3. GEOLOGIC RESOURCES

This chapter discusses the regulatory setting, study area, affected environment, and potential direct and indirect impacts on geologic resources present or in close proximity to the proposed project. Existing geologic resources that could be potentially impacted by construction and operation of the proposed project include topsoils, subsoils, and topographic features. Potential impacts on these geologic resources from unplanned events such as spills and associated response activities are also evaluated. In addition, this section discusses potential direct and indirect impacts from geologic hazards associated with unplanned natural events, such as earthquakes, tsunamis, landslides, and lahars on the construction and operation of the proposed project.

3.1. Laws, Regulations, and Guidance for Geologic Resources and Geologic Hazards

Table 3-1 provides a summary of the laws, regulations, and guidance applicable to geologic resources and geologic hazards.

Table 3-1: Laws, Regulations, and Guidance for Geologic Resources

Regulation, Policy, or Guideline	Description
Federal	
Federal Resource Conservation and Recovery Act (RCRA)	Enacted in 1976, this federal law regulates solid waste and hazardous wastes including facilities that generate, transport, treat, store, or dispose of hazardous waste 940 CFR 260-282). The USEPA has delegated its authority to states, including Washington, to carry out the law through their own hazardous waste programs.
National Pollutant Discharge Elimination System (NPDES)	Section 402 of the CWA authorizes discharges of pollutants, such as stormwater and industrial wastewater, from point sources into waters of the U.S. through the NPDES permitting program. The USEPA has delegated its authority to states to administer the NPDES permitting program. Ecology regulates stormwater runoff through a series of general and individual permits for both construction and industrial activities. A Construction Stormwater General Permit would be required for proposed project construction, since it would entail clearing, grading, and excavating activities that disturb one or more acres and potentially the discharge stormwater to surface waters of the state.
40 CFR 112 (Oil Pollution Prevention)	Establishes the procedures, methods, equipment, and other requirements to prevent the discharge of oil from non-transportation-related onshore and offshore facilities. This includes requirements for the preparation and implementation of Spill Prevention, Control, and Countermeasure (SPCC) Plans.
State	
Washington State Growth Management Act (GMA) (RCW 36.70A; WAC 365-190, 195-199)	Requires local governments to adopt comprehensive plans, develop regulations to manage future growth, and protect critical areas and natural resource lands. Critical areas are environmentally sensitive areas and ecosystems that are designated for protection and management under RCW 36.70A.170. The specific critical area resource relevant to this chapter is geologically hazardous areas.

Regulation, Policy, or Guideline	Description
Washington State Shoreline Management Act (SMA) (RCW 90.58; WAC 173-26)	RCW 90.58 provides a statewide framework for managing, accessing, and protecting shorelines of the state. Jurisdiction includes all “shorelines,” “shorelines of statewide significance” (Padilla Bay), and “shorelands” within 200 feet landward of the ordinary high water mark, as defined in RCW 90.58.030. This chapter evaluates the potential impacts of the proposed project on geologic resources associated with shorelines of the state.
Oil and Hazardous Substance Spill Prevention and Response (RCW 90.56; WAC 173-180 to 186)	Requires Class 1 facilities, such as the Tesoro Anacortes Refinery, to establish oil spill prevention plans and oil spill contingency plans. The current refinery spill prevention and response plans would need to be updated to account for additional oil storage and spill response for oil and hazardous substances associated with the proposed project.
Washington Hazardous Waste Management Act (WAC 173-303; RCW 70.105)	The Hazardous Waste Management Act established a statewide framework for managing hazardous wastes to prevent land, air, and water pollution, and to conserve the natural, economic, and energy resources of the state. In the state of Washington, hazardous wastes are regulated as “dangerous wastes” under the State’s Dangerous Waste Regulations (WAC173-303) in accordance with the Hazardous Waste Management Act (RCW 70.105) and the federal RCRA. Dangerous wastes are defined as solid wastes that are designated as dangerous, extremely hazardous, or mixed wastes (WAC 173-303-070 through 173-303-100). In the event of spill of hazardous materials, any contaminated materials such as soils would need to be removed, appropriately characterized, and disposed of at an approved site.
Local	
Skagit County Critical Areas Ordinance (SCC 14.24)	Local development regulations designed to protect environmentally sensitive areas and ecosystems that are designated for protection and management under the Growth Management Act. The Critical Areas relevant to this chapter are geologically hazardous areas, which are defined as “areas that may not be suited to development consistent with public health, safety, or environmental standards because of their susceptibility to erosion, sliding, earthquake, or other geological events”. These areas are designated by WAC 365-190-080(4), and described in Section 3.4 of this chapter.
Skagit County Grading Permit	A Fill and Grade Permit may be required for any grading work involving substantial ground disturbing activity (either fill or excavation) or that impacts drainage in the area. A Fill and Grade Permit would be required for ground disturbing activity associated with the proposed project, particularly the areas planned for the New Tanks Area and improvements to North Texas Road.
Stormwater Management Manual for Western Washington (SWMMWW) (SCC Chapter 14.32; SCC 14.32.040, SCC 14.04.020)	Provides guidance on stormwater quantity and quality management. Skagit County requires specific stormwater management measures including obtaining an appropriate development permit for land clearing and land disturbing activities, grading, installing or expanding a building, creating or replacing impervious surfaces, and performing other construction activities (SCC Chapter 14.32, SCC 14.04.020). Applicants are required to submit a stormwater site plan compliant with Ecology’s 2012 SWMMWW, as amended in December 2014 (SCC 14.32.040), including stormwater pollution prevention provisions for erosion and sediment control (Ecology 2014). In addition, SWMMWW describes soil BMPs to preserve topsoil, reduce soil compaction, and protect local waterways in accordance with NPDES stormwater permits.

Regulation, Policy, or Guideline	Description
International Building Code (SCC 15.04)	Skagit County adopted the International Building Code (SCC; Chapter 15.04), which details seismic design of buildings based on seismic ground motion maps. Rules and regulations are provided to control excavation, grading, and earthwork construction including fills and embankments. According to the building code and Skagit County regulations, the proposed project would require a grading permit due to grading (including excavation and filling) associated with the project areas, particularly for the New Tanks Area and improvements to North Texas Road.

3.2. Study Area and Methodology

This section describes the specific considerations used to assess potential impacts of the proposed project on geologic resources.

3.2.1. Study Area

Geologic resources include topsoils, subsoil and topographic features within the refinery boundary and geologic features such as subsurface geologic units and fault zones in the proposed project vicinity. Geologic resources and features in the study area are shown on Figures 3-1 through 3-3. The geologic resources study area primarily includes the refinery boundary plus North Texas Road, where topsoils, subsoil, and topographic features would potentially be directly or indirectly impacted by construction and operation of the proposed project (see proposed project area on Figure 2-2 in Chapter 2, Proposed Actions and Alternatives). The geologic resources study area also considers the refinery's wharf structure and marine vessel transportation route.

Specifically, the geologic resources study area encompasses the following areas:

- The area within or immediately adjacent to the proposed project area where soils would be disturbed and/or excavated and where filling or grading activities would occur. These areas are within the refinery boundary or are within the two improvement areas along North Texas Road.
- The area in the vicinity of the proposed project area where regional geologic features could result in an unplanned natural event such as an earthquake, tsunami, landslide, or volcanic eruption that could impact the proposed project. These areas include the refinery boundary, North Texas Road, refinery wharf system, and marine vessel transportation route.

3.2.2. Methodology

Potential impacts on geologic resources that were evaluated as part of this analysis were determined through a public scoping process and by considering the proposed project's potential to impact these resources. Potential impacts on geologic resources that could occur during both construction (short term) and operations (long term) of the proposed project were considered in the analysis. A series of scoping meetings were conducted during the scoping period for the proposed project, with the public, tribes, and government agencies providing verbal and written comments. The primary issues related to geologic resources and geologic hazards that are addressed in this section include:

- Soil loss or erosion
- Slope destabilization
- Soil quality degradation

The following potential impacts from geologic hazards on construction and operation of the proposed project are evaluated in this section:

- Ground shaking, landslides, soil settlement, liquefaction, and surface faulting associated with an earthquake
- Landslides and soil settlement from heavy precipitation events or unstable slopes
- Direct damage from a tsunami or seiche
- Direct damage from volcanism and associated lahars

Direct impacts on geologic resources could result from ground-disturbing activities causing soil loss, erosion, or slope destabilization. In addition, geologic hazards associated with an unplanned natural event such as an earthquake, tsunami, landslide, or volcanic eruption, have the potential to impact the proposed project, which could result in loss of life, damage to property, or damage to the environment.

