fuca plate is at present moving northeastward at an average rate of about 40 mm/year relative to the North American plate. The Juan de Fuca plate is still forming at its boundary with the Pacific plate farther west in the Pacific Ocean.

These relative plate motions result in the Juan de Fuca plate subsiding below the North American plate along the Cascadia Subduction zone, which lies offshore of northern California, Oregon, Washington, and British Columbia. Plate interactions at the subduction zone result in the creation of faults and folds, and the generation of most of the earthquakes in the Pacific Northwest.

Major earthquakes in the Pacific Northwest have four principal origins:

- Shallow earthquakes from active spreading at the boundary of the Pacific and Juan de Fuca plates;
- Large interplate earthquakes at the boundary of the North American and Juan de Fuca plates;
- Deeper earthquakes resulting from internal stresses associated with the bending and arching of the Juan de Fuca plate as it is subducted beneath the North American plate; and
- Shallow crustal earthquakes in the overlying North American plate, particularly where it overlies the change in subduction direction of the Juan de Fuca plate.

Historical Seismicity:

Western Whatcom County is located in a region of moderate historical seismicity (Figure 3.1-5). Earthquake shaking intensity records from the National Earthquake Intensity Database (National Geophysical Data Center, November 2001) show intensities of Modified Mercalli Intensity (MMI) III or greater have been recorded 34 times in Bellingham and 12 times in Ferndale (6 miles southeast of the proposed Cogeneration Project site) from the late 19th Century to 1985. The shaking comes from earthquakes located both within and distant from Whatcom County (Table 3.1-1).

The largest known earthquake in the Pacific Northwest occurred on 26 January 1700. This earthquake probably occurred offshore along the boundary between the Juan de Fuca and North American plates. While the magnitude (M) of the event is not certain, it was probably larger than M 8, and may have been as large as M 9. These magnitude estimates are based on the area of ground deformation associated with the earthquake (Atwater et al., 1995) and the record of the major tsunami that affected the west coast of North America and Japan (Satake et al., 1996). Geological evidence summarized by Atwater et al. (1995) indicates that these large interplate earthquakes may occur about every 1000 years.

Instrument records reveal that at least 24 earthquakes of magnitude 4.0 or greater have occurred within 100 miles of the proposed Cogeneration Project site since the early 1970s (Table 3.1-1). Twelve of these earthquakes were located within 30 miles of the proposed Cogeneration Project site.

TABLE 3.1-1

Significant Historical Earthquakes in Northwestern Washington
and Southern British Columbia

Date (dd/mm/y)	Latitude (°North)	Longitude (°West)	Magnitude	Depth (km)	Maximum MMI	Approx. Distance to Cherry Point (miles)
14/12/1872	48.8	121.4	7.4	?	IX	>125
17/03/1904	48.5	122.8	5.3	?	V	24
11/01/1909	49.0	122.7	6.0	?	VII	11
18/08/1915	48.5	121.4	5.6	?	V	62
24/01/1920	48.8	123	5.5	?	VI	15
31/12/1931	47.5	123.0	4.8	?	VI	93
18/07/1932	47.75	121.83	5.2	?	VI	84
13/11/1939	47.5	122.5	5.75	?	VII	92
29/11/1943	48.4	122.9	4.8	?	VI	31
15/02/1946	47.4	122.67	5.75	18	VII	98
15/05/1954	48.0	122.00	5.0	?	VI	65
26/01/1957	48.33	122.43	5.0	?	VI	36
10/09/1960	47.70	122.70	4.6	25	VI	78
24/01/1963	47.60	122.10	4.5	17	VI	89
14/07/1964	49.00	122.60	4.6	13	VI	12
10/11/1969	48.50	121.40	4.7	?	V	62
16/04/1975	47.57	122.90	4.0	47	V	87
16/05/1976	48.80	123.36	5.4	62	VI	31
02/09/1976	48.21	122.76	4.3	24	VI	43
10/07/1977	48.53	122.45	4.3	11	VI	23
05/03/1977	48.06	123.00	4.0	57	IV	55
11/03/1978	47.42	122.71	4.8	25	VI	97
31/03/1978	47.42	122.71	4.2	23	VI	97
19/08/1978	48.63	123.55	4.3	32	V	42
23/08/1978	48.38	123.2	4.4	17	V	39
31/12/1978	47.58	121.85	4.0	20	VI	94

