3.5 GEOLOGY

3.5.1 Introduction

This section describes the environmental setting for geology within the PMPU area, identifies applicable regulations, and analyzes the potential impacts that could result from implementing the proposed Program. Mitigation measures and the significance of impacts after mitigation are also described.

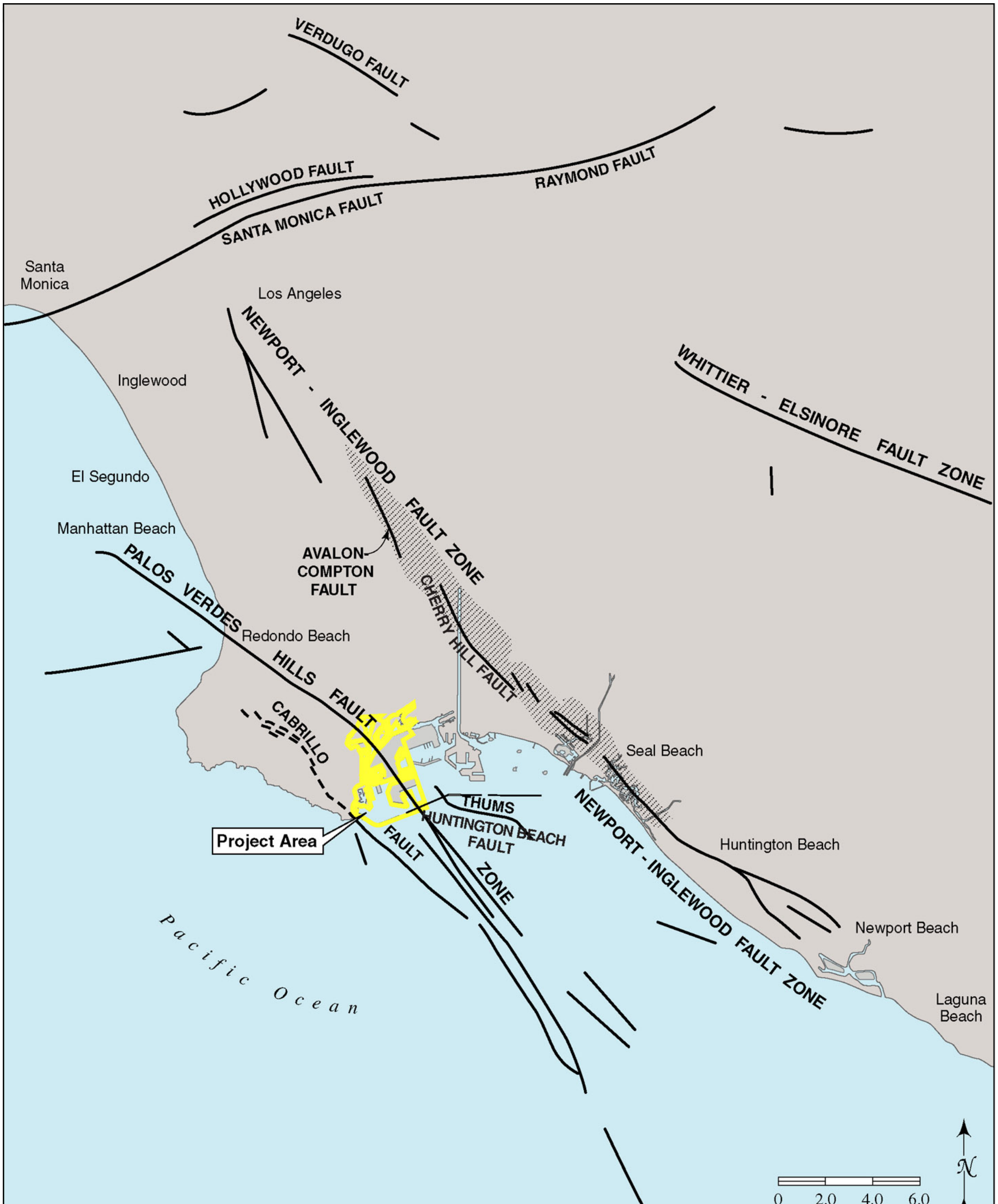
3.5.2 Environmental Setting

3.5.2.1 Regional Setting

The PMPU area is located near sea level on Holocene alluvial outwash materials, Pleistocene terrace deposits, and Pleistocene Palos Verdes Sand, within the southwestern structural block of the Los Angeles Basin Province (Yerkes et al. 1965; Kennedy 1975; Bryant 1987). The southwestern structural block, one of four such blocks underlying the Los Angeles Basin, is marked by a northwest-southeast trending fault system (Yerkes et al. 1965) (Figure 3.5-1).

3.5.2.1.1 Seismicity and Major Faults

An earthquake is classified by the magnitude of wave movement (related to the amount of energy released), which traditionally has been quantified using the Richter scale. This is a logarithmic scale, wherein each whole number increase in Richter magnitude (M) represents a tenfold increase in the wave magnitude generated by an earthquake. A M8.0 earthquake is not twice as large as a M4.0 earthquake; it is 10,000 times larger (i.e., 10^4, or 10 x 10 x 10 x 10). Damage typically begins at M5.0. Earthquakes of M6.0 to 6.9 are classified as moderate; those between M7.0 and 7.9 are classified as major; and, those of M8.0 or greater are classified as great.



Source: Ninyo & Moore 1992, McNeilan et al 1996, Earth Mechanics, Inc. 2006

Figure 3.5-1. Regional Faults

Southern California is recognized as one of the most seismically active areas in the U.S. The region has been subjected to at least 52 major earthquakes, of M6 or greater, since 1796. Ground motion in the region is generally the result of sudden movements of large blocks of the earth's crust along faults. Great earthquakes, like the 1857 San Andreas Fault earthquake (Table 3.5-1), are quite rare in southern California. Earthquakes of M7.8 or greater occur at the rate of about two or three per 1,000 years, corresponding to a 6 to 9 percent probability in 30 years. However, the probability of a M7.0 or greater earthquake in southern California before 2024 is 85 percent (Working Group on California Earthquake Probabilities 1995).

Table 3.5-1. Known Earthquakes with Richter Magnitude Greater than 5.5 in the Los Angeles Basin Area

Fault Name	*Date*	*Richter Magnitude*
Palos Verdes Fault	*	*
San Pedro Basin Fault	*	*
Santa Monica-Raymond Fault	1855	6.0
San Andreas Fault	1857; 1952	8.2; 7.7
Newport-Inglewood Fault	1933	6.3
San Jacinto Fault	1968	6.4
San Fernando/Sierra Madre-Cucamonga Fault	1971; 1991	6.4; 6.0
Whittier-Elsinore Fault Zone	1987	5.9
Camp Rock/Emerson Fault	1992	7.4
Blind thrust fault beneath Northridge	1994	6.6

Note: * No known earthquakes within the last 200 years.
Source: Ninyo & Moore 1992; U.S. Geological Survey and Caltech 1992, 1994

Numerous other active faults and fault zones are located within the general region, such as the Newport-Inglewood, San Pedro, Whittier-Elsinore, Santa Monica, Hollywood, Raymond, San Fernando, Sierra Madre, Cucamonga, San Jacinto, and San Andreas faults (Figure 3.5-1). Table 3.5-2 presents potentially hazardous faults and anticipated earthquake magnitudes in the Los Angeles Basin area.

Table 3.5-2. Hazardous Faults and Bedrock Accelerations — Los Angeles Basin Area

Fault Name	*Distance in Miles*	*Richter Magnitude (Ziony 1985)*	*Maximum Credible Earthquake Magnitude (Greensfelder 1974)*	*Duration in Seconds (Bolt 1973)*
Palos Verdes Fault	<1	6.4-6.6	7.25*	26
Newport-Inglewood Structural Zone	5	6.5-6.7	7	26
San Pedro Basin Fault	15	6.3-6.6	no data	18
Whittier-Elsinore Fault Zone	22	6.4-6.7	7.5	16
Santa Monica-Raymond Fault	23	6.2-6.6	7.5	15
San Fernando-Cucamonga Fault	31	6.4-6.5	6.5	14
San Jacinto Fault	57	6.4-7.0	7.5	22
San Andreas Fault	53	7.2-8.1	8.25	28

Source: Ninyo & Moore 1992; Earth Mechanics Inc. (EMI) 2001

Active faults, such as those noted above, are typical of southern California. Therefore, it is reasonable to expect a strong ground motion seismic event during the lifetime of any proposed project in the region.