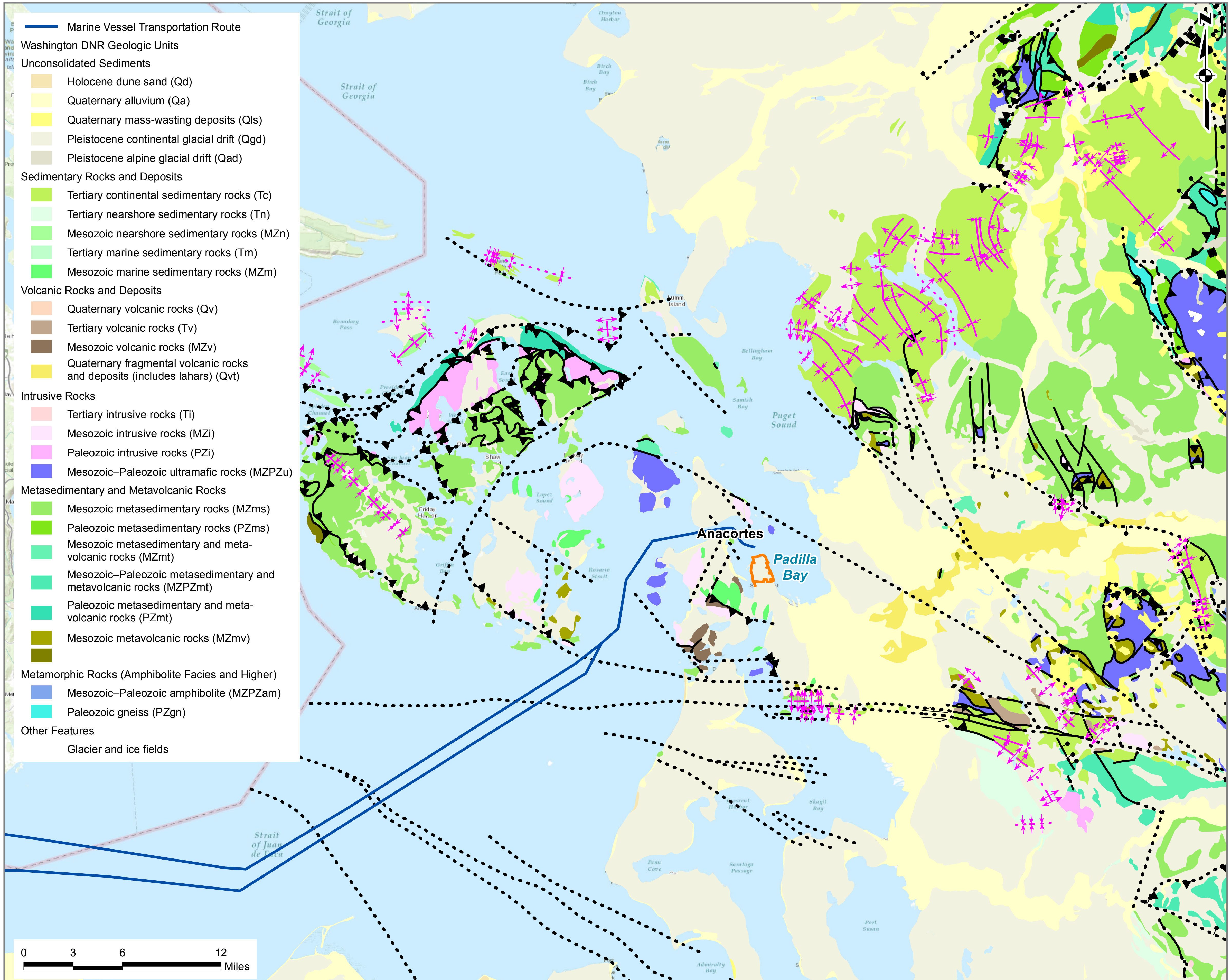
A significant impact on geologic resources is one that would result in one of the following:

- Soil loss, erosion, or degradation to the extent that soil can no longer support a functional natural or agricultural system at a landscape scale
- Slope destabilization to an extent that presents a risk of loss of life, substantive damage to property, or damage to the environment beyond the proposed project area

Impacts on other resources as a result of soil loss, erosion, or degradation, or slope destabilization are described in Chapter 5, Freshwater Resources; Chapter 6, Terrestrial Vegetation and Wildlife; and Chapter 9, Environmental Health.

A significant impact on the proposed project from geologic hazards is one that would damage proposed project infrastructure to an extent that could result in loss of life or a spill that would impact the environment beyond the developed portion of the refinery.

The results of the analysis are summarized using a significance assigned for each potential impact on geologic resources and geologic hazards. The process for characterizing the significance of each potential impact involved analyzing the magnitude, geographic extent, and duration of the impact (see Chapter 1, Section 1.7, Methodology). Based on the results of this analysis, the significance of each potential adverse impact was then assigned to one of two categories: *less than significant* or *potentially significant.* Criteria for assessing the significance of potential adverse impacts on geologic resources and geologic hazards are included in Table 1-B.1 in Appendix 1-B, Impact Criteria Tables.



Legend

- Marine Vessel Transportation Route
- Tesoro Refinery Boundary

Washington DNR Folds

- Anticline - Identity and existence certain, location accurate [1]
- Anticline - Identity and existence certain, location concealed [3]
- Syncline - Identity and existence certain, location accurate [13]
- Syncline - Identity and existence certain, location concealed [15]

Faults 500K

Dip-Slip Movement

- Normal fault - Identity and existence certain, location accurate. Bar and ball on downthrown block [43]
- Normal fault - Identity and existence certain, location concealed. Bar and ball on downthrown block [45]
- Low-angle normal fault - Identity and existence certain, location accurate. Rectangles on upper plate [31]
- Low-angle normal fault - Identity and existence certain, location concealed. Rectangles on upper plate [33]
- Thrust fault - Identity and existence certain, location accurate. Sawteeth on upper plate [7]
- Thrust fault - Identity and existence certain, location concealed. Sawteeth on upper plate [9]

Strike-Slip Movement

- Left-lateral strike-slip fault - Identity and existence certain, location concealed. Arrows show relative motion [21]

Movement Unknown

- Fault, unknown offset - Identity and existence certain, location accurate [1]
- Fault, unknown offset - Identity and existence certain, location concealed [3]

Notes:
Seismogenic data provided by Bowman, J. D.; Czajkowski, J. L., 2016, Washington State seismogenic features database--GIS data: Washington Division of Geology and Earth Resources Digital Data Series 1, version 4.1, originally issued December 2013
Source:
ESRI Topographic Web Mapping Service
NAD 1983 UTM Zone 10N

Figure 3-1
Regional Geology
Tesoro Anacortes Refinery
Clean Products Upgrade Project
Draft Environmental Impact Statement
Anacortes, Washington

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In addition to the potential impacts that could occur during regular and routine construction and operation activities over the life of the proposed project, impacts may also result from an unplanned event. In the case of this chapter, land-based spills at the refinery and geologic hazards associated with unplanned natural events such as earthquakes, tsunamis, landslides, and volcanism fall into this category. The methodology for evaluating impacts related to unplanned events follows the same methodology as for planned events–impacts are characterized as to their potential magnitude, geographic extent, and duration. However, for unplanned events, if the impact of the unplanned event is ***potentially significant***, then the likelihood, or probability, of an event occurring is assigned using a qualitative scale of probability categories described as Negligible, Low, Medium, or High (see Chapter 1, Section 1.7, Methodology).

3.3. Geologic Resources

The proposed project would disturb soils during construction and change the surface of the ground. These disturbances and surface changes are evaluated for their potential to increase erosion, degrade soil quality, or destabilize slopes. Potential impacts on soils from unplanned events such as spills and associated response activities are also evaluated.

3.3.1. Affected Environment

This section describes baseline geologic conditions for the proposed project area based on a review of various publicly available data sources and the studies completed for the proposed project.

3.3.1.1. Geologic Setting

The proposed project is located on March Point, which is within the Cascadia Subduction Zone (CSZ) geologic setting where the Juan de Fuca plate subducts the North American plate. Tectonic processes of subduction in the region have shaped the broad-scale topography and have created fault systems, formed the Cascade volcanic range, and distributed older basement rocks known as the Northwest Cascades system (Lapen 2000). Folds and faults in the region and in the vicinity of the proposed project are illustrated on Figures 3-1 and 3-2, respectively. Additionally, glaciation has eroded basement rocks and has deposited large volumes of glacial sediment in successive glacial periods (Shipman 2008). The current regional landscape is shaped by fluvial erosion and deposition, coastal processes, and volcanic eruptions.

The Skagit Valley and nearby low hills were created by the Vashon Glacier more than 14,000 years ago. Pleistocene age glacial sediment deposits, known collectively as the Vashon Drift, commonly overlie a sequence of older glacial and non-glacial sediments throughout the vicinity of the proposed project. The general location of Vashon Drift deposits are illustrated on Figure 3-1 as Pleistocene continental glacial drift (Qgd). Within the study area, a ridge of artificial fill (Qf) overlies these glacial outwash deposits along the north–south ridge of March Point (see Figure 3-2). The artificial fill is also illustrated as “Modified Land” (Qml), consisting of controlled and uncontrolled fill (Dragovich et al. 2000, 2002). Underlying the artificial fill, Pleistocene glacial outwash deposits consist of sand, sandy gravel, and gravel with minor interlayered silt and silty sand (Dragovich et al. 2000, 2002). These deposits are underlain by Pleistocene continental glacial till (Qgt,) which is dense to very dense, poorly sorted, and unconsolidated glacial outwash sediment consisting of clay, silt, sands, with scattered gravels and boulders, interbedded with silt and fine sand layers. Other nearby deposits include Quaternary alluvium (Qa) deposits located along the northern section of March Point and Quaternary beach deposits (Qb) located along the shoreline west of West March Point Road outside the refinery boundary.

3.3.1.2. Topography

Topography within the refinery boundary is relatively flat, with elevations ranging from approximately 100 to 200 feet above mean sea level (amsl), sloping gently (between 0 and 15 degrees) to the west toward Fidalgo Bay, and east toward Padilla Bay. Slopes on March Point range from 0 to 15 degrees (USGS 2014; Skagit County 2015). No erosion hazard soils, unstable slopes, or landslide areas are mapped on March Point in the Skagit County Potential Landslide and Erosion Areas critical areas maps (USGS 2014; Skagit County 2015).