Date (dd/mm/y)	Latitude (°North)	Longitude (°West)	Magnitude	Depth (km)	Maximum MMI	Approx. Distance to Cherry Point (miles)
09/11/1979	49.00	124.42	4.3	28	IV	80
29/11/1979	48.59	122.40	4.1	21	V	20
28/08/1983	47.93	122.85	4.2	51	IV	62
14/02/1989	48.43	122.23	4.2	0	VI	34
05/03/1989	47.81	123.26	4.6	46	V	77
06/03/1989	48.43	122.23	4.2	1	V	34
18/06/1989	47.41	122.78	4.4	44	V	100
02/04/1990	48.83	122.19	4.3	0	VI	22
03/04/1990	48.84	122.18	4.8	1	V	22
14/04/1990	48.85	122.16	5.2	12	VI	23
19/02/1991	49.70	122.72	4.3	5	V	60
22/02/1996	49.90	123.90	4.1	2	IV	92
23/06/1997	47.60	122.57	5.0	7	VI	85
24/06/1997	49.24	123.62	4.6	3	IV	51

Notes:
(1) Locations, depths, and magnitudes were obtained from the USGS/NEIC PDE (1973-present) and Significant Worldwide Earthquake Catalog (2150 B.C.-1994 A.D.) catalogs.
(2) Earthquake magnitudes are M_b, M_s, M_w and M_L.
(3) Time is Universal time.
(4) Earthquake depths before 1969 are approximate only.
(5) Distance to proposed Cogeneration Project site based on its location at 48.833°N, 122.673°W
(6) Intensity scale after Bolt (1993).

Most of the larger earthquakes ($M \geq 6.5$) recorded by instruments in Washington State have been located in the southern part of the Puget Lowland, near Seattle and Olympia in 1949, 1965, and 2001. These earthquakes have occurred within the upper part of the Juan de Fuca plate at depths greater than 15 miles.

The most significant local earthquake in recent history was the M 5.2 Deming earthquake of 14 April 1990. It had an epicenter about 25 miles southwest of the proposed Cogeneration Project site (Dragovich et al., 1997). The main shock and aftershocks occurred at shallow depths (2 to 2.5 miles). Although no surface fault rupture was recorded, Dragovich et al. (1997) believe that the earthquake was caused by subsurface movement along a shallow, northeast-dipping thrust fault. They inferred from a range of local topographic features that this fault has moved repeatedly over the last approximately 15,000 years.

Recent Faulting and Tectonic Uplift:

No surface fault ruptures are known to have accompanied large historical earthquakes in Washington State. Most of these larger historical earthquakes have occurred within the subducting Juan de Fuca plate. Geomorphic evidence of land deformation associated with prehistoric earthquakes (coseismic) in the North American plate has been described from several places in western Washington:

- Macaulay Creek Thrust in western Whatcom County (Dragovich et al., 1997)

- The Devils Mountain Fault zone in the eastern Strait of Juan de Fuca (Johnson et al., 2000)
- The Southern Whidbey Island Fault in Puget Sound (Johnson et al., 1996)
- The Seattle Fault in central Puget Sound (Bucknam, 1992)
- Repeated subsidence of coastal lowlands during the last 7000 years in northern California, Oregon, Washington, and southern British Columbia (Atwater et al., 1995)

Recent analysis by Easterbrook et al. (unpublished) infers the existence and recent activity of two northeast-southwest-trending faults to the east of the proposed Cogeneration Project site. Easterbrook et al. (unpublished) infer that a 6-mile-wide structural valley (graben) formed from repeated movement along the Sumas and Vedder Mountain faults. They infer that these faults have created the Sumas Valley.

The existence, precise location, and potential for coseismic movement along these inferred faults are speculative and controversial. Neither of these inferred faults trends into the proposed Cogeneration Project site. These inferred faults are not believed to present a hazard to the proposed Cogeneration Project site.