Numerous active faults located off-site are capable of generating earthquakes in the proposed PMPU area (Tables 3.5-1 and 3.5-2). Most noteworthy, due to its proximity to the Port, is the Newport-Inglewood Fault, which has generated earthquakes ranging from M4.7 to M6.3 on the Richter scale (LAHD 1991). Large events could occur on more distant faults in the general area, but because of the greater distance from the site, earthquakes generated on these faults may be considered less significant with respect to ground accelerations.

3.5.2.2 PMPU Area

3.5.2.2.1 Seismicity and Major Faults

Segments of the active Palos Verdes Fault traverse the PMPU area (Figure 3.5-2). Although well constrained in the channel areas of the Inner Harbor, such as at the intersection of the West Basin and the Southwest Slip, the onshore location of the fault zone in the West Basin area is not well defined. However, current data suggest the fault most likely crosses north-northwest across Berths 121-132 and immediately southwest of Berths 136-147. Further to the south, the most recent data regarding the fault was acquired in the Outer Harbor area, prior to construction of Pier 400. The location of the fault in this area has been well defined as trending southeast/northwest across the central portion of Pier 400 (McNeilan et al. 1996; Earth Mechanics Inc. [EMI] 2001).

The Port is also underlain by the Texaco, Humble, Union, Mobil, and Shell (THUMS)-Huntington Beach Fault (Figure 3.5-1). This fault splays southeastward from the Palos Verdes Fault Zone. Interpretive cross-sections differ on fundamental issues about this fault, such as one interpretation indicates a normal fault that dips east and is downthrown on the east, whereas another interpretation shows that the fault dips west and is downthrown on the west and merges at depth with the Palos Verdes Fault Zone (Fischer et al. 2004). An additional interpretation indicates this fault is a large blind thrust fault, which was responsible for uplift of the Wilmington Anticline. Although the THUMS-Huntington Beach Fault has probably been active during Holocene time, this fault is deeply buried, does not displace Holocene or Pleistocene strata, and is therefore does not pose a surface rupture hazard in the harbor (Edwards et al. 2001; Port of Long Beach 2004). Although the extent of the hazard is poorly understood because of the complexity of fault geometries and uncertainties in earthquake locations, this fault poses significant seismic hazards to the San Pedro Bay Ports area (Baher et al. 2003).

In 1974, the California Division of Mines and Geology (CDMG) was designated by the Alquist-Priolo Act to delineate those faults deemed active and likely to rupture the ground surface. No faults within the Port area are currently zoned under the Alquist-Priolo Act; however, there is evidence that the Palos Verdes Fault may be active and ground rupture cannot be ruled out (Fischer et al. 1987; McNeilan et al. 1996).

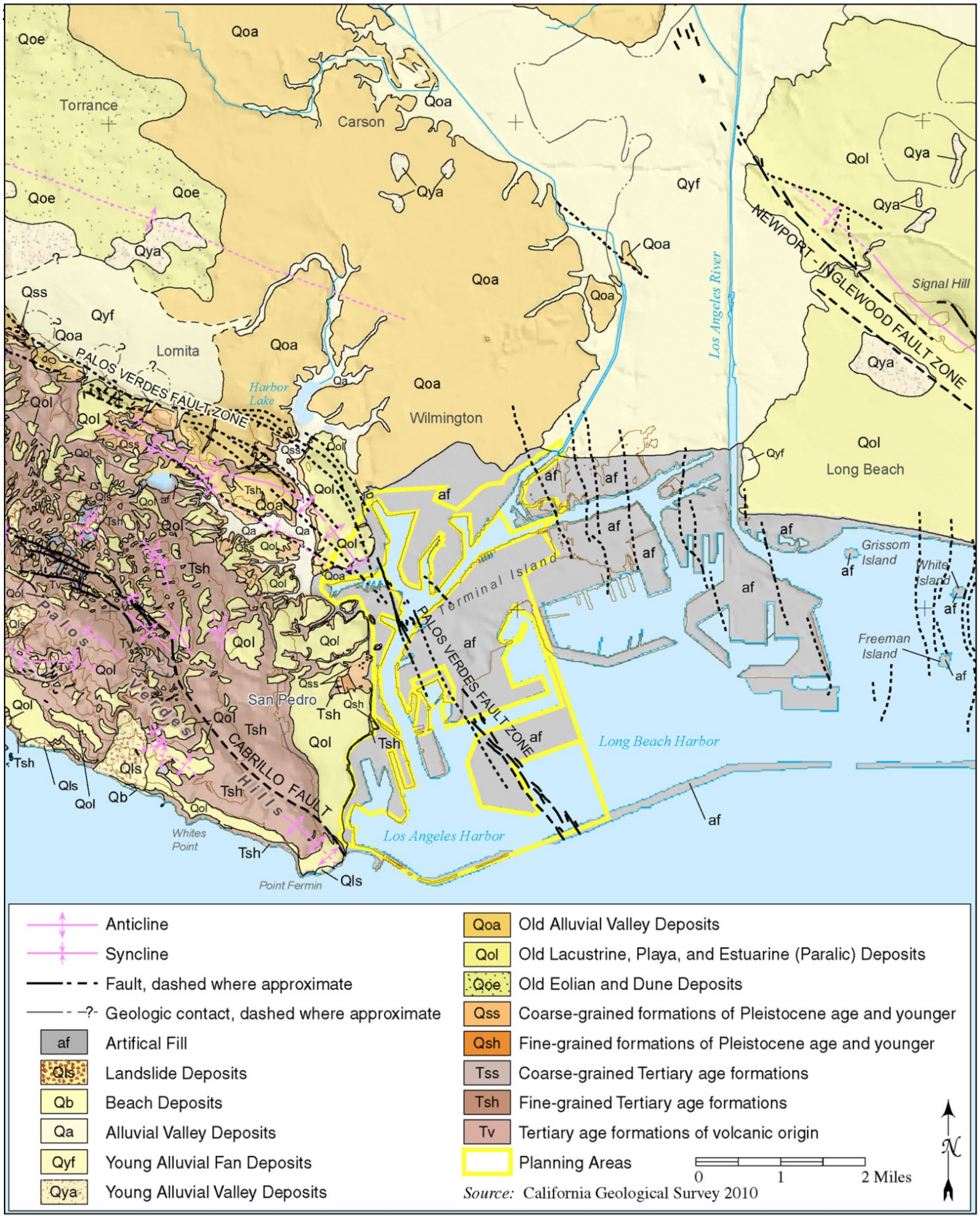


Figure 3.5-2. Geologic and Palos Verdes Fault Zone Map

Seismic analyses generally include discussions of maximum credible and maximum probable earthquakes (MPE). A maximum credible earthquake (MCE) is the largest event a fault is believed to be capable of generating. The probability of occurrence is not considered in this characterization. The MPE is the largest earthquake to have occurred on a given fault within the last 200 years, or is an earthquake that ruptures 10 percent of the total length of the fault. In addition, LAHD uses a combination of probabilistic and deterministic seismic hazard assessments for seismic design. Probabilistic hazard assessments are required to define two-level design events, including the operational level earthquake (OLE), which is the peak horizontal firm ground acceleration with a 50 percent probability of exceedance in 50 years, and the contingency level earthquake (CLE), which is the peak ground acceleration with a 10 percent probability of exceedance in 50 years.

Recent studies indicate that the MCE for the Palos Verdes Fault is M7.25, with a recurrence interval of 900 years and peak ground accelerations in the Port area of 0.28g and 0.52g, for the OLE and CLE, respectively (McNeilan et al. 1996; EMI 2001). The potentially active Cabrillo Fault is also considered an important local fault because it may be a segment or branch of the Palos Verdes Fault and capable of producing an earthquake of M6.25 to M6.5 (EMI 2006).

3.5.2.2.2 Liquefaction

Liquefaction is defined as the transformation of a granular material from a solid state into a liquefied state as a consequence of increased pore pressure, which results in the loss of grain-to-grain contact. Seismic ground shaking is capable of providing the mechanism for liquefaction, usually in fine-grained, loose to medium dense, saturated sands and silts. The effects of liquefaction may be excessive if total and/or differential settlement of structures occurs on liquefiable soils.