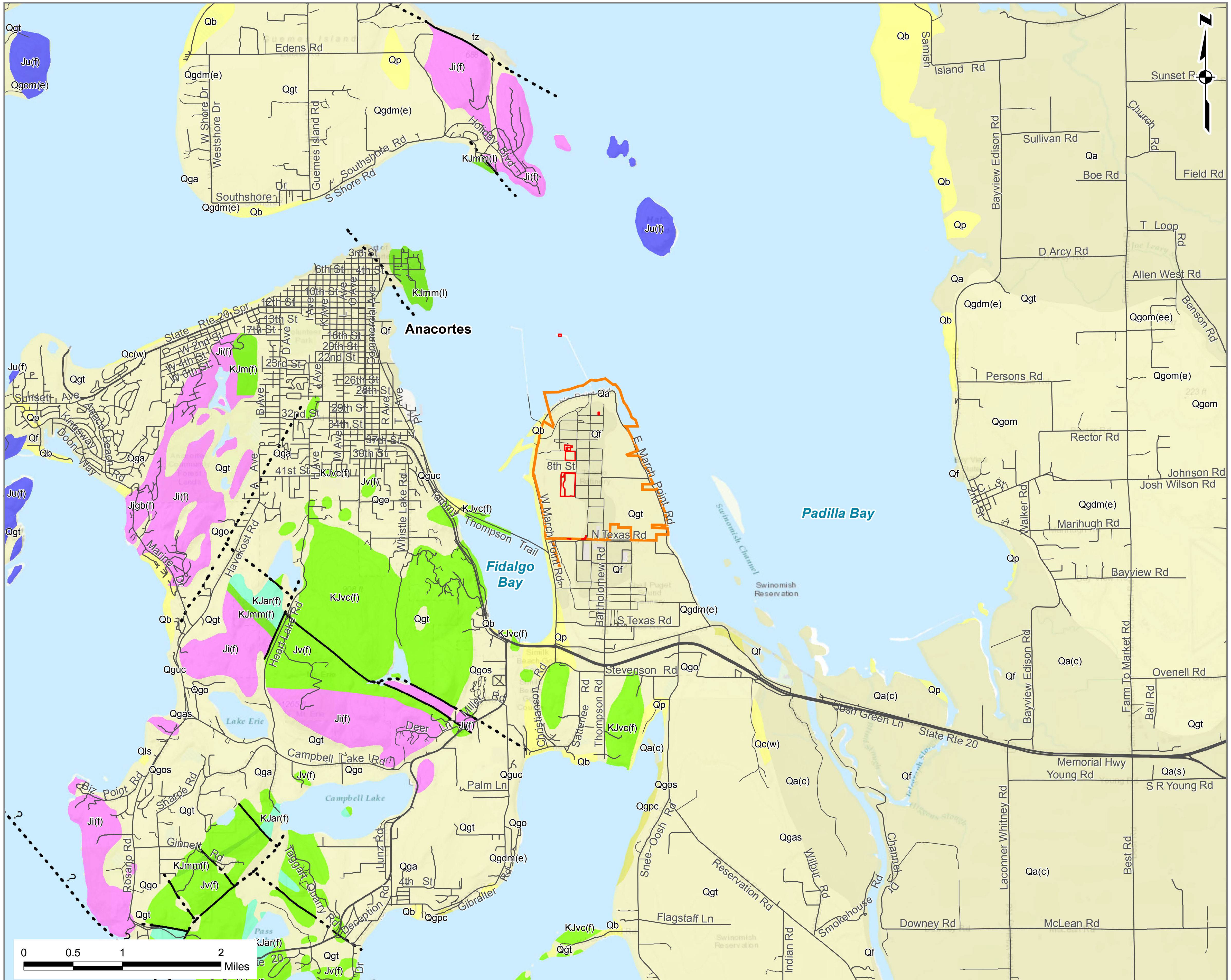
The steepest slopes within the proposed project area are found in the New Tanks Area with slopes of up to 8 degrees. The New Tanks Area ranges from approximately 90 feet amsl at the northwest to approximately 137 feet amsl at the southeast (AECOM 2015). The area around the VCU is gently sloped, and the area around the ARU, NHT, and Isom Unit is generally flat.

3.3.1.3. Soils

Soil within the study area is generally consistent with the mapped units described above in Section 3.3.1.1. NRCS has identified soils in the study area as 28 percent Bow gravelly loam, 19 percent Coveland gravelly loam, and 50 percent Xerorthents, also known as artificial fill (NSIS 2016; see Figure 3-3). The NRCS data indicate that soils within the study area are not classified as prime agricultural soils nor are they identified as rare or unique soils for the area.

Bow and Coveland gravelly loams are poorly drained soils from glaciolacustrine material described above in Section 3.3.1.1. Bow loam formed on hillslopes and glaciated terraces, while Coveland loam formed in valleys and outwash plains.

Artificial fill is classified as an excessively drained soil on hillslopes and floodplains from human-transported and disturbed material. Artificial fill within the study area consists of two strata; approximately 0.5 to 5 feet of variable granular fill overlying 1 to 11 feet of cohesive fill (AECOM 2015), depending on location. Granular fill is a medium density, variable granular fill consisting of sandy gravel to fine sands and sandy silts. Underlying cohesive fill is medium stiff to stiff and consists of mostly lean clays with zones of sandy silt. The fill overlies approximately 300 feet of interbedded glacial outwash of typically medium density to very dense silty clay, clayey silt, silty sand, sandy silt and gravels overlying Goat Island Terrane metasedimentary rocks (Eungard 2014; Dragovich et al. 2000, AECOM 2015).



Legend

- Proposed Project Area
- Tesoro Refinery Boundary

Washington Faults

- Fault, unknown offset - Identity and existence certain, location accurate [1]
- Fault, unknown offset - Identity and existence certain, location concealed [3]
- Fault, unknown offset - Identity or existence questionable, location concealed [6]

Washington Geologic Units

Unconsolidated Sediments

- Quaternary alluvial fans, beach deposits, landslides, and talus (Qb, Qc(w), Qls, Qp)
- Quaternary alluvium, dune sand, loess, and artificial fill (Qa, Qa(c), Qa(s), Qf)
- Pleistocene continental glacial, glaciolacustrine, and outburst flood deposits, Fraser-age (Qga, Qgas, Qgdm(e), Qgo, Qgom, Qgom(e), Qgom(ee), Qgos, Qgt, Qguc)
- Pleistocene continental glacial deposits, pre-Fraser (Qgpc)

Sedimentary Rocks and Deposits

- Cretaceous-Jurassic marine sedimentary rocks (KJm(f))

Sedimentary and Volcanic Rocks

- Cretaceous-Jurassic volcanic, volcaniclastic, and mixed volcanic and sedimentary rocks (Jv(f), KJvc(f))

Intrusive Igneous Rocks

- Mesozoic intrusive igneous rocks (Ji(f), Jigb(f))
- Mesozoic-Paleozoic ultramafic rocks (Ju(f))

Metasedimentary and Metavolcanic Rocks

- Cretaceous-Jurassic marine metasedimentary and metavolcanic rocks (KJmm(f), KJmm(l), KJms)
- Mesozoic metasedimentary and metavolcanic rocks (Kjar(f))

Other Features

- Deformed rocks in tectonic zones (tz)

Notes:
Geologic data provided by Washington State Department of Natural Resources, Division of Geology and Earth Resources (June, 2010)
Source:
ESRI Topographic Web Mapping Service
NAD 1983 UTM Zone 10N

Figure 3-2
Geology in Site Vicinity
Tesoro Anacortes Refinery
Clean Products Upgrade Project
Draft Environmental Impact Statement
Anacortes, Washington

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Legend

- Proposed 3-Inch Natural Gas Line
- Proposed Project Areas
- Tesoro Refinery Boundary
- NRCS SSURGO Data

Label - Map Unit Name - Acreage

9 - Beaches - 10.3 Acres

18 - Bow gravelly loam, low precipitation, 0 to 3% slopes - 227.7 Acres

19 - Bow gravelly loam, low precipitation, 3 to 8% slopes - 66.8 Acres

35 - Coveland gravelly loam, 0 to 3% slopes - 193.5 Acres

72 - Hydraquents, tidal - 14.2 Acres

165 - Xerorthents, 0 to 5% slopes - 521.6 Acres

Notes:
Contours shown are at 5 ft intervals.
NRCS SSURGO Soils from Soil Survey Geographic (SSURGO) database for Skagit County Area, Washington, 1998
Source:
USDA National Agricultural Imagery Program, flown 7/15/2013 at 1 m per pixel
NAD 1983 UTM Zone 10N

Figure 3-3
Site Soils
Tesoro Anacortes Refinery
Clean Products Upgrade Project
Draft Environmental Impact Statement
Anacortes, Washington

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Surface conditions and underlying soils within each of the areas proposed for development have been classified during previous geotechnical studies as follows (AECOM 2015):

- Expanded NHT and new Isom Unit: Existing Portland cement pavement underlain by artificial fill with 0 to 5 percent slopes (NSIS 2016), 20 to 40 feet stiff hard silt or clay overlying dense sand.
- New ARU: Existing bare earth and/or gravel (formerly a hazardous waste land treatment unit that has been remediated) underlain by artificial fill with 0 to 5 percent slopes (NSIS 2016), 20 to 25 feet stiff to very stiff silt or clay overlying generally dense to very dense sand.
- New Tanks Area: Pasture land with two isolated wetlands underlain by artificial fill with 0 to 5 percent slopes (NSIS 2016), 50 feet of very dense sand over hard clay or silt.
- Potential temporary construction laydown area: Pasture land with the southern half underlain by Coveland gravelly loam, 0 to 3 percent slopes and the northern half underlain by Bow gravelly loam, 3 to 8 percent slopes.
- New MVEC System: Existing grass underlain by artificial fill with 0 to 5 percent slopes (NSIS 2016), 5 to 12 feet medium stiff compressible cohesive fill overlying 35 to 40 feet stiff to very stiff clay over very dense sand.