3.1.1.5 Volcanic Conditions

There are five major composite volcanoes (or stratovolcanoes) in the State of Washington that are all part of the Cascade Range, a volcanic arc that stretches from southwestern British Columbia to northern California. These five volcanoes are Mount Baker, Glacier Peak, Mount Rainier, Mount St. Helens, and Mount Adams. All Washington volcanoes, except Mount Adams, have erupted within the last 250 years (Pringle, 1994).

Of the five Washington volcanoes, only Mount Baker and, to a far lesser degree Glacier Peak, have any potential to affect the proposed Cogeneration Project site. Mount Baker is located approximately 45 miles east and Glacier Peak is located approximately 100 miles southeast of the proposed Cogeneration Project site. Tephra (aerial volcanic debris) deposition is the principal potential concern to the proposed Cogeneration Project site from an eruption of a Cascade volcano; lava flow and debris is not a concern due to the relative distance and the upland location of site. Because the other Cascade volcanoes are far more distant from the Cogeneration Project site, only tephra would be a potential concern and it is highly unlikely that airborne debris would reach the site in noticeable amounts. Volcanic hazards are discussed in more detail in Section 3.1.2.1 below.

3.1.2 Environmental Impacts of the Proposed Action

3.1.2.1 Natural Earth Hazards to the Proposed Action

Natural hazards that could affect the safety or operation of the proposed Cogeneration Project include the following:

- Erosion hazards as a result of flooding
- Seismic hazards
- Volcanic hazards
- Tsunami hazards

Flooding Hazards:

The proposed Cogeneration Project and all associated components are located outside of any FEMA-designated 5-, 100-, or 500-year floodplains. Site soils are fairly impervious (clay/silt), topography is relatively flat, and the vegetation is well established. Based on these factors, there is a very low risk for flooding hazards.

Seismic Hazards:

Ground shaking is the most pervasive earthquake hazard. The amplitude, frequency, and duration of the shaking at a site are related to the:

- Magnitude of the earthquake;
- Distance of the site from the earthquake source; and
- Earth materials underlying the site.

In general, the closer a site is to the source of the earthquake, the greater the earthquake shaking.

A useful way to describe earthquake shaking for engineering purposes is in terms of peak horizontal ground acceleration (PGA). This measure provides useful information about the forces that might be applied to engineered structures during earthquake shaking.

The U.S. Geological Survey (USGS) National Seismic Hazard Mapping Project has completed a probabilistic seismic hazard assessment for the contiguous United States. They estimate probabilistic seismic hazard by considering the probability of occurrence of all earthquakes and the probability of all the ground motions associated with these earthquakes, and calculating the probability that a certain level of shaking will be exceeded in a chosen time period. The 10% probability of exceeding a mean PGA value in a 50-year period is a common measure used in engineering studies.[1] This is equivalent to the mean ground motion with a return period of 475 years.

The proposed Cogeneration Project site has a moderate level of earthquake hazard. A PGA of 0.23g has a 10% chance of being exceeded in the next 50 years. Strong shaking of 0.54g has a 1% chance of being exceeded in 50 years (Table 3.1-2). These levels of

[1] This probability can also be expressed as a 90% probability that the ground motion will **not** be exceeded in 50 years.

earthquake shaking are estimated for weak rock sites. The character (frequency and duration) of earthquake shaking expected at the proposed Cogeneration Project site will be different than calculated by the USGS models because the proposed Cogeneration Project site is underlain by more than 60 m of soil. The soil layer will modify the character of earthquake ground motions (see below).

TABLE 3.1-2

Existing Estimates of mean PGA for Rock at the Cogeneration Project Site

Probability of Exceedence	**Return Period (years)**	**USGS**	**Canadian Building Code**
10% in 50 yrs	475	0.23g	0.16-0.23g
5% in 50 yrs	975	0.31g	
2% in 50 yrs	2475	0.44g	
1% in 50 yrs	4975	0.54g	

The USGS also provides a disaggregation of the calculated hazard. This disaggregation splits the total hazard into its contributing earthquake sources for distance and magnitude classes. Disaggregation of the Cogeneration Project site hazard shows that the 475-year PGA value has approximately equal contributions from moderate local magnitude earthquakes and larger, but more distant deeper earthquakes. The hazard from large magnitude earthquakes at the subduction zone has been incorporated into the hazard estimate.