Natural drainages at Port berths have been backfilled with undocumented fill materials. Dredged materials from the harbor area were spread across lower Wilmington from 1905 until 1910 or 1911 (Ludwig 1927). In addition, the natural alluvial deposits below the PMPU area generally are unconsolidated, soft, and saturated. Groundwater is present at depths as shallow as 2 to 6 feet locally. These conditions are conducive to liquefaction.

Some authors (Davis et al. 1982; Tinsley and Youd 1985; Toppozada et al. 1988) have indicated that the liquefaction potential in the Port area during a major earthquake on either the San Andreas or Newport-Inglewood fault is high. The PMPU area is identified as an area susceptible to liquefaction in the *City of Los Angeles General Plan, Safety Element* because of the presence of recent alluvial deposits and groundwater less than 30 feet below ground surface (City of Los Angeles 1996). Other authors (e.g., Pyke 1990) indicate that the overall probability of widespread liquefaction of uncompacted hydraulic fills and major damage in the Port is judged to be relatively low. However, even minor damage resulting from liquefaction can be very significant in terms of loss of functionality and repair costs (Pyke 1990).

3.5.2.2.3 Tsunamis

Tsunamis are gravity waves of long wavelength generated by a sudden disturbance in a body of water. Typically, oceanic tsunamis are the result of sudden vertical movement along a fault rupture in the ocean floor, submarine landslides or subsidence, or volcanic eruption, where the sudden displacement of water sets off transoceanic waves with wavelengths of up to 125 miles and with periods generally from 5 to 60 minutes. The trough of the tsunami wave arrives first, leading to the classic retreat of water from the shore as the ocean level drops. This is followed by the arrival of the crest of the wave which can run up on the shore in the form of bores or surges in shallow water or simple rising and lowering of the water level in relatively deeper water such as in harbor areas.

Tsunamis are a relatively common natural hazard, although most of the events are small in amplitude and not particularly damaging. However, in the event of a large submarine earthquake or landslide, coastal flooding may be caused by either run-up of broken tsunamis in the form of bores and surges or by relatively dynamic flood waves. In the process of bore/surge-type run-up, the onshore flow (up to tens of feet per second) can cause tremendous dynamic loads on the structures onshore in the form of impact forces and drag forces, in addition to hydrostatic loading. The subsequent drawdown of the water after run-up exerts the often crippling opposite drags on the structures and washes loose/broken properties and debris to sea; the floating debris brought back on the next onshore flow have been found to be a significant cause of extensive damage after successive run-up and drawdown. As has been shown historically, the potential loss of human life in the process can be great if such events occur in populated areas.

Abrupt sea level changes associated with tsunamis in the past have reportedly caused damage to moored vessels within the outer portions of the Port. The Chilean Earthquake of May 1960, for example, caused local damages of over $1 million and Port closure. One person drowned at Cabrillo Beach and one was injured. Small craft moorings in the Port area, especially in the Cerritos Channel, where a seiche occurred, were seriously damaged. Hundreds of small boats broke loose from their moorings, 40 sank, and about 200 were damaged. Gasoline from damaged boats caused a major spill in Port waters and created a fire hazard. Currents of up to 8 knots and a 6-feet rise of water in a few minutes were observed in the West Basin. The maximum water level fluctuations recorded by gauges were 5.0 feet at Port Berth 60 (near Pilot Station) and 5.8 feet in Long Beach Harbor (Lander et al. 1993).

Until recently, projected tsunami run-ups along the western U.S. were based on farfield events, such as submarine earthquakes or landslides occurring at great distances from the U.S. However, more recent studies (e.g., Synolakis et al. 1997; Borrero et al. 2001, 2005a) have projected larger tsunami run-ups based on near-field events, such as earthquakes or submarine landslides occurring in proximity to the California coastline. Offshore faults present a larger local tsunami hazard than previously thought, posing a direct threat to nearshore facilities. For example, one of the largest such features, the Catalina Fault, lies directly underneath Catalina Island, located only 22 miles from the Port. Simulations of tsunamis generated by uplift on this fault suggest waves in the Port in excess of 12 feet, with an arrival time within 20 minutes (Legg et al. 2003; Borrero et al. 2005b). These simulations were based on rare events, representing worst-case scenarios.

Landslide-derived tsunamis are now perceived as a viable local tsunami hazard. In a study modeling potential tsunami generation by local offshore earthquakes, Legg et al. (2004) considers the relative risk of tsunamis from a large catastrophic submarine landslide (likely generated by a seismic event) in offshore southern California versus fault-generated tsunamis. The occurrence of a large submarine landslide appears quite rare by comparison with the tectonic faulting events. Although many submarine landslides have been mapped off the southern California shore, few appear to be of the scale necessary to generate a catastrophic tsunami. Of two large landslides that appear to be of this magnitude, Legg et al. (2004) indicated that one landslide is over 100,000 years old and the other landslide approximately 7,500 years old. In contrast, the recurrence of 3 to 20 feet fault movements on offshore faults would be several hundred to several thousand years. Consequently, the study concludes that the most likely direct cause of most local tsunamis in southern California is tectonic movement during large offshore earthquakes.

Based on these recent studies (e.g., Synolakis et al. 1997; Borrero et al. 2001), the CSLC has developed tsunami run-up projections for the Port and Port of Long Beach of 8.0 feet and 15.0 feet above MSL at 100- and 500-year intervals, respectively, as a part of their MOTEMS (CSLC 2005). However, these projections do not incorporate consideration of the localized landfill configurations, bathymetric features, and interactions of the diffraction, reflection, and refraction of the tsunami wave propagation within the Port/Port of Long Beach complex in its predictions of tsunami wave heights.

Most recently, a model was developed specifically for the port complex that incorporates consideration of the localized landfill configurations, bathymetric features, and the interaction of the diffraction, reflection, and refraction of tsunami wave propagation, in the predictions of tsunami wave heights (Moffatt & Nichol 2007). The port complex model uses a methodology similar to the above studies to generate a tsunami wave from several different potential sources, including local earthquakes, remote earthquakes, and local submarine landslides. This model indicates that a reasonable maximum source for future tsunami events within the PMPU area would either be a M7 earthquake on the Santa Catalina Fault or a submarine landslide along the nearby Palos Verdes Peninsula.

The port complex model predicts tsunami wave heights within the PMPU area locally in excess of 23 feet above MSL at the western and southern faces of Pier 400. However, in more protected areas, such as West Basin, the model predicts tsunami wave heights of 1.3 to 5.3 feet above MSL (Moffatt & Nichol 2007).

3.5.2.2.4 Seiches

Seiches are seismically induced water waves that surge back and forth in an enclosed basin and may be expected in the harbor as a result of earthquakes. Any significant wave front could cause damage to seawalls and docks, and could breach sea walls within the PMPU area. Modern shoreline protection techniques are designed to resist seiche damage. The port complex model referred to above considered impacts from tsunamis and seiches. In each case, impacts from a tsunami were equal to or more severe than those from a seiche. As a result, the impact discussion below refers primarily to tsunamis as this will be considered the worst case of potential impacts.

3.5.2.2.5 Sea Level Rise

Models suggest that sea level along the California coast could rise substantially over the next century as a result of climate change (Section 3.2, Air Quality and Greenhouse Gases). Risks associated with rising sea levels include inundation of low lying areas along the coast, exposure of new areas to flood risk, an increase in the intensity and risk in areas already susceptible to flooding, and an increase in coastal erosion in erosion prone areas.

The *State of California Sea-Level Rise Interim Guidance Document*, prepared by the Sea Level Rise Task Force of the Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT 2010), recommends using the ranges of Sea Level Rise presented in the December 2009 *Proceedings of the National Academy of Sciences* publication by Vermeer and Rahmstorf (2009), as a starting place for estimating sea level rise, as shown in Table 3.5-3. These estimates do not account for catastrophic ice melting, so the predictions may be underestimates.