3.3.2. Potential Impacts on Geologic Resources

This section evaluates the potential direct and indirect impacts on geologic resources as a result of construction and operation of the proposed project. The results of the impact analysis are presented below and are summarized in Section 3.3.2.4. Potential impacts of the proposed action are described separately for construction and operation.

3.3.2.1. Potential Impacts on Geologic Resources from Construction

Construction of the proposed project would include ground disturbance within the areas planned for the proposed project components within the refinery boundary and along North Texas Road where refinements to the width of the existing road are planned. Potential construction impacts on geologic resources include soil erosion, slope destabilization, and soil quality degradation. Soil erosion could occur directly as a result of soil disturbance and exposure during site preparation and construction activities. Slope destabilization could occur as a result of alteration or removal of large amounts of topsoil or subsoil material in areas of natural or artificial steep slopes. Degradation of soil quality could result from introduction of contaminated fill material, spread of existing contamination during soil disturbance, or spills during construction.

Impacts from Soil Erosion due to Construction

Activities associated with site preparation and construction would include direct disturbance of existing topsoil and subsoil (see Chapter 2, Section 2.7, Construction of Proposed Facilities). Disturbance consists of clearing vegetation and topsoil; grading and filling; burying of drainage lines, catch basins, tank ring wall bases; and other components. These activities could make soil susceptible to erosion from wind and rain, which could ultimately lead to loss of soil in the study area. Loss of soil from the study area can impact other resources in the receiving environment. Impacts on water from erosion are discussed in Chapter 5, Freshwater Resources, and impacts on terrestrial vegetation and wildlife are discussed in Chapter 6, Terrestrial Vegetation and Wildlife. The complete construction program is expected to occur over a 19-month period; however, exposure of soils would last no more than 6 months at any given location.

The proposed project would directly disturb up to 28 acres of land during construction. Approximately 23 acres of land is planned for development including 4.72 acres for the NHT, Isom Unit, ARU, and VCU within developed areas of the refinery; 18 acres for the New Tanks Area; and 0.37 acre for the improvements along North Texas Road. In addition, approximately 5 acres may be temporarily disturbed for use as a construction laydown area west of the New Tanks Area. The proposed project areas would be graded and leveled using an estimated 165,000 cubic yards of on-site cut material and approximately 133,000 cubic yards of structural fill material (Tesoro 2016). The greatest amount of cutting and filling would be necessary for the New Tanks Area and ARU. Over 90 percent of the fill and grade activities would occur within the 18-acre New Tanks Area for construction of three new tanks, associated pumps, appurtenances, and containment berms. Grading for the site would be completed using loaders, bulldozers, earthmovers, and graders. Appropriate wheeled trucks and dump trucks would be used to remove or transfer dirt or deliver other various construction materials.

The sites for the MVEC System, New Tanks Area, temporary construction laydown area, and North Texas Road Refinements are currently undeveloped and covered with grass. The Gate 10 Access Refinement, a portion of the North Texas Road Refinements, contains open cattle feeding pens with exposed soil and grass. Before starting earthwork activities, these areas would be cleared of vegetation, roots, and topsoil from within the limits of construction. Site preparation activities would then be followed by excavation, grading, compacting, paving or hard-packing surfaces, and rerouting underground lines, as required.

The expanded NHT, Isom Unit, and ARU are all located within previously developed areas characterized by paved or hard-packed soil surfaces. Construction and site preparation for the expanded NHT, Isom Unit, and ARU would include removal of existing pavement and excavation of structural fill, with the primary fill and grade activities occurring at the 4-acre ARU site. Auger cast piling and concrete base foundations for the NHT and ARU would be installed along with foundations for the Isom Unit. Areas excavated to install these units would then be backfilled to prepare the area for paving.

Measures that would be implemented during construction to reduce the risk of soil erosion include the following:

- A construction stormwater pollution prevention plan (SWPPP) would be prepared that identifies applicable BMPs (such as covering stockpiled soils and installing temporary silt barriers around construction areas) in accordance with the Stormwater Management Manual for Western Washington (SWMMWW) to minimize or prevent soil erosion and sediment discharge to waters of the state and waters of the U.S.

- A temporary erosion and sediment control (TESC) plan would be developed that would include measures to limit the amount of sediment leaving the construction site such as clearing limits, soil cover measures, dust control, sediment retention, surface water control, dewatering control, perimeter protection, and soil stabilization measures.
- General erosion control BMPs for soil stockpiles would include stabilizing soil stockpiles from erosion, covering soil stockpiles to prevent erosion and protect with sediment trapping measures, and where possible, locating soil stockpiles away from storm drain inlets, waterways and drainage channels.
- Slopes along earthen containment berms within the containment basins would be sprayed with asphalt cement binder for erosion control. Slopes along the west side of the earthen containment berm would be graded and reseeded with grass to control erosion.
- During construction and post-construction of the tank containment berms, additional sediment containment silt barriers would be installed adjacent and parallel to the exterior of the berm's base and maintained until tank berms and adjacent disturbed soils outside the berms have achieved stabilization.
- Construction boundaries would be established to limit surface disturbance to only those areas that require disturbance as part of construction (and to avoid impacts outside the boundaries).
- The amount and duration of soil exposed during construction activity and revegetation of temporarily disturbed areas would be minimized so that soil exposure during site preparation activities would be temporary, lasting no more than six months.
- The disturbance of steep slopes would be minimized.

Additional measures are in place to avoid eroded soils entering surface waters and degrading water quality. These measures are discussed in Chapter 5, Freshwater Resources. Additional details regarding construction site controls are provided in Chapter 2, Section 2.7.6, Construction Site Controls.

Based on implementation of the above BMPs, as well as permitting requirements, the extent of soil erosion would be limited to the proposed project area and its immediate vicinity. Exposure of soils would be temporary, lasting no more than 6 months. Therefore, impacts on soil from erosion would be ***less than significant***.

Impacts from Slope Destabilization due to Construction

Activities associated with site preparation and construction would alter topography of the proposed project area by excavating and grading the soil and underlying sedimentary. Site construction activities for the expanded NHT, Isom Unit, ARU, and MVEC (VCU) would alter topography within these areas, and would directly impact topsoil and, in some cases, the underlying sedimentary materials. Unprotected steep slopes during construction could present a slope failure risk. Foundations for most structures would be shallow, and grading would predominantly be limited to the ground surface, as fill is preferred to grading in these areas.

Drilled piers or auger cast-in-place concrete (auger-cast) piling may be selected as an alternative to excavation and installation of shallow foundations if insufficient space is available at the structure location and a traditional shallow footing or mat cannot be used (AECOM 2015). Disturbance of topsoil and subsoils would occur as a result of the auger-cast piling and concrete base foundations. However, the topography within these areas is relatively flat with an elevation range of approximately 30 to 40 feet, and they are within the developed area of the refinery. Site preparation and construction activities in these areas, therefore, would not result in slope destabilization. Because most of the proposed project is located in the refinery's developed areas and the New Tank Area and North Texas Road are adjacent and similar to existing development, changes to topographic features from excavation, grading, and filling would be ***less than significant***.

The steepest slopes within the proposed study area are found in the New Tanks Area, which ranges in elevation from approximately 90 feet amsl at the northwest to an elevation of approximately 137 feet amsl at the southeast (AECOM 2015). As described above, the majority of excavation and grading, and therefore the alteration of topography, would occur in this area. Grading in this area would involve cuts of up to about 25 feet along the east side of the tanks area as well as fills up to about 22 feet along the west side of the tanks/perimeter access road. Excavation and grading/filling would be completed to level the area for the foundations of the New Tanks Area. Most of the fill would be used for dikes and spill containment along the western perimeter of the construction area. The grade would be raised, in approximately 6-inch compacted lifts, by using on-site fill from the subsoil excavation and supplemented with imported select structural fill, if necessary.

Fill used for grading would be compacted to the maximum dry density to prevent destabilization after grading and fill work. Shoring of cuts more than 4 feet deep would be designed to account for lateral earth pressure distribution, which linearly increases with depth. Interior and exterior slopes of the containment basin and roadway embankment slopes would be constructed to an inclination of 2H:1V[1] or 50 percent (AECOM 2015). Perimeter roadway exterior slopes, which would be about 14 to 22 feet high, would be covered with grass to control erosion. Slopes along earthen containment berms within the containment basins would be sprayed with asphalt cement binder for erosion control. Slopes along the west side of the earthen containment berm would be graded and reseeded with grass to control erosion.

Subsoils have been classified per regulations for excavations, trenching, and shoring. A geotechnical engineer would be on-site to monitor grading and verify fill suitability, placement, and compaction to prevent failure of new slopes.

In addition to the BMPs and construction control measures described above, earthwork and foundation construction would adhere to applicable regulations under Skagit County Code Title 14.24, Critical Areas Ordinance, and Title 15, Buildings and Construction. Adhering to the development permit issued by Skagit County and applicable federal and state regulations would protect the slopes in the construction areas from destabilization; therefore, the impact on

[1] Ratio of 2 horizontal to 1 vertical

geologic resources of site preparation work, and foundation and containment berm installations would be ***less than significant***.

Impacts from Degradation of Soil Quality

The proposed project would use both on-site cut materials and off-site fill for fill and grade activities. In total, approximately 164,000 cubic yards of on-site cut material and approximately 132,000 cubic yards of structural fill material would be used for the proposed project (Tesoro 2016). Over 90 percent of the fill and grade activities would occur within the New Tanks Area. Soil disturbance at the proposed project area has potential to degrade soil quality by releasing or spreading existing contamination at the proposed project area, if contaminated soils were present. The introduction of fill materials from an external source has potential to introduce a new source of contamination to the proposed project area.