All of western Washington, including the proposed Cogeneration Project site and Oregon lie in Seismic Zone 3 of the 1997 Uniform Building Code (UBC). The region of Canada immediately north of the Cogeneration Project site lies within Canadian Building Code seismic acceleration Zone 2. This Canadian zonation specifies acceleration with a 10% probability of exceedance in 50 years of 0.16-0.23g. These data indicate that there is no significant difference between the USA and Canadian code seismic zonation of the Proposed Cogeneration Project site.

Potential effects of ground motions at the proposed Cogeneration Project site and surrounding area include:

- Amplification of ground motions by subsurface materials (site effects);
- Earthquake-triggered slope instability;
- Soil liquefaction and lateral spreading; and
- Surface fault rupture.

Site Amplification of Earthquake Ground Shaking: Existing investigations for sites close to the proposed Cogeneration Project site suggest that the site is underlain by more than

200 feet of Quaternary-age glacial and glaciomarine deposits. The upper 100 feet of these deposits are typically soft to medium stiff clay to about 50 feet below ground surface. Below about 50 feet they are very stiff to hard clay.

The upper 50 feet of sediment are expected to have a low average shear wave velocity. Average shear wave velocity in the upper 30 m of soil determines earthquake response and, shear wave velocity is used to characterize the soil profile type in the 1997 Uniform Building Code. Low average shear wave velocity deposits can filter out short-period ground motions and amplify the longer-period motions. Amplification of longer period motions is potentially more damaging to taller structures, and requires consideration during design. The magnitude of site amplification will depend primarily on the frequency, content, and intensity of the ground motions and local soil conditions. Topographic amplification of earthquake shaking is not expected because of the low relief of the site.

Dynamic Slope Instability: The site does not contain significant slopes. Earthquake-triggered slope instability is not a hazard at the proposed Cogeneration Project site.

Soil Liquefaction: Preliminary analysis of subsurface materials close to the proposed Cogeneration Project site indicates a lack of sand layers within the soft and stiff clay deposits. Without significant sand or silt layers, the potential for liquefaction at the site is low.

Surface Fault Displacement: No active faults are known beneath the site. Our analysis indicates that the potential hazard from surface faulting at the site is extremely low.

Volcanic Hazards:

The main volcanic hazards near Mount Baker are from debris flow and debris avalanches. The proposed Cogeneration Project site is not vulnerable to debris hazards from Mount Baker except for tephra. The nearest other hazard to the proposed Cogeneration Project site from a Mount Baker emotion would be a debris flow that could potentially inundate the Nooksack River floodplain, approximately 10 miles southeast of the proposed Cogeneration Project site. The largest debris flow in the past 14,000 years on Mount Baker occurred 6,800 years ago. This flow moved down the Middle Fork of the Nooksack to the main Nooksack, and can be traced as far downstream as Deming, where it is buried by younger river deposits. It is likely that this debris flow traveled all the way to the mouth of the Nooksack (Gardner and others, 1995).

The annual probability for the deposition of 1 centimeter or more of tephra at the proposed Cogeneration Project site from any Cascade volcano is 0.02%. The annual probability for the deposition of 10 centimeters or more of tephra at the proposed Cogeneration Project site from any Cascade volcano is less than 0.01%. Mount Baker has not historically produced large amounts of tephra and probably will not in the future (Gardner and others, 1995).

No lateral blast deposits have been recognized at Mount Baker. The probability for a future large event is considered low (Gardner and others, 1995). The proposed Cogeneration Project site is well outside the limits of the Mount Baker blast hazard zone.