Table 3.5-3. Sea Level Rise Projections Using 2000 as the Baseline

Year	*Level of GHG Emissions*	*Average of Models (in inches)*	*Range of Models (in inches)*
2030		7	5-8
2050		14	10-17
2070	Low Medium High	23 24 27	17-27 18-29 20-32
2100	Low Medium High	40 47 55	31-50 37-60 43-69
Source: CO-CAT 2010			

Leading up to 2050, there is a strong disagreement among the various climate models on sea level projections. For dates after 2050, three different values for sea level rise are shown based on low, medium, and high future GHG emission scenarios. As shown in Table 3.5-3, sea level rise is predicted to be greater with higher concentrations of GHGs, including a possible 55-inch sea level rise in 2100 under the highest GHG emissions scenario. LAHD reported to the CSLC, in response to a survey in 2009, that some possible flooding and wave damage would occur from a 55-inch rise in sea level (CSLC 2009).

LAHD and Lempert el al. analyzed various strategies for managing risk associated with sea level rise at the Port and identified sea level rise considerations for incorporation into design guidelines. The analyses examined four Port facilities of varying height above sea level, including the bottoms of container terminals, which carry high-voltage electric lines underneath the main floor (9.2 feet above MSL), the top of the terminals (12.14 feet above MSL), Berths 206-209 (7.62 feet above MSL), and the Alameda and Harry Bridges Crossing (6.13 feet above MSL). A cost-benefit analysis was completed with respect to whether or not to harden Port facilities to withstand rising sea level at the next scheduled facilities upgrade of those facilities. Overall, this analysis concluded that a decision to harden at the next upgrade would merit serious consideration for only one of four Port facilities considered (the

Alameda and Harry Bridges Crossing) and that the Port would have to identify hardening costs 5 to 250 times smaller than current estimates to warrant consideration for the other three facilities (Lempert et al. 2012).

3.5.2.2.6 Subsidence

Subsidence is the phenomenon where the soils and other earth materials underlying the site settle or compress, resulting in a lower ground surface elevation. Fill and native materials within the PMPU area can be water saturated, and a net decrease in the pore pressure and contained water will allow the soil grains to pack closer together. This closer grain packing results in less volume and the lowering of the ground surface.

Subsidence in the Port/Port of Long Beach area was first observed in 1928 and has affected the majority of the harbor area. Based on extensive studies by the City of Long Beach and the California Division of Oil and Gas and Geothermal Resources, it has been determined that most of the subsidence was the result of oil and gas production from the Wilmington Oil Field, starting in about 1936.

The Port area experienced maximum cumulative subsidence of approximately 1.6 feet, from 1928 to 1970 (Allen 1973). Today, water injection continues to be maintained at rates greater than the total volume of produced substances, including oil, gas, and water, to prevent further reservoir compaction and subsidence (City of Long Beach 2006).

3.5.2.2.7 Landslides

Generally, a landslide is defined as the downward and outward movement of loosened rock or earth down a hillside or slope. Landslides can occur either very suddenly or slowly, and frequently accompany other natural hazards such as earthquakes, floods, or wildfires. Most landslides are single events, but more than a third are associated with heavy rains or the melting of winter snows. Landslides can also be triggered by ocean wave action or induced by the undercutting of slopes during construction, improper artificial compaction, or saturation from sprinkler systems or broken water pipes. In areas on hillsides where the ground cover has been destroyed, landslides are probable because there is nothing to hold the soil. Immediate dangers from landslides include destruction of property and possible fatalities from rocks, mud, and water sliding downhill or downstream. Other dangers include broken electrical, water, gas, and sewage lines. The PMPU area is relatively flat and paved, and no known or probable bedrock landslide areas have been identified (City of Los Angeles 1996).

3.5.2.2.8 Expansive and Corrosive Soils

Expansive soils generally result from specific clay minerals that expand when saturated and shrink in volume when dry. These expansive clay minerals are common in the geologic units in the adjacent Palos Verdes Peninsula. Clay minerals in geologic units within the PMPU area could be expansive, and previously imported fill soils could be expansive as well.

Corrosive soils could be present in the PMPU area. Corrosive soils result from the presence of high moisture content, high electrical conductivity (i.e., the ability to pass electrical current), high acidity, and high dissolved salts. These conditions result in the flow of electrical current between the soil and metallic materials, such as tanks, pipelines, and other objects in contact with the soil. This flow of electrical current results in corrosion of metallic objects that are not constructed of, or protected by, corrosion-resistant materials.

3.5.2.2.9 Mineral Resources

The northern portion of the PMPU area is located within the Wilmington Oil Field, a broad, asymmetric anticline broken by a series of transverse normal faults that have created seven major oil-producing zones, from which production began in 1936 (Mayuga 1970). The field is approximately 11 miles long and 3 miles wide, covering approximately 13,500 acres. The Wilmington Oil Field produced 84.4 million barrels of oil from January 1998 through October 2002, making it the 6th largest producing oil field in the state (California Department of Conservation 2002). Numerous oil wells were formerly present within this northern portion of the PMPU area. All of these wells have been abandoned in accordance with California Division of Oil and Gas and Geothermal Resources specifications.

The PMPU area is located primarily on dredged fill material. According to the CDMG, these areas of fill material are located in a Mineral Resource Zone (MRZ) area classified as “MRZ-1,” which is defined as an area where adequate information indicates that no significant mineral deposits (i.e., aggregate deposits) are present or where it is judged that little likelihood exists for their presence. A small area of Quaternary sediments underlies the northwest portion of the PMPU area, adjacent to West Basin (Figure 3.5-2). This area has been designated as MRZ-3, which is an area containing mineral deposits, the significance of which cannot be evaluated from available data (CDMG 1994).

3.5.3 Applicable Regulations

The only regulations that apply to geology are state and local regulations. There are no applicable federal regulations.

3.5.3.1 State Regulations

3.5.3.1.1 Alquist-Priolo Act

California’s Alquist-Priolo Act (PRC 2621 *et seq.*), originally enacted in 1972 as the Alquist-Priolo Special Studies Zone Act and renamed in 1994, is intended to reduce the risk of life and property from surface fault rupture during earthquakes. The Alquist-Priolo Act prohibits the location of most types of structures intended for human occupancy across the traces of active faults and strictly regulates construction in the corridors along active faults. It also defines criteria for identifying active faults, giving legal weight to terms such as “active”, and establishes a process for reviewing building proposals in and adjacent to active faults.

Under the Alquist-Priolo Act, faults are zoned and construction along or across those faults is strictly regulated if the faults are "sufficiently active" and "well defined." A fault is considered sufficiently active if one or more of its segments or strands shows evidence of surface displacement during Holocene time (defined for the purposes of the Act as within the last 11,000 years). A fault is considered well-defined if its trace can be clearly identified by a trained geologist at the ground surface or in the shallow subsurface, using standard professional techniques, criteria, and judgment.

3.5.3.1.2 California Building Code

The State of California provides minimum standards for building design through the California Building Code (CBC). The CBC is based on the International Building Code (formerly known as the Uniform Building Code), established by the International Code Council (formerly known as the International Council of Building Officials), which is used widely throughout the U.S. (generally adopted on a state-by-state or agency-by-agency basis), and has been modified for conditions within California. In 2008, a revised version of the CBC took effect. In accordance with the CBC, a grading permit is required if more than 50 cubic yards of soil is moved during implementation of a project. Chapter 16 of the CBC contains definitions of seismic sources and the procedures used to calculate seismic forces on structures.

Building codes provide minimum standards regulating a number of aspects of construction that are relevant to geology and geologic hazards. These include excavation, grading, and fill placement; foundations; mitigation of soil conditions such as expansive soils; and, seismic design standards for various types of structures.

3.5.3.1.3 Mineral Resources

The Surface Mining and Reclamation Act of 1975 was enacted to promote conservation of the state's mineral resources and to ensure adequate reclamation of mined lands. Among other provisions, the Surface Mining and Reclamation Act requires the State Geologist to classify land in California for mineral resource potential. The four categories include MRZ-1, areas of no mineral resource significance; MRZ-2, areas of identified mineral resource significance; MRZ-3, areas of undetermined mineral resource significance; and, MRZ-4, areas of unknown mineral resource significance.