There is no known contaminated soil within the proposed project area. The ARU site was a former hazardous waste land treatment unit with a permit for Land Treatment of Dangerous Waste (Permit No. WAD009275082); however, historical waste associated with this area has been removed and Tesoro received a letter of clean closure from Ecology in November 2006 (Ecology 2006). If evidence of contamination is discovered during construction activities (which is not expected since this area has previously been remediated), potentially contaminated soils would be segregated from clean materials and stockpiled for subsequent analysis. If the materials are found to be contaminated, they would be removed from the site and disposed of in accordance with applicable regulations.

On-site cut materials could be used as common fill throughout the proposed project area with appropriate treatment as needed (AECOM 2015). Common fill could be used to construct the working pads for the New Tanks Area and VCU, to construct tank containment dikes and separation berms, to construct the embankments for the perimeter roadway at the New Tanks Area, for backfill around the exterior of footings and trenches, and for general grading (AECOM 2015). Onsite cut materials would be inspected and tested to verify suitability before being used. If evidence of contamination is discovered, potentially contaminated soils would be segregated from clean materials and stockpiled for subsequent analysis. If materials are found to be contaminated, they would be removed from the site and disposed of at an approved facility in accordance with applicable regulations. On-site cut materials would not be suitable for use as structural fill (AECOM 2015). Therefore, structural fill would be brought on-site from an external source. The source of structural fill has not yet been identified; however, potential sources of fill include: Whatcom Pit, located in Bellingham; Axton Pit, located approximately 6 miles north of Bellingham; and the Conway Pit, located approximately 6 miles south of Mount Vernon. Fill material from off-site sources would be inspected before bringing them on-site to confirm that contaminated materials are not present.

Considering the appropriate fill materials inspection, the clean closure of the former hazardous waste land treatment unit, and the identification and disposal of contaminated soils, if present, it is unlikely that construction activities would result in the introduction or spread of contaminated soil. Therefore, the potential impact on soil from the introduction or spread of contaminated material is ***less than significant***.

3.3.2.2. Potential Impacts on Geologic Resources from Operations and Maintenance

After construction of the proposed project, impacts on geologic resources from soil erosion or slope destabilization are anticipated to be ***less than significant***. Exposed soil surfaces would be stabilized following construction activities by paving or seeding surfaces. Excavating, grading, and re-grading activities are not anticipated following construction of the proposed project. Changes to the topography in the proposed project area would be permanent.

Once constructed, the proposed project area would be considered developed areas of the refinery. Developed areas would be paved with impervious Portland cement or the ground surface would be compacted to near impervious conditions. Approximately 15.18 acres of new impervious surface would be created as a result of the proposed project. This includes 14.66 acres for the New Tanks Area, 0.15 acre for the VCU, and 0.37 acre for North Texas Road. This would add approximately 1.5 percent of new impervious surface to the 1,020 acres of the overall refinery property. Potential impacts related to drainage patterns and runoff rates from impervious surfaces are described in Chapter 5, Freshwater Resources.

An evaluation of potential long-term shallow foundation settlements was conducted for the proposed project (AECOM 2015). According to the report, settlement tolerances for the proposed project components are 1 inch in total for the NHT, Isom Unit, ARU, and MVEC structures. Settlement tolerances were not provided for the New Tanks Area; however, the report concluded that they could handle settlements on the order of 5 inches based on past settlement at previous tank installations of similar size. According to the geotechnical report, settlements greater than the 1 inch tolerance levels could occur in the proposed project area depending on foundation design and site preparation work. Majority of the settlement (approximately 75 percent) would occur within two months following completion of construction, with the remainder occurring over a period of roughly 5 years. The geotechnical report provided foundation design parameters, seismic design parameters per the International Building Code, static design parameters for shallow foundations, estimated settlement of foundations, design parameters for drilled piers for tight spaces, design parameters for retaining walls or below-ground walls, pavement design and recommendations for construction related concerns. Adhering to the site preparation, foundation design and general construction mitigation measures recommended in the report would likely maintain settlement in the proposed project area to within the tolerance limits.

Once developed, soil and slopes in the proposed project area would remain stable. As such, operations and maintenance of the proposed project would have a ***less than significant*** impact on geologic resources.

3.3.2.3. Potential Impacts on Geologic Resources from Spills

This section addresses impacts from a spill at the refinery as a result of construction or operations and maintenance of the proposed project.

Impacts from Refinery Spills during Construction

Construction activities present a risk of an unplanned release of hazardous materials, such as fuels, lubricants, oils or hydraulic fluids, which could contaminate soil. Spills during construction would most likely be associated with material storage or fueling, and would be small in volume.

Multiple layers of spill prevention and response measures are currently in place at the refinery, and would be in place for the proposed project. These include the following measures:

- Spills would be prevented by undertaking regular monitoring and maintenance of construction equipment.
- Secondary containment would be used around temporary chemical storage and equipment refueling areas so that if material was released, it would be held at the immediate release location.
- Stormwater and oily water within developed portions of the refinery would be captured in a sewer system, which routes stormwater runoff and oily water to the wastewater treatment plant (WWTP) for treatment.
- For areas outside developed portions of the refinery, temporary stormwater controls would be used during construction.
- Trained personnel would be available to support spill response activities.

These measures are described in further detail in Chapter 2, Section 2.7.6, Construction Site Controls.

In the event that one or more of the above controls failed, spilled materials could be released to soil. However, the potential for spills during construction are limited to relatively small volumes of materials, and it is unlikely that multiple levels of controls would fail simultaneously.

Based on the spill prevention and response measures described above, it is expected that, if a spill did occur during construction, impacts on soil would be limited to the immediate spill location, and would be temporary, as spills would be cleaned up. Therefore, impacts on soil quality from a refinery spill during construction would be ***less than significant*** with controls in place.

Impacts from Refinery Spills during Operations and Maintenance

Operation of the proposed project presents a risk of releases of hazardous materials such as xylene, reformate, sulfolane, ammonia, perchloroethylene and other petroleum products to soil. Spills could occur during transfer operations, from transfer pipeline or valve leaks, pump or sump failures, overfilling storage tanks or from routine maintenance activities. Spills during operation could involve larger spills volumes than during construction.

As described above, multiple layers of spill prevention and response measures are currently in place at the refinery, and would be in place for the proposed project. Controls for operation of the proposed project include the following measures:

- Spills would be prevented by constructing facilities in accordance with applicable standards, and undertaking regular monitoring and maintenance of equipment.
- Secondary containment would be used so that if material was released it would be held at the immediate release location.
- Stormwater and oily water would be captured in a sewer system and routed to the WWTP for treatment.
- Trained personnel would be available to support spill response activities.
- The refinery currently conducts self-inspections on all tanks, secondary containment units, and response equipment at the refinery, and the proposed project components would be included in these self-inspections.

These measures are described in further detail in Chapter 2, Section 2.8.5, Operational Site Controls.

In the event that one or more of the above controls failed, spilled materials could be released to bare ground. However, based on the multiple layers of spill prevention and response measures it is unlikely that spilled materials would reach bare ground. Further, the materials would be rapidly cleaned up, and the materials, in particular the more volatile materials such as mixed xylenes, reformate, and ammonia, would dissipate fairly quickly.

Indirect impacts from a spill could occur as a result of response activities. Response methods could include mechanical recovery, manual cleanup, in-situ burning, low-pressure flushing, high-pressure spraying, in-place tilling and mechanical reworking, depending on the chemical and amount spilled (RRT10/NWAC 2016). Potential impacts of spill response on geologic resources range from soil disturbance and erosion to soil removal. Use of heavy equipment may result in soil erosion or the removal of excessive amounts of soil and destruction of soil profiles due to mechanical recovery and heavy traffic. In the event of a spill, the response process would be immediate and impacts would be short term and temporary.

The measures described above are expected to minimize the probability of a spill during operations. Based on the spill prevention and response measures described above, it is expected that, if a spill did occur, impacts on soil would be limited to the immediate spill location, and would be temporary, as spills would be cleaned up. Therefore, impacts on soils from a refinery spill during operation would be ***less than significant*** with controls in place.

3.3.2.4. Summary of Impacts on Geologic Resources

The above evaluation identified that the proposed project would have ***less than significant*** impacts on geologic resources. The potential impacts of the proposed project discussed in this section are summarized in Table 3-2.

Table 3-2: Summary of Potential Impacts on Geologic Resources

Impact Topic	Impact Summary	Potential Impact Significance	
		Less than Significant	***Potentially Significant***
Construction			
Soil erosion during construction	Up to 28 acres of land would be directly disturbed during construction activities such as clearing, grading and excavation which could result in soil erosion. Construction would last for no more than 6 months at any given location. Implementation of BMPs and compliance with permitting requirements would limit soil erosion to the proposed project area and its immediate vicinity.	✓	
Slope destabilization due to construction	Development of the New Tanks Area would require cuts of up to 25 feet and grading/filling of up to 22 feet. The excavation works would last no more than 6 months at any given location, and following construction, the slopes created would be permanent. Design and construction controls would be in place to stabilize slopes.	✓	
Degradation of soil quality due to construction	There is no known contaminated soil within the proposed project area, and imported fill material would be inspected to verify it is not contaminated before laying fill at the proposed project area. Based on the controls in place, it is unlikely that the proposed project would introduce or spread contaminated soils.	✓	
Operations			
Soil erosion during operations	There would be no exposed soil during operations. Exposed soil surfaces would be stabilized following construction activities and excavating, grading, and re-grading activities are not anticipated following construction of the proposed project.	✓	
Slope destabilization during operations	The proposed project would produce steep slopes at the New Tanks Area; however, these slopes would be stabilized.	✓	
Unplanned Events			
Spill at the refinery during construction	A release of fuel or other material to soil during construction could contaminate soil; however, with BMPs in place, the volume of a spill would be small and the spill would be rapidly contained and cleaned up. Spilled material would be contained within the proposed project area.	✓	
Spill at the refinery during operations	A spill during operations could contaminate soil, and could involve larger spill volumes than spills during construction. With BMPs in place, the spill would be unlikely to occur on permeable soils. In the event a spill was to occur outside of containment and impervious areas, it would be immediately contained and cleaned up.	✓	

3.3.3. Potential Impacts of the No Action Alternative

Under the no action alternative, Tesoro would not proceed with the proposed project. Because no construction or operation would take place under the no action alternative, there would be no new impacts on geologic resources including soils, bedrock, and topographic features.