Volcanic hazards near Glacier Peak include tephra fall, pyroclastic flows, pyroclastic surges, ballistic ejection, debris avalanches, debris flows (lahars), and floods. Debris flows represent the greatest hazard, followed by tephra fall. The proposed Cogeneration Project site is well outside the likely of hazard area from Glacier Peak, except for tephra fall. Debris flows have descended the Suiattle, White Chuck, Sauk, and Skagit River valleys during several eruptive periods (Waitt and others, 1995). All of these mentioned river valleys are relatively distant from the proposed Cogeneration Project site and well to the south and southeast. There are no indications that debris flows from Glacier Peak has ever affected the Nooksack River valley. The probability of a significant tephra fall occurring at the proposed Cogeneration Project site from Glacier Peak or other Cascade volcanoes is low.

Tsunami:

The vulnerability of the proposed Cogeneration Project site to tsunamis that have been historically recorded or interpreted from the geologic record is very low. The site is at an elevation of 120 feet above mean sea level (amsl) and is two miles from the Strait of Georgia. Sea cliffs ranging from 60 to 100 feet high protect most of the shoreline along the Strait of Georgia closest to the Cogeneration Project site.

The shoreline near the proposed Cogeneration Project site is generally protected from tsunamis generated from distant trans-Pacific sources or Cascadia subduction zone seismic events by the relatively narrow confines of the Strait of Juan de Fuca, Strait of Georgia, and the buffering of the San Juan and Gulf islands. Similar protection is afforded from tsunamis generated from a large seismic event along the Seattle fault to the south. More commonly, a tsunami could be generated from a local earthquake disturbing the sea floor or by slumping along the front of the Nooksack delta (Easterbrook, 1973). Such a tsunami could have severe local shoreline impacts but is not expected to affect the proposed Cogeneration Project site.

There is evidence that a tsunami occurred in Puget Sound between 1,000 and 1,100 years ago that probably originated from an earthquake on the Seattle fault (Atwater and Moore, 1992). The evidence is the deposition of sand sheets at two locations, Cultus Bay on Whidbey Island and West Point near Seattle. The sand sheet deposition appeared to be localized to shallow tidal marsh areas, indicating that the tsunami run-up did not affect inland areas beyond the near-shore environment.

3.1.2.2 Construction Impacts to Earth

Excavation and Fill Materials: The existing terrain at the proposed Cogeneration Project site is relatively flat. Therefore, there will be only a moderate amount of soil cut and fill for project construction. The imported fill, sand, and aggregate gravel are expected to be obtained from local sources within Whatcom County. Site grading would use onsite fill to the extent possible, to reduce the need for imported fill. For details on imported fill, sand, and gravel refer to Section 3.8.

Undesirable site soil materials (with respect to engineering properties) will be removed and disposed at an approved location. There is no evidence to suggest that contaminated soils exist at the proposed Cogeneration Project site. However, field screening will be conducted during geotechnical investigations. Any suspect soils encountered at the proposed Cogeneration Project site will be sampled and analyzed for hydrocarbon contamination before excavation. Any contaminated soils that are encountered will be segregated and properly disposed at a permitted disposal facility.

Topographic Modifications: Existing slopes range from 0.5% to 1% (Figure 3.1-4). Therefore, no significant topographic modifications will be required to prepare the site. Site grading will include cutting and filling with slopes directing stormwater drainage toward collection structures. Some unsuitable materials onsite will require removal, and some imported fill of suitable quality will be needed for replacement, site preparation, and backfill. This fill material will have minimal impacts on existing topography.

The proposed Cogeneration Project and related components will be located approximately 2 miles northeast of the nearest shoreline, beach, or submarine area. Therefore, there will be no changes to any shoreline, beach, or submarine areas.

Erosion: Existing slopes range from 0.5% to 1%, with minimal potential for significant erosion. The potential for erosion will be further reduced using the Best Management Practices described in Section 3.1.4.

The erosion factor K for soils at the proposed Cogeneration Project site (Birch Bay – Whitehorn) ranges from 0.10 to 0.49 (low to high). All soil at and in the vicinity of the proposed Cogeneration Project site is described as presenting no hazard of erosion due to the flat slopes and vegetation in the area (Goldin, 1992). Site grading and stockpiling will expose soils and increase the potential for erosion. Deposition of eroded soils will be controlled, minimized, and contained through the erosion control procedures and mitigation described in Section 3.1.4.