The distinction between these categories is important for land use considerations. The presence of known mineral resources, which are of regional significance and possibly unique to that particular area, could potentially result in non-approval or changes to a given project if it were determined that those mineral resources would no longer be available for extraction and consumptive use. To be considered significant for the purpose of mineral land classification, a mineral deposit, or a group of mineral deposits that can be mined as a unit, must meet marketability and threshold value criteria adopted by the California State Mining and Geology Board. The criteria vary for different minerals depending on the following: 1) whether the minerals are strategic or non-strategic; 2) the uniqueness or rarity of the minerals; and, 3) the commodity-type category (metallic minerals, industrial minerals, or construction materials) of the minerals. The State Geologist submits the mineral land classification report to the California State Mining and Geology Board, which transmits the information to appropriate local governments that maintain jurisdictional authority in mining, reclamation, and related land use activities. Local governments are required to incorporate the report and maps into their general plans and consider the information when making land use decisions.

3.5.3.1.4 Marine Oil Terminal Engineering and Maintenance Standards

The MOTEMS were approved by the California Building Standards Commission on January 19, 2005 and are codified as part of CCR Title 24, Part 2, Marine Oil Terminals, Chapter 31F. These standards apply to all existing marine oil terminals in California and include criteria for inspection, structural analysis and design, mooring and berthing, geotechnical considerations, fire, piping, and mechanical and electrical systems. MOTEMS became effective on January 6, 2006 (CSLC 2005). The process of developing the MOTEMS has produced parallel guidelines and recommended provisions. The *Seismic Design Guidelines for Port Structures* (Port International Navigation Association [PIANC] 2001) uses text virtually identical to that found in the MOTEMS. The language for PIANC and the MOTEMS is derived from the *Naval Facilities Engineering Service Center Technical Report* (TR-2103-SHR), *Seismic Criteria for California Marine Oil Terminals* (Priestley 2000).

3.5.3.2 Local Regulations

3.5.3.2.1 City of Los Angeles General Plan Conservation and Safety Elements

Geologic resources and hazards in the PMPU area are governed primarily by the City of Los Angeles. The Conservation and Safety elements of the *City of Los Angeles General Plan* contain policies for the protection of geologic features and avoidance of geologic hazards (City of Los Angeles 1996). Local grading ordinances establish detailed procedures for excavation and earthwork required during construction.

3.5.3.2.2 City of Los Angeles Building Code

The City of Los Angeles Building Code establishes requirements for construction of building structures (City of Los Angeles 2011). LAHD uses the 2010 CBC as a basis for seismic design for land-based structures. However, with respect to wharf construction, the LAHD standards and specifications would be applied to the design of individual projects.

3.5.3.2.3 Port of Los Angeles Code for Seismic Design, Upgrade, and Repair of Container Wharves

The LAHD must comply with regulations of the Alquist-Priolo Act, which regulates development near active faults to mitigate the hazard of a surface fault rupture. In addition, the LAHD has developed a seismic code to provide construction standards. The LAHD seismic design codes are contained in the *Proceedings of the Port of Los Angeles Seismic Workshop on Seismic Engineering* (LAHD 1990) and *The Port of*

Los Angeles Code for Seismic Design, Upgrade, and Repair of Container Wharves (LAHD 2010).

3.5.4 Impacts and Mitigation Measures

3.5.4.1 Methodology

Potential geologic impacts as a result of the proposed Program were identified and assessed based on existing published reports, surface reconnaissance, and knowledge of the general geologic setting. Design-level engineering geology and geotechnical investigations, subsurface explorations, laboratory testing, and analyses were not conducted. In this document, geological impacts were evaluated in two ways: 1) proposed Program impacts on the local geologic environment; and, 2) geohazard impacts to the proposed Program.

3.5.4.2 Thresholds of Significance

The *L.A. CEQA Thresholds Guide* (City of Los Angeles 2006) is the basis for the following significance criteria and for determining significance of impacts on geology resulting from the proposed Program. The NOP/IS (Appendix B) concluded that the proposed Program would have no impact under the following threshold; therefore, this significance criterion was not carried forward for detailed analysis:

- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?
  - The Los Angeles Department of Public Works (LADPW) BOS provides sewer service to all areas within its jurisdiction, including the PMPU area. Any new development associated with the proposed appealable/fill projects and land use changes included in the PMPU would be connected to this system, and sewage would be sent to the TIWRP. There would be no use of septic tanks or alternative wastewater disposal systems; therefore, no impacts would occur.

Geologic impacts would be significant under the following conditions:

GEO-1: The proposed Program would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from fault rupture, seismic ground shaking, liquefaction, or other seismically induced ground failure;

GEO-2: The proposed Program would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from tsunamis or seiches;

GEO-3: The proposed Program would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from land subsidence/soil settlement;

GEO-4: The proposed Program would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from expansive soils;

GEO-5: The proposed Program would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from landslides, mudflows; or,

GEO-6: The proposed Program would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from unstable soil conditions from excavation, grading, or fill.

In addition, the proposed Program would normally have a significant impact with respect to landform alteration or mineral resources if:

GEO-7: The proposed Program would destroy, permanently cover, or materially and adversely modify one or more distinct and prominent geologic or topographic features. Such features may include, but not be limited to, hilltops, ridges, hillslopes, canyons, ravines, rock outcrops, water bodies, streambeds, and wetlands;

GEO-8: The proposed Program would result in the permanent loss of availability of a known mineral resource of regional, state, or local significance that would be of future value to the region and the residents of the state; or,

GEO-9: The proposed Program would result in substantial damage to structures or infrastructure or expose people to substantial risk of injury from sea level rise.

Section 3.6, Groundwater and Soils, addresses significance criteria related to erosion.

3.5.4.3 Impacts and Mitigation

Impact GEO-1: The proposed Program would not result in substantial damage to structures or infrastructure or expose people to substantial risk of injury from seismic activity along the Palos Verdes Fault Zone or other regional faults that could produce fault ruptures, seismic ground shaking, liquefaction, or other seismically induced ground failure.

Planning Area 2

Construction

Construction of the proposed appealable/fill projects within Planning Area 2 would not cause or accelerate geologic hazards. However, the Los Angeles region, as with the southern California region as a whole, cannot avoid earthquake-related hazards, such as liquefaction, ground rupture, ground acceleration, and ground shaking. Although no faults within the Port area are currently zoned under the Alquist-Priolo Act, potential hazards exist due to seismic activities associated with the Palos Verdes Fault Zone and presence of hydraulic fill.

New construction associated with the proposed appealable/fill projects and related land use changes within Planning Area 2 (i.e., Berths 187-189 Liquid Bulk Relocation, Yang Ming Terminal Redevelopment [Berths 120-127], and construction of new fill at both the Yang Ming Terminal and China Shipping Terminal [Berth 102]) would expose people and structures to geologic hazards. The Yang Ming and China Shipping terminals are both located within the Palos Verdes Fault Zone and therefore would be susceptible to surface fault rupture. All three proposed appealable/fill projects would be susceptible to liquefaction and subsidence. Proposed fills at the Yang Ming and China Shipping terminals would increase the potential area subject to these geologic hazards. Removal of the Kinder Morgan liquid bulk facility at Berths 118-120 would decrease the potential for surface fault rupture of a liquid bulk facility at the current location. Relocation of the Vopak facility would also decrease the potential for surface fault rupture of a liquid bulk facility at the current location (Berths 187-189) but increase the risk at the new location (Berths 191-194). Also, changing the current vacant land on Mormon Island, an optional land use site, to liquid bulk would increase the potential for future surface fault rupture affecting a liquid bulk facility, including storage tanks and pipelines, if such a facility is constructed at this location. In addition, creation of new open space at Berths 187-89 would create an area not subject to structural failure as a result of earthquakes on the Palos Verdes Fault Zone and/or other regional faults.

The City of Los Angeles Building Code, Sections 91.000 through 91.7016 of the LAMC, regulates construction. These building codes and criteria provide requirements for construction, grading, excavations, use of fill, and foundation work, including type of materials, design, procedures, etc. These codes are intended to limit the probability of occurrence and the severity of consequences from geological hazards, such as earthquakes. Necessary permits, plan checks, and inspections are also specified. The LAMC also incorporates structural seismic requirements of the CBC. LAHD's and City of Los Angeles' Department of Building and Safety engineers would review the individual project plans for compliance with the appropriate standards in the building codes. Proposed appealable/fill projects in Planning Area 2 would comply with the appropriate standards established in the building codes. These projects would comply with seismic requirements and applicable building code sections with respect to excavation, grading, and paving. Means and methods to minimize the effects of seismic events during demolition and excavation of foundations include the proper use of shoring or sloping for excavations and proper equipment support.