3.3.4. Additional Mitigation Measures

No additional mitigation measures are recommended beyond the embedded controls that are already incorporated into the proposed project design.

3.4. GEOLOGIC HAZARDS

3.4.1. Affected Environment

Geologic hazard areas are defined as those areas that are susceptible to erosion, landslides, and seismic activity including earthquakes and tsunamis, or volcanic hazards.

3.4.1.1. Earthquakes

The Pacific Northwest is an active earthquake region due to the subduction of the oceanic Juan de Fuca plate under the continental North American plate along the CSZ plate boundary (see Figure 3-4).

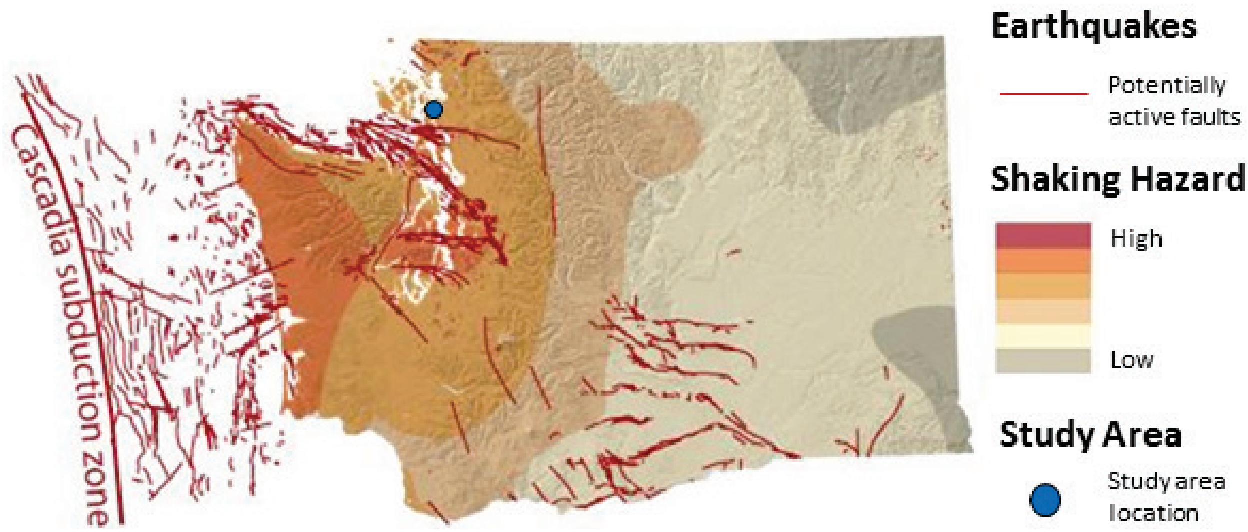
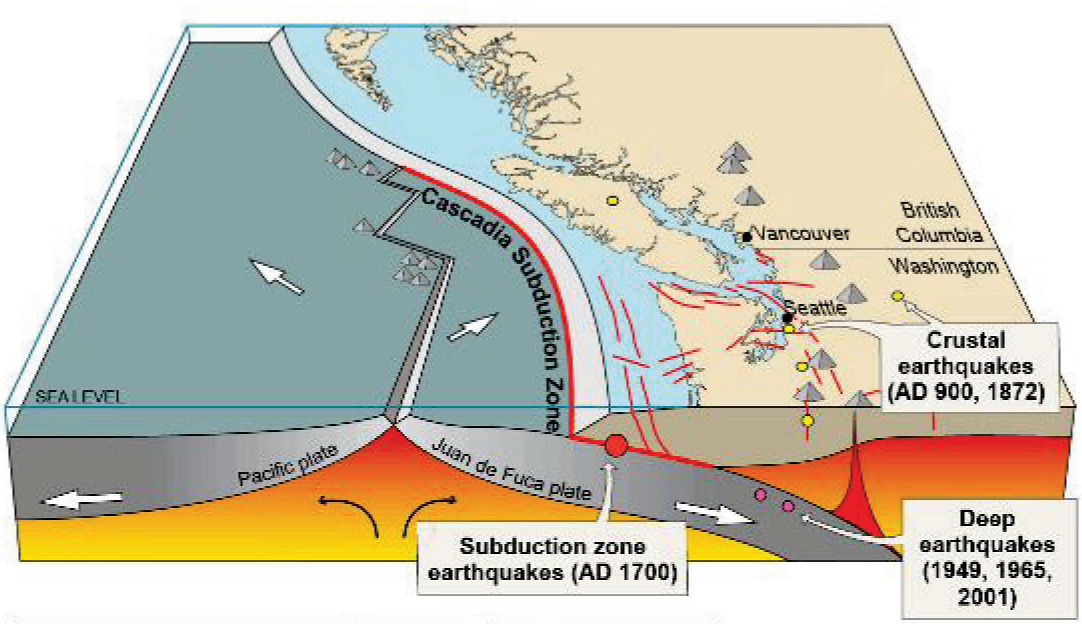


Figure 3-4: Cascadia Subduction Zone

The collision of the plates produces several different types of earthquakes: shallow, deep, and subduction zone. Shallow earthquakes originate within the crustal plate and are felt over a smaller area; however, they can cause intense shaking, numerous aftershocks, and tsunamis. Deep earthquakes originate in the descending oceanic plate and are felt over a large area, with less damage than a shallow quake, fewer aftershocks, and typically without generating tsunamis. Subduction zone earthquakes, associated with megathrust faults occur at the boundary of two plates (see Figure 3-5). These earthquakes are generated when a large area, locked together, suddenly releases. According to the Cascadia Region Earthquake Workgroup, “The convergent boundary along which the Explorer, Juan de Fuca, and Gorda plates are sinking beneath the North American Plate is a long megathrust fault capable of producing very large earthquakes” (CREW 2013). The energy released during a subduction zone earthquake is more than other earthquakes, and because the North American plate is moving up and over the Juan de Fuca Plate, a release along this boundary would generate a large tsunami.



Source	Max. Size	Recurrence
Subduction zone	M 9+	200–600 years
Deep Juan de Fuca plate	M 7+	30–50 years
Crustal faults	M 7+	Hundreds of years?

Volcano
Active crustal fault
Active plate boundary fault

*figure modified from USGS Cascadia earthquake graphics at http://geomaps.wr.usgs.gov/pacnw/pacnweq/index.html

Figure 3-5: Pacific Northwest Tectonic Plates

Two shallow earthquakes have been recorded within a mile of the refinery: a magnitude (mag) 2.3 in 1978 and a mag 2.1 in 2003, both associated with a normal fault on the southeastern end of Guemes Island (Palmer et al. 2004) (see Figure 3-6).

According to Czajkowski and Bowman (2014), several large crustal faults are located due south of the proposed project: the Darrington–Devils Mountain Fault Zone, the Strawberry Point Fault, and the Utsalady Point Fault. These faults have ruptured within the last 2 million years resulting in earthquakes with magnitudes between 2.0 and 6.8.