3.1.2.3 Operation and Maintenance Impacts to Earth

Plant Operation and Maintenance Impacts

There are no significant impacts anticipated to soils or local topography during the operation and maintenance of the Cogeneration Project. Additional fill or aggregate materials may be needed for repairs to roads and underground utilities, but the amounts would be minimal. The surface topography of the site is not expected to be altered after construction of the plant. The potential for erosion of site soils is small because exposed soils would be covered with maintained landscaping.

Seismic Hazard Impacts:

A large earthquake could impact plant operation. However, it is unlikely that the impacts would be significant, and potential impacts would be limited to closure of the facility for a period of time.

3.1.3 Environmental Impacts of the No Action Alternative

There are no benefits or impacts to Earth associated with the No Action Alternative.

3.1.4 Mitigation Measures

3.1.4.1 Erosion Control Procedures and Mitigation

BMPs will be implemented during construction and operation for erosion control and prevention. The BMPs will be described in a Stormwater Pollution Prevention Plan (SWPPP) and Temporary Erosion and Sedimentation Control Plan (TESC) developed prior to construction and operation. These BMPs may include the installation of control structures such as silt fences/straw bales, sediment traps, and diversion ditches. Construction activities will be controlled to limit erosion. Graded areas will be smooth, compacted, free from irregular surface changes, and sloped to drain. Because the existing slopes range from 0.5% to 1%, extensive grading of the site will not be required. Disturbed areas will be bermed with stabilized soil berms or sand bags to prevent erosion from impacting adjacent areas. Piles of excavated materials will be stabilized and protected using BMPs in accordance with a SWPP and TESC. Dust control and wind erosion will be controlled by maintaining surficial moisture content with regular application of water.

Excavated materials of acceptable quality will be reused as much as possible. Excess materials will be disposed at permitted fill sites or will be placed where they will not easily erode, and will not be placed on slopes steeper than 3 horizontal: 1 vertical unless compacted to the requirements of structural fills. Upon completion of construction, disturbed areas will be revegetated by seeding or hydroseeding. Seed mixes would be selected that are known to effectively stabilize erodible soils in the northwestern portion of the State of Washington. Sprinkler systems may be employed to sustain vegetation on bermed areas with high exposure to the erosive forces of wind.

Soil stockpiles will be covered with tarps or emulsion and surrounded by silt fences and straw bales or sand bags, where necessary, to prevent excessive erosion by wind or rain.

Erosion control measures for construction, such as silt fencing, straw bales, tarps, etc., will be inspected and maintained periodically and after major storm events as needed to ensure their continued effectiveness.

Stormwater runoff from the construction site will be collected and routed to a sediment control system. Sediment control measures, such as an oil-water separation system and detention ponds, are sized for likely events ranging from the water quality storm (6-month, 24-hour) up to the 100-year, 24-hour event. Details on the proposed stormwater and sediment control systems are provided in Section 3.3.

3.1.4.2 Seismic Hazard Mitigation

One natural hazard that has a potential to impact plant operation is a large seismic event. The Cogeneration Project will be designed and built in accordance with applicable federal, state and local building standards and codes specifically for power generating facilities. Impacts to the plant occurring from natural hazards mainly affect the ability of the plant to produce electricity or steam. Significant environmental impacts from natural hazards on major power plants have been rare or non-existent, which attests to the safety of the industry building standards and codes (AIS 2001).

3.1.5 Cumulative Impacts

There would be no cumulative impacts to Earth from the proposed Cogeneration Project.

3.1.6 Unavoidable Significant Adverse Impacts

There are no unavoidable significant adverse impacts associated with the construction or operation and maintenance of the Cogeneration Project. The potential for seismic induced impacts is low, but the potential would be greater if the underlying soils were soft. The characteristics of the soils under the proposed Cogeneration Project site will be determined during the geotechnical analysis during detailed project design. Should the soils prove to be susceptible to induced amplification, the project design will incorporate protection measures against such seismic events.