LAHD would design and construct wharf improvements in accordance with LAHD seismic design and engineering criteria, including recommendations in geotechnical reports that are prepared as part of the design process, to minimize potential damage risks to new terminal features in the event of seismically-induced geologic hazards. Such design and construction practices would include, but not be limited to, completion of site-specific geotechnical investigations regarding construction and foundation engineering. The design would incorporate measures pertaining to temporary construction conditions, such as maximum temporary slope gradient. New wharf construction associated with relocation of the liquid bulk facility at Berths 187-189 (to Berths 191-194) would also be designed per the MOTEMS to protect against seismic hazards that would occur. These regulations, which were drafted by the CSLC, have been adopted as state law. A licensed geologist or engineer would monitor construction to verify that construction occurs in concurrence with project design.

Operations

Because active faults are located within and near Planning Area 2, and the area is mapped within an area of historic liquefaction, there is a potential for substantial risk of seismic impacts and subsequent potential to contribute to seismically-induced ground shaking that could result in injury to people and damage to structures during project operations. However, the proposed appealable/fill projects in Planning Area 2 would be completed in compliance with established building codes and LAHD design criteria, as described above, including incorporation of modern construction engineering and safety standards.

Planning Area 3

Construction

Construction of proposed the appealable/fill project and other land use changes within Planning Area 3 would not cause or accelerate geologic hazards. However, the Los Angeles region, as with the southern California region as a whole, cannot avoid earthquake-related hazards, such as liquefaction, ground rupture, ground acceleration, and ground shaking. In particular, the harbor area cannot avoid these potential hazards due to the presence of the Palos Verdes Fault Zone and hydraulic fill.

Construction associated with the Berth 300 Development Project, including 18 acres of new fill for container uses, would expose people and structures to geologic hazards. Berth 300 is located within the Palos Verdes Fault Zone and is therefore susceptible to surface fault rupture. Pier 300 would also be susceptible to liquefaction and subsidence. Proposed increased areas of fill would increase the potential area subject to these geologic hazards. Proposed land use changes would also increase the exposure of people and structures to geologic hazards. New construction would occur in association with converting 1) Berths 206-209 to break bulk, dry bulk, and /or container uses and Berths 210-211 to dry bulk and/or container; 2) the vacant uses to maritime support south of Seaside Avenue and south of Reeves Avenue; 3) vacant land to maritime support along Ferry Street; 4) Berth 301, an optional land use site, from maritime support to liquid bulk or container; and 5) Pier 400, conversion of container area to maritime support uses. Structures and infrastructure, including wharf upgrades per the MOTEMS and an underground pipeline for transferring product to the LAXT rail loop, that would be constructed for these land use changes, would be subject to geologic hazards. In contrast, converting the existing ExxonMobil liquid bulk facility, located north of the TIWRP, and the commercial fishing/industrial area near Fish Harbor to container areas would create areas with fewer structures susceptible to structural failure as a result of earthquakes on the Palos Verdes Fault Zone and/or other regional faults.

As described for Planning Area 2, the proposed appealable/fill project and associated land use change in Planning Area 3 would comply with the appropriate standards established in the building codes. This project would comply with seismic requirements and applicable building code sections with respect to excavation, filling, grading, and paving. In addition, LAHD would design and construct wharf improvements in accordance with LAHD seismic design and engineering criteria, including recommendations in geotechnical reports that are prepared as part of the design process, to minimize potential damage risks to new terminal features in the event of seismically-induced geologic hazards. New wharf construction associated with 18 acres of new fill at Berth 300 and conversion of Berth 301 to liquid bulk would also be designed per the MOTEMS to minimize risks from seismic hazards.

Operations

Because active faults are located within and near Planning Area 3, and the area is mapped within an area of historic liquefaction, there is a potential for substantial risk of seismic impacts and subsequent potential to contribute to seismically-induced ground shaking that could result in injury to people and damage to structures during project operations. However, the proposed appealable/fill project and land use changes on Terminal Island, including Pier 300 and Berth 301 would be completed in compliance with established building codes, LAHD design criteria, and MOTEMS, as described above, including incorporation of modern construction engineering and safety standards.

Planning Area 4

Construction

Construction of the proposed appealable/fill projects and other land use changes within Planning Area 4 would not cause or accelerate geologic hazards. However, the Los Angeles region, as with the southern California region as a whole, cannot avoid earthquake-related hazards, such as liquefaction, ground rupture, ground acceleration, and ground shaking. In particular, the harbor area cannot avoid these potential hazards due to the presence of the Palos Verdes Fault Zone and hydraulic fill.

Construction associated with the proposed appealable/fill projects in Planning Area 4 (Tri Marine Expansion, 338 Cannery Street Adaptive Reuse, and the Al Larson Marina) would expose people and structures to geologic hazards. Fish Harbor is located within the Palos Verdes Fault Zone and is therefore susceptible to surface fault rupture. The Fish Harbor area would also be susceptible to liquefaction and subsidence.

Proposed land use changes would not increase the exposure of people and structures to geologic hazards. Recreational boating areas would be converted to maritime support; the existing Southwest Marine shipyard would be converted to maritime support and break bulk; and, existing commercial fishing and institutional uses would be replaced with commercial fishing and maritime support. In addition, converting a liquid bulk facility to commercial fishing and maritime support would create areas with fewer structures susceptible to structural failure as a result of earthquakes on the Palos Verdes Fault Zone and/or other regional faults.

Proposed appealable/fill projects and other land use changes in Planning Area 4 would comply with the appropriate standards established in the building codes. These projects would comply with seismic requirements and applicable building code sections with respect to excavation, filling, grading, and paving. In addition, LAHD would design and construct wharf improvements in accordance with LAHD seismic design and engineering criteria, including recommendations in geotechnical reports that are prepared as part of the design process, to minimize potential damage risks to new terminal features in the event of seismically-induced geologic hazards.

Operations

Because active faults are located within and near Planning Area 4, and the area is mapped within an area of historic liquefaction, there is a potential for substantial risk of seismic impacts and subsequent potential to contribute to seismically-induced ground shaking that could result in injury to people and damage to structures during project operations. However, the proposed appealable/fill projects and other land use changes in the Fish Harbor area would be completed in compliance with established building codes and LAHD design criteria, as described above, including incorporation of modern construction engineering and safety standards.

Impact Determination

Construction

New construction associated with the proposed appealable/fill projects and other land use changes in Planning Areas 2, 3, and 4 would be susceptible to fault surface rupture, liquefaction, and subsidence. However, these projects within the PMPU area would be completed in compliance with established building codes, LAHD, and MOTEMS design criteria, including incorporation of modern construction engineering and safety standards. As a result, impacts due to seismically-induced ground failure would be less than significant.

In addition, proposed land use changes potentially would result in beneficial impacts in several planning areas. Specifically, removal of 1) the Kinder Morgan liquid bulk facility at Berths 118-120 (Planning Area 2), 2) the ExxonMobil liquid bulk facility, located north of the TIWRP (Planning Area 3), and 3) the small liquid bulk facility in Fish Harbor (Planning Area 4) would decrease the potential for damage to liquid bulk facilities due to surface fault rupture, as these facilities are located within the Palos Verdes Fault Zone. These beneficial impacts, associated with reduced risks of earthquake damage to structures, would be offset if the vacant land on Mormon Island in Planning Area 2 is developed consistent with a liquid bulk allowable land use and/or the optional land use site at Berth 301 is converted to a liquid bulk wharf. Similarly, creation of new open space at Berths 187-89 (Planning Area 2) would create an area that would not be subject to structural failure as a result of earthquakes on the Palos Verdes Fault Zone and/or other regional faults.

Operations

The proposed appealable/fill projects and other land use changes would be completed in compliance with established building codes, LAHD design criteria, and MOTEMS, as described above, including incorporation of modern construction engineering and safety standards. Therefore, impacts to geological resources from operations of the proposed appealable/fill projects and land use changes associated with the proposed Program would be less than significant.

Mitigation Measures

No mitigation is required.

Residual Impacts

Residual impacts would be less than significant.

Impact GEO-2: The proposed Program would not expose people and structures to substantial risk involving tsunamis or seiches.