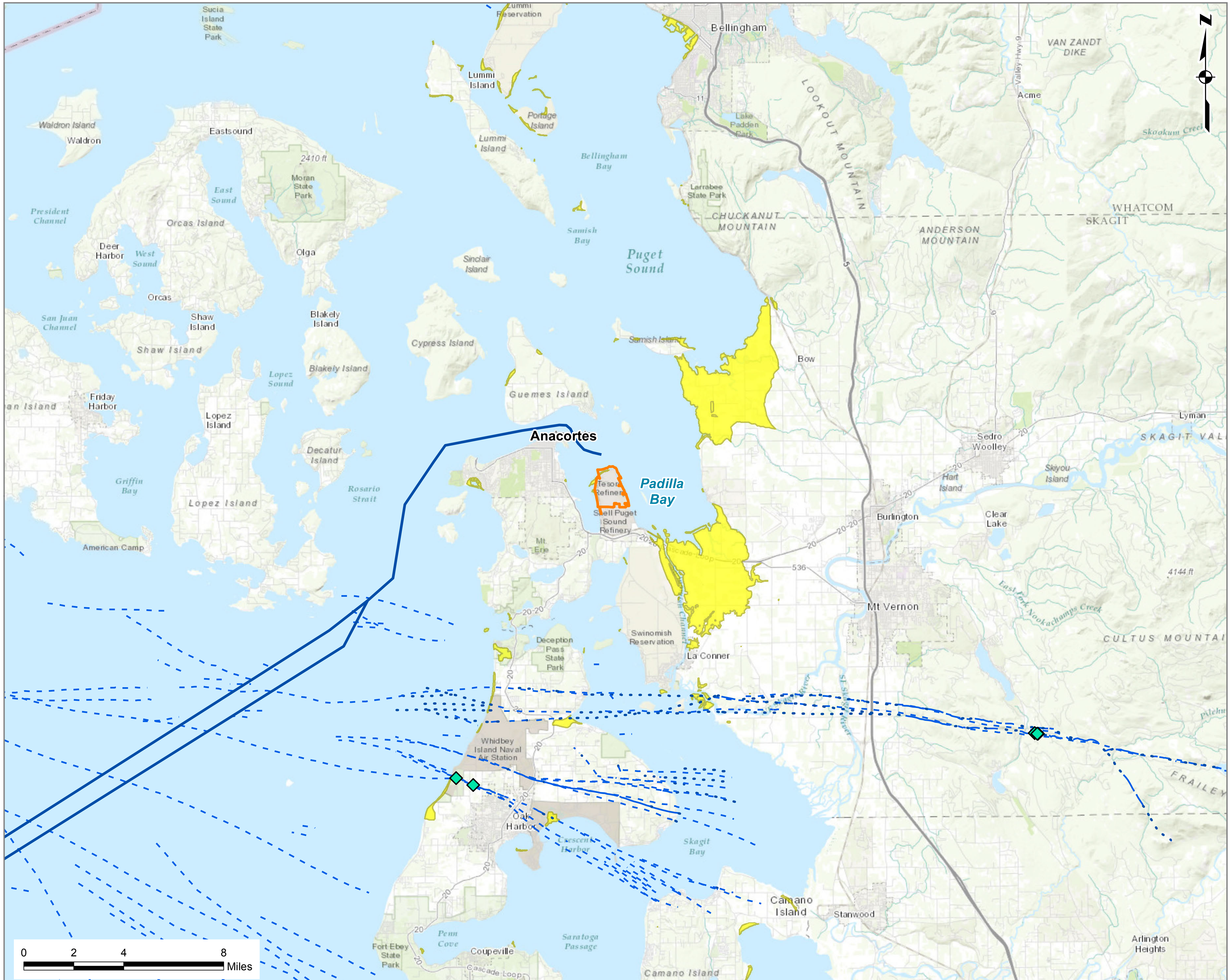
Geologic evidence indicates at least six great earthquakes (magnitude about 8 or 9) have occurred along the CSZ in the past 7,000 years (Atwater 1987). Within the next 50 years the probability of a rupture along the CSZ resulting in a geologically detectable subduction zone earthquake in the Northwest is 10 to 17 percent for the Washington Coast and 15 to 20 percent for the central and northern Oregon coast (Goldfinger et al. 2016). A full or partial rupture of the CSZ would be considered a severe magnitude earthquake. The subduction zone earthquake prediction does not indicate where the plate rupture might occur, but it is assumed that damage would be greatest in the area of the rupture. During an earthquake, ground shaking can cause saturated soil and/or sediment to lose strength, prompting the soil to behave as a liquid instead of a solid. Unlike landslides, liquefaction occurs in low-lying areas, especially soft and wet tidal areas that have been filled. SCC 14.24.410(3) defines seismic hazard zones, including specific areas susceptible to liquefaction. According to the WDNR liquefaction map by Palmer et al. (2004), the glacial drift soil in the proposed project area has as "Very Low" liquefaction susceptibility and the artificial fill has as "High" liquefaction susceptibility. However, as noted by Palmer et al (2004), the map "is not a substitute for site-specific investigation. This determination requires a site-specific geotechnical investigation performed by a qualified practitioner." According to the site-specific geotechnical report (AECOM 2015), the risk of liquefaction for soils in the proposed project area is considered to be "negligible or non-existent due to the relatively flat topography and combination of stiff/dense and/or cohesive soils." According to the site-specific geotechnical report (AECOM 2015), soils in the proposed project area are identified as consisting of "a thin layer of variable granular fill or a moderately thick…cohesive fill, followed by a relatively thick sequence of hard to medium stiff silty clay/clayey silt layers that overlie a dense water-bearing silty sand" with a "negligible or non-existent" risk of liquefaction. The USGS has classified potential ground shaking in the study area of between 0.39 to 0.47 g of peak ground acceleration (PGA), with a 2 percent probability of being exceeded in 50 years and 2 to 2.5 g PGA with a 10 percent probability of being exceeded in 50 years (USGS 2008). Peak acceleration is a measure of the maximum force experienced in a given area.

3.4.1.2. Tsunamis and Seiches

Tsunamis are a series of large waves caused when earthquakes, landslides, or volcanic eruptions move a large volume of water. A tsunami wave is a wall of water that runs quickly over land and can reach heights of 150 feet (Palmer et al. 2004).

An earthquake from rupture along the CSZ could trigger a tsunami. This could result in inundation of coastal areas. For example, one model predicted a 12 percent probability of a tsunami inundating Padilla Bay in the next 50 years as a result of a great moment earthquake on the CSZ (NOAA 2016). The model showed inundation of Padilla Bay with depths of 3 to 5 meters for up to six or seven hours after the earthquake (NOAA 2016).

Resonating wave energy from earthquakes and landslides can also cause standing waves, known as seiches, in partially enclosed and closed bodies of water. Seiche hazard areas include lake and marine shoreline areas susceptible to inundation from waves. The USGS, WDNR, and Skagit County have not identified specific seiche hazard areas.



Legend

- Tesoro Refinery Boundary
- Marine Vessel Transportation Route
- Fault Trenches

Active Faults, Known or Suspected

- Visible fault trace
- Inferred fault trace
- Concealed fault trace

Tsunami Inundation

- Cascadia Scenario 1A

Notes:
Seismogenic data provided by Bowman, J. D.; Czajkowski, J. L., 2016, Washington State seismogenic features database--GIS data: Washington Division of Geology and Earth Resources Digital Data Series 1, version 4.1, originally issued December 2013
Source:
ESRI Topographic Web Mapping Service
NAD 1983 UTM Zone 10N

Figure 3-6
Geological Hazards
Tesoro Anacortes Refinery
Clean Products Upgrade Project
Draft Environmental Impact Statement
Anacortes, Washington

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3.4.1.3. Landslides

According to Palmer et al. (2004), thousands of landslides occur in the state of Washington each year. Landslides occur on slopes when the stress exerted on soil and rock exceeds its strength. Triggers include: rainfall, earthquakes, water level changes, vibrations, excavation, and low strength or unstable geology.

According to the Skagit County critical areas maps for Potential Landslide and Erosion Areas (USGS 2014; Skagit County 2015), the topography for the majority of March Point is between 0 and 15 degrees, with a topographic high in the middle of the peninsula at the top of North Texas Road of approximately 160 feet amsl. The map indicates that erosion hazard soils, unstable slopes, and landslide areas are not present on March Point.

3.4.1.4. Volcanism and Lahars

Washington has five volcanoes in the Cascade Range, with Glacier Peak and Mount Baker nearest to the study area. Mount Baker is approximately 40 miles northeast and Glacier Peak is approximately 70 miles southeast of the study area. Over the past 600 years, large-volume debris avalanches and lahars from Mount Baker have occurred approximately once every 150 years. A worst-case, low-probability scenario for a volcanic hazard that could impact the proposed project would be a large eruption of Mount Baker on the east flank of the volcano. Material associated with the eruption would enter Baker Lake and potentially generate a wave that could overtop the Baker Lake dam, which would result in a downstream inundation zone impacted by flooding and cohesive debris flow (Hoblitt et al. 1987). The inundation zone would be largely constrained by the narrow topography of the Skagit River valley before expanding into the topographically flat areas of the Skagit River delta east of March Point. USGS hazard analysis results show the inundation zone for the potential worst-case scenario from Mount Baker would dissipate after crossing the Swinomish Channel before reaching March Point or the refinery (Gardner et al. 1995). Lahars associated with Glacier Peak historically impacted the Skagit River valley and its delta during a major eruptive period approximately 11,000 to 12,000 years ago and 5,000 years ago. The Skagit River delta and the area adjacent to March Point and the refinery is classified as low hazard for impacts from an eruption due to the low probability of an eruption in the near-term and the remote geographic location of Glacier Peak (Hoblitt et al. 1987).

3.4.2. Potential Impacts from Geologic Hazards

There is potential for geologic hazards associated with unplanned natural events, such as earthquake, tsunami, landslide, or volcanic eruption, to cause damage to proposed project infrastructure. Damage to infrastructure could include collapse of structures, rupture of gas lines that could cause fire or explosion, or rupture of tanks that could lead to spills of xylene or reformate. These types of destruction have the potential to result in loss of life and impacts on the terrestrial and marine environment. This section evaluates how the proposed project could exacerbate impacts of an earthquake, tsunami, landslide or volcanic eruption. Potential impacts on the proposed project due to geologic hazards are summarized in Section 3.4.2.5.

3.4.2.1. Impacts from Earthquakes

The study area is located near active faults zones including the CSZ and local crustal faults located directly southwest. Earthquakes associated with fault movement cause ground shaking, slope failure, soil settlement, liquefaction, and surface faulting. These events could cause direct damage to construction and operational infrastructure and equipment resulting in indirect impacts including loss of life, spills, and disruption of local and regional transportation and communication.

SCC 14.24.410(3) defines seismic hazard zones, including specific areas susceptible to liquefaction. According to the WDNR liquefaction map by Palmer et al. (2004), artificial fill in the area is highly susceptible to liquefaction. However, according to the site-specific geotechnical report (AECOM 2015), soils in the proposed project area have a "negligible or non-existent risk of liquefaction due to the relatively flat topography and combination of stiff/dense and/or cohesive soils." Therefore, potential direct and indirect impacts from liquefaction would be ***less than significant***.