Planning Area 2

Construction

The Port region historically has been subject to tsunamis and seiches; therefore, development on or near the shore within exposed portions of the PMPU area would risk the exposure of people to hazards from a tsunami or seiche. Although relatively rare, if a large tsunami or seiche occurred it would be expected to cause some amount of damage and possibly injuries in exposed on- or near-shore locations. As a result, this is considered by the LAHD as the average, or normal condition for most on- and near-shore locations in southern California. Therefore, a tsunami or seiche related impacts would be any that exceeded this normal condition and cause substantial damage and/or substantial injuries.

Since tsunamis and seiches are derived from wave action, the risk of damage or injuries from these events at any particular location is lessened if the location is high enough above sea level, far enough inland, or protected by manmade structures such as dikes or concrete walls. The height of a given site above sea level is either the result of an artificial structure (e.g., a dock or wall), topography (e.g., a hill or slope), or both, and a key variable related to the height of a site location relative to sea level is the behavior of tides. During high tide, for instance, the distance between a site and sea level is less. During low tide, the distance is greater. How high a site must be located above sea level to avoid substantial wave action during a tsunami or seiche depends on the height of the tide at the time of the event and the height of the potential tsunami or seiche wave. These factors would be considered for any new construction within the PMPU area.

The port complex model (Moffatt & Nichol 2007) indicates that a reasonable maximum source for future tsunami events within the PMPU area would either be a M7 earthquake on the Santa Catalina Fault or a submarine landslide along the nearby Palos Verdes Peninsula. Planning Area 2 is generally protected from excessive tsunami runup. The port complex model predicts tsunami wave heights of 1.3 to 5.3 feet above MSL in West Basin and 0 to 3.2 feet above MSL in East Basin. Based on maximum predicted wave heights with respect to wharf elevations, overtopping would not occur within Planning Area 2 (Moffatt & Nichol 2007).

New construction associated with land use changes and proposed appealable/fill projects within Planning Area 2, including Berths 187-189 Liquid Bulk Relocation, Yang Ming Terminal Redevelopment (Berths 120-127), and construction of new fill at both the Yang Ming Terminal and China Shipping Terminal (Berth 102), would not expose people and structures to tsunamis or seiches, as anticipated runup as a result of such an event would not likely overtop existing wharves.

Operations

Impacts associated with operations within Planning Area 2 would be the same as discussed above for construction.

Planning Area 3

Construction

The port complex model predicts tsunami wave heights locally in excess of 23 feet above MSL at the western and southern faces of Pier 400, located within Planning Area 3. However, no proposed appealable/fill projects or land use changes that would result in new construction are located on this portion of Pier 400. Proposed land use changes would involve changing an institutional area to open space (least tern habitat) and conversion of container area to maritime support uses on the eastern face of Pier 400. Runup at the exposed, southerly portion of Pier 300, including Berth 301, may overtop wharves as a result of maximum projected tsunami related wave heights in that area, which are projected to be up to 16 feet above MSL. However, proposed appealable projects and land use changes in the southerly portion of Pier 300, including Berth 300 Development (18-acre fill), converting break bulk and vacant land at Berths 206-209 and 210-211 to mixed use, converting vacant land, commercial fishing, and industrial areas near Fish Harbor to container cargo uses, and converting the ExxonMobil tank farm to container storage, would reduce the need for constructing new structures on this portion of Pier 300 as a result of the PMPU. Although containers could be damaged, potential tsunami runup would not likely result in damage to structures, other than the wharves. In addition, changing a commercial fishing and industrial area near Fish Harbor to a container storage area would reduce the number of people working in that area, thus reducing tsunami related impacts. However, converting the optional land use site at Berth 301 to a liquid bulk facility would require installation of a transfer pipeline that would be susceptible to tsunami damage.

The probability of a tsunami-generating M7 earthquake on the Santa Catalina Fault or a submarine landslide along the nearby Palos Verdes Peninsula is relatively low with respect to the life span of the proposed appealable/fill projects and land use changes (through 2035). In addition, the probability of occurrence differs between the two potential tsunamis sources. The most likely, worst-case, tsunami scenario was based partially on a M7.6 earthquake on the offshore Santa Catalina Fault. The recurrence interval for a M7.5 earthquake along an offshore fault in the Southern California Continental Borderland is about 10,000 years. However, there is no certainty that such an earthquake event would result in a tsunami, since only about 10 percent of earthquakes worldwide result in a tsunami. In addition, available evidence indicates that tsunamigenic landslides would be extremely infrequent and occur less often than large earthquakes. This suggests recurrence intervals for such landslide events would be longer than the 10,000-year recurrence interval estimated for a M7.5 earthquake (Moffatt & Nichol 2007).

Operations

Impacts associated with operations within Planning Area 3 would be the same as discussed above for construction.

Planning Area 4

Construction

The Fish Harbor area is generally protected from tsunami runup, in large part due to a breakwater that protects the entrance to Fish Harbor. However, the port complex model predicts tsunami wave heights of 15 to 20 feet above MSL along this protective breakwater, with the highest runup being adjacent to the southeast portion of Planning Area 4. Such runup could overtop the breakwater and adjacent wharves of Planning Area 4. Proposed land use changes in this portion of the planning area would result in increased susceptibility of people and new structures to tsunami-related runup. Proposed land use changes would include new construction associated with 1) a recreational boating area would be converted to maritime support; and, 2) currently vacant land at the former Southwest Marine facility would be converted to maritime support and break bulk. In addition, new construction would likely occur in association with the Tri Marine Expansion, 338 Cannery Street Adaptive Reuse, and Al Larson Marina projects. However, as discussed for Planning Area 3, the probability of a tsunami-generating M7 earthquake on the Santa Catalina Fault or a submarine landslide along the nearby Palos Verdes Peninsula is relatively low with respect to the life span of the proposed appealable/fill projects and land use changes (through 2035).

Operations

Impacts associated with operations within Planning Area 4 would be the same as discussed above for construction.

Impact Determination

Construction

Construction of the proposed appealable/fill projects and other land use change within portions of Planning Areas 3 and 4 would be at lower elevations than predicted tsunami wave heights. As a result, there is a risk of inundation due to tsunamis. Projects in construction phases are especially susceptible to damage due to temporary conditions, such as unfinished structures, which are typically not in a condition to withstand coastal flooding. Designing new facilities based on existing building codes and incorporation of emergency planning in accordance with current state and city regulations would minimize damage to structures and injury to personnel from tsunami inundation. Impacts due to tsunamis and seiches would not be increased by construction of projects within the PMPU area. However, there is a potential for flooding due to tsunamis within Planning Areas 3 and 4. As a result, impacts have the potential to be significant for any future projects located in these planning areas.

Operations

Due to the potential for tsunami-related flooding within Planning Areas 3 and 4, impacts have the potential to be significant for operations of any future projects located in these planning areas.

Mitigation Measures

The following mitigation measure would be implemented, as applicable, for the proposed appealable/fill projects and land use changes under the proposed Program.

MM GEO-1: Emergency Response Planning. Individual project operators shall work with LAHD engineers and Los Angeles Port Police (Port Police) to develop tsunami response training and procedures to assure that construction and operations personnel would be prepared to act in the event of a large seismic event. Such procedures shall include immediate evacuation requirements in the event that a large seismic event is felt at the project site, as part of overall emergency response planning for individual projects.

Such procedures shall be included in any bid specifications for construction or operations personnel, with a copy of such bid specifications to be provided to LAHD, including a completed copy of its operations emergency response plan prior to commencement of construction activities and/or operations.

Residual Impacts

Incorporation of emergency planning in accordance with current state and city regulations and implementation of **MM GEO-1**, as applicable, would reduce injuries to onsite personnel during a tsunami. Therefore, residual impacts would be less than significant.

Impact GEO-3: The proposed Program would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from subsidence/soil settlement.

Planning Area 2

Construction

Subsidence due to previous oil extraction in the Port area has been mitigated and is not anticipated to adversely impact new construction associated with the proposed appealable/fill projects and land use changes within the PMPU area. During the design phase of the Berths 187-189 Liquid Bulk Relocation and Yang Ming Terminal Redevelopment (Berths 120-127) projects, and construction of new fill at both the Yang Ming Terminal and China Shipping Terminal (Berth 102), the project engineer would evaluate the settlement potential in all areas of new fill and where structures are proposed. The fill and structures would be designed to accommodate anticipated settlement, as necessary.

The settlement potential of existing onshore soils and proposed new fill material would be evaluated through a site-specific geotechnical investigation, which includes subsurface soil sampling, laboratory analysis of samples collected to determine soil compressibility, and an evaluation of the laboratory testing results, by a geotechnical engineer. Recommendations of the engineer would be incorporated into the design specifications for the individual project, consistent with city design guidelines, including Sections 91.000 through 91.7016 of the LAMC, in conjunction with criteria established by LAHD. Recommendations for soils subject to structural settlement typically include overexcavation and recompaction of compressible soils, which would allow for construction of a conventional slab-on-grade; or alternatively, installation of concrete or steel foundation piles through the settlement prone soils, to a depth of competent soils. Such geotechnical engineering would substantially reduce the potential for soil settlement and would ensure that construction of individual projects would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury.

The settlement potential associated with creation of a new fill areas would similarly be evaluated through a site-specific geotechnical investigation, which includes sampling of sediments to be placed as fill, as well as sampling of the substrate (harbor bottom sediments) on which the fill would be placed. Laboratory analysis of samples would be conducted, under the supervision of a geotechnical engineer, to determine soil compressibility. Recommendations of the engineer would be incorporated into the design specifications for the individual project, consistent with city design guidelines, including Sections 91.000 through 91.7016 of the LAMC, in conjunction with criteria established by LAHD and Caltrans. Recommendations for sediments subject to settlement typically include placement of excess sediments above final anticipated grade in order to surcharge (or compress) the underlying, newly placed sediments. When geotechnical instrumentation indicates that sufficient compaction has been achieved in the area of newly-place fill, the overburden soil would then be removed and construction would commence. Such geotechnical engineering would substantially reduce the potential for soil settlement and would ensure that construction of the fill would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury.

Operations

Impacts associated with operations within Planning Area 2 would be the same as discussed above for construction.

Planning Area 3

Construction

As discussed for Planning Area 2, subsidence due to previous oil extraction in the Port area, has been mitigated and is not anticipated to adversely impact the proposed appealable/fill project or land use changes within Planning Area 3. During the design phase of new construction associated with the Berth 300 Development Project (i.e., creating an additional 18 acres of fill at Pier 300 for container cargo uses) potential upgrades to Berth 301, and other land use changes in Planning Area 3, the project engineer would evaluate the settlement potential in all areas where structures are proposed. The structures would be designed to accommodate anticipated settlement, as necessary. New construction in Planning Area 3 would occur in association with converting 1) the vacant uses to maritime support south of Seaside Avenue and south of Reeves Avenue; 2) existing open space to maritime support along Ferry Street; and, 3) the optional land use site at Berth 301 from maritime support to liquid bulk. However, converting the existing ExxonMobil liquid bulk facility, located north of the TIWRP, and the commercial fishing/industrial area near Fish Harbor to container areas would create areas with fewer structures susceptible to structural failure as a result of subsidence and settlement.

The settlement potential associated with creation of a new fill areas would be evaluated through site-specific geotechnical investigations, which would include sampling of sediments to be placed as fill, as well as sampling of the substrate (bottom sediments) on which the fill would be placed. Such geotechnical engineering would substantially reduce the potential for soil settlement and would ensure that construction of the fill would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury.

Operations

Impacts associated with operations within Planning Area 3 would be the same as discussed above for construction.

Planning Area 4

Construction

Subsidence due to previous oil extraction in the Port area has been mitigated and is not anticipated to adversely impact the proposed appealable/fill projects or other land use changes within the PMPU area. During the design phase of new construction associated with the proposed appealable/fill projects and land use changes in Planning Area 4, the project engineer would evaluate the settlement potential in all areas where structures are proposed. The structures would be designed to accommodate anticipated settlement, as necessary. Proposed land use changes would include new construction, including 1) a recreational boating area to be converted to maritime support; and, 2) currently vacant land at the former Southwest Marine facility to be converted to maritime support and break bulk. In addition, new construction would likely occur with the Tri Marine Expansion, 338 Cannery Street Adaptive Reuse, and Al Larson Marina projects.

Operations

Impacts associated with operations within Planning Area 4 would be the same as discussed above for construction.

Impact Determination

Construction

Settlement/subsidence impacts would be less than significant, as new construction and fill placement associated with the proposed appealable/fill projects and land use changes in Planning Areas 2, 3, and 4 would be designed and constructed in compliance with recommendations of a geotechnical engineer, consistent with Sections 91.000 through 91.7016 of the LAMC, and in conjunction with criteria established by LAHD and Caltrans. Therefore, these impacts would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury.

Operations

Impacts associated with operations would be the same as discussed above for construction.

Mitigation Measures

No mitigation is required.

Residual Impacts

Residual impacts would be less than significant.

Impact GEO-4: The proposed Program would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from soil expansion.

Planning Area 2

Construction

Expansive soil may be present in Planning Area 2 and may be present in dredged or imported soils used for grading and fill placement associated with the proposed appealable/fill projects. New construction associated with the proposed appealable/fill projects and land use changes in Planning Area 2 includes Berths 187-189 Liquid Bulk Relocation, Yang Ming Terminal Redevelopment (Berths 120-127), and construction of new fill at both the Yang Ming Terminal and China Shipping Terminal (Berth 102). Expansive soils beneath foundations could result in cracking and warping due to settlement, thereby resulting in structural damage and/or risk of injury. However, during the individual project design phase, the project engineer would evaluate the expansion potential associated with onsite soils through a site-specific geotechnical investigation, which includes subsurface soil sampling, laboratory analysis of samples collected to determine soil expansion potential, and an evaluation of the laboratory testing results, by a geotechnical engineer. Recommendations of the engineer would be incorporated into the design specifications for the individual project, consistent with city design guidelines, including Sections 91.000 through 91.7016 of the LAMC, in conjunction with criteria established by LAHD. Recommendations for soils subject to expansion typically include overexcavation and replacement of expansive soils with sandy, non-expansive soils, which would allow for construction of a conventional slab-on-grade; construction of post-tensioning concrete slabs, which can accommodate movement of underlying expansive soils; or alternatively, installation of concrete or steel foundation piles through the expansion prone soils, to a depth of non-expansive soils. Such geotechnical engineering would substantially reduce the potential for soil expansion and damage to overlying structures.

Operations

Impacts associated with operations within Planning Area 2 would be the same as discussed above for construction.

Planning Area 3

Construction

Expansive soil may be present in Planning Area 3 and may be present in dredged or imported soils used for grading and fill placement associated with the proposed appealable/fill projects. New construction in Planning Area 3 would occur in association with converting 1) the vacant uses to maritime support south of Seaside Avenue and south of Reeves Avenue; 2) existing open space to maritime support along Ferry Street; and, 3) the optional land use site at Berth 301 from maritime support to liquid bulk or container uses. Expansive soils beneath new foundations could be cracked and warped by settlement. However, during the individual project design phase, the project engineer would evaluate the expansion potential associated with onsite soils through a site-specific geotechnical investigation. Such geotechnical engineering would substantially reduce the potential for soil expansion and damage to overlying structures.

In addition, converting the existing ExxonMobil liquid bulk facility, located north of the TIWRP, and the commercial fishing/industrial area near Fish Harbor to container areas would create areas with fewer structures susceptible to structural failure as a result of expansive soil.

Operations

Impacts associated with operations within Planning Area 3 would be the same as discussed above for construction.

Planning Area 4

Construction

Expansive soil may be present in Planning Area 4 and may be present in dredged or imported soils used for grading and fill placement associated with the proposed appealable/fill projects. Proposed land use changes would include new construction, including 1) a recreational boating area to be converted to maritime support; and, 2) currently vacant land at the former Southwest Marine facility to be converted to maritime support and break bulk. In addition, new construction would likely occur in association with the Tri Marine Expansion, 338 Cannery Street Adaptive Reuse, and Al Larson Marina projects. Expansive soils beneath new foundations could be cracked and warped by settlement. However, during the individual project design phase, the project engineer would evaluate the expansion potential associated with onsite soils through a site-specific geotechnical investigation. Such geotechnical engineering would substantially reduce the potential for soil expansion and damage to overlying structures.

Operations

Impacts associated with operations within Planning Area 4 would be the same as discussed above for construction.

Impact Determination

Construction

Expansive soil impacts in Planning Areas 2, 3, and 4 would be less than significant, as individual projects would