However, earthquakes could impact the proposed project through other disturbances, such as ground shaking or surface faulting. A severe magnitude earthquake along the CSZ or a lower magnitude earthquake along one of the local faults south of the proposed project could potentially damage proposed project infrastructure to an extent that could result in loss of life, or a spill that would impact the environment beyond the developed portion of the refinery. Disruption of local and regional transportation or communications within the study area could also occur as a result of an earthquake, which could hinder emergency response, such as medical response or spill response.

Potential direct damage to construction and operational equipment and infrastructure from an earthquake and associated indirect impacts would be limited through compliance with the International Building Code administered through Skagit County (SCC 15.04). Requirements include structures be built with a 1 percent or less probability of collapsing due to an earthquake within 50 years. Taking into consideration the 10 to 17 percent probability of a geologically detectable earthquake from the CSZ (i.e., a rupture of the CSZ) within 50 years, proposed project structures would be built using applicable design requirements to withstand such an event as required by the International Building Code. While the risk of impacts from earthquakes cannot be completely eliminated, these measures would reduce the risk of an earthquake causing the collapse of a building, fire or explosion, or rupture of secondary containment.

Direct damage to proposed project infrastructure would be restricted to the proposed project area and would be short-term, until infrastructure was repaired. Indirect impacts resulting from impacts on proposed project infrastructure, such as loss of life or spill of petroleum-based materials could extend beyond the proposed project area, and could be long term. Therefore, the impact of earthquakes on the proposed project could be ***potentially significant***.

3.4.2.2. Impacts from Tsunamis

Rupture of the CSZ could cause a tsunami as depicted in NOAA's current modeling scenario (NOAA 2016). NOAA identified a 5-meter tsunami inundation zone for a worst-case scenario (see Figure 3-6). The severity of a tsunami in the study area would be limited compared to a tsunami on the outer coast of Washington, due to the limited vector of entry into the Salish Sea, the large and deep marine waters encompassing the marine vessel transportation route, and the presence of land masses providing protection in some areas. In addition, seiches that occur after an earthquake could result in damage to shoreline areas that are outside of the tsunami inundation area; however, the risk is considered low as there are no historical records of seiches in Skagit County.

The proposed project components described in Chapter 2, Proposed Action and Alternatives, would be constructed at elevations greater than the 15-foot (5-meter) worst-case scenario for a tsunami. The causeway structure, on which the 3-inch natural gas line would be installed, is the lowest component of the proposed project with a minimum elevation approximately 19 feet amsl. The other proposed project components are much higher in elevation, ranging from 40 feet to 111.5 feet amsl. Therefore, proposed project infrastructure and operations would be located at higher elevations than the worst-case inundation scenario provided by NOAA for a tsunami in the study area (see Figure 3-6).

Marine vessels could potentially sustain direct damage from a tsunami during transit along the marine vessel transportation route or when docked at the refinery wharf structure. Damage to vessels would present a safety risk to personnel and a risk of release of fuel, xylene or reformate to the marine environment. Disruption of local and regional maritime transportation within the study area could also occur, which could hinder emergency response, such as medical response or spill response.

Marine vessels transiting the Salish Sea would be less susceptible to potential direct damage since they could implement standard emergency procedures to avoid or safely pilot the vessel in the event of an approaching tsunami. If time was available, the safest place for a marine vessel during a tsunami would be in open water where the depths are in excess of 25 fathoms (approximately 150 feet).

Marine vessels moored at the wharf would be most likely to sustain damage during a tsunami. If a marine vessel was moored and transferring product at the refinery wharf structure during a tsunami emergency, the transfer systems would be shut down immediately and precautionary measures would be taken to prevent damage to the vessel or wharf system.

The USCG Sector Seattle (Puget Sound) Vessel Traffic Service would announce warnings if a tsunami were to occur, and mariners are required by regulations to heed warnings and to keep informed of maritime weather reports.

While the risks of impacts from a tsunami cannot be completely avoided, these measures would minimize the risk of a tsunami causing damage to proposed project infrastructure.

Direct damage to infrastructure associated with the proposed project would be restricted to the location of marine vessels and would be short term, until marine vessels were repaired. Indirect impacts due to a spill of xylenes or reformate would be short term, as these materials fully evaporate within three days for the worst-case spill scenario (see Chapter 13, Marine Transportation); however, short-term impacts to humans and wildlife could be significant (see Chapter 6, Terrestrial Vegetation and Wildlife; Chapter 7, Marine and Nearshore Resources; and Chapter 9, Environmental Health). Indirect impacts resulting from damage to proposed project infrastructure, such as loss of life, could be long term. Therefore, the impact of a large tsunami on the proposed project could be ***potentially significant***.

3.4.2.3. Impacts from Landslides

Heavy precipitation can cause landslides in unstable slopes and soils. A landslide in or near the proposed project would endanger personnel. The proposed project could exacerbate impacts of a landslide if the proposed project structures became unstable during the landslide, or if proposed project pipelines or tanks were to rupture from moving debris caused.

Skagit County has published a map of potential landslide and erosion areas which identifies unstable slopes, slide areas, and erosion hazard soils. According to the map (Skagit County 2015), the proposed project is not located within landslide or erosion hazard areas as defined in SCC 14.24.410. Geology of the study area does not contain soils and bedrock susceptible to landslides. In addition, implementation of engineered design controls and procedures during construction and operation of the proposed project would further reduce potential impacts from landslides or settling soils. Therefore, landslides or substantial soil settling are unlikely to occur in the proposed project area, and would result in ***less than significant*** impacts for the proposed project.

3.4.2.4. Impacts from Volcanism and Lahars

The proposed project is not located within a volcanic hazard area identified in SCC 14.24.410(4). The USGS Volcano Hazard Zone maps for Mount Baker and Glacier Peak indicate that the extent of a lahar during an eruption would be the Swinomish Channel (USGS 2014). The map shows that a lahar would lose momentum approximately 3 miles before reaching March Point and the boundary of the study area. Therefore, it is unlikely that a lahar would damage proposed project infrastructure.

A volcanic eruption in the region may result in ash fall over the proposed project area. The impacts of ash fall on proposed project equipment would depend on the amount of ash deposited. In a worst-case scenario, ash fall could result in collapse of roofs due to ash loading, which presents a safety risk to personnel, and a potential spill risk.

Buildings would be constructed in accordance with the International Building Code administered through Skagit County (SCC 15.04), which would reduce the risk of a roof collapse due to ash fall. Further, winds are predominately from the west, which would blow ash from Mount Baker away from the proposed project area (USGS 2014). However, if wind was not blowing from the west at the time of an eruption, the proposed project area could be impacted by ash fall.

Direct damage to proposed project infrastructure would be restricted to the proposed project area and would be short-term, until infrastructure was repaired. Indirect impacts resulting from damage to proposed project infrastructure, such as loss of life or spill of hydrocarbon or other chemical products could extend beyond the proposed project area, and could be long term. Therefore, in a worst-case scenario, the impact on the proposed project of ash fall from a volcanic eruption would be ***potentially significant***.

3.4.2.5. Summary of Impacts from Geologic Hazards

The potential impacts of the proposed project discussed in this section are summarized in Table 3-3.

Table 3-3: Summary of Potential Impacts from Geologic Hazards

Impact Topic	**Impact Summary**	**Potential Impact Significance**	
		Less than Significant	***Potentially Significant***
Unplanned Events during Construction or Operations			
Damage to infrastructure or equipment from an earthquake	Depending on severity of the earthquake and location of the fault, an earthquake could potentially damage proposed project infrastructure to an extent that could result in loss of life, or a spill that would impact the environment beyond the developed portion of the refinery. The likelihood of a CSZ rupture is estimated to be 10 to 17 percent within the next 50 years. The risk of an earthquake causing the collapse of a building, rupture of secondary containment, fire, or explosion is minimized through design and construction controls.		✓
Damage to infrastructure or equipment from a tsunami	A large tsunami could cause damage to marine vessels, particularly when docked at the wharf, to an extent that could result in loss of life, or a spill. The probability of a tsunami occurring that would inundate Padilla Bay is 12%. The risk of such a tsunami causing severe damage to proposed project infrastructure is minimized through safety precautions.		✓
Damage to infrastructure or equipment from a landslide	Landslides are unlikely to occur within the proposed project area, as the proposed project is not located in a landslide hazard area, and design controls and procedures would be implemented to reduce the risk of landslide.	✓	
Damage to infrastructure, equipment, or loss of life from volcanism and lahars	In the event of a volcanic eruption, large amounts of ash fall could result in collapse or roofs or other structures of the proposed project to an extent that would present a risk of loss of life or a spill. The construction of buildings in accordance with international standards would reduce the risk of roof collapse, and it is considered unlikely that a large amount of ash from a volcanic eruption would fall on the proposed project area, due to the prevailing wind direction. However, the risk cannot be completely eliminated.		✓

3.4.3. Potential Impacts of the No Action Alternative

Under the no action alternative, Tesoro would not proceed with the proposed project. Because no construction or operation would take place under the no action alternative, there would be no new potential for damage to infrastructure from unplanned natural events.

3.4.4. Additional Mitigation Measures

No additional mitigation measures are recommended beyond the embedded controls that are already incorporated into the proposed project design.

3.5. Cumulative Impacts

As described above, construction and operation of the proposed project could result in less than significant impacts on geological resources. Within the study area, there has been significant past agricultural, industrial, commercial and residential growth that has resulted in impacts on earth resources. There are no present or reasonably foreseeable future actions that would impact earth resources in the area of the proposed project. Cumulative impacts as a result of the proposed project in addition to the past impacts on geologic resources associated with refinery development on March Point are considered to be negligible. These impacts would be minimized by construction BMPs and localized to the Tesoro Anacortes Refinery property.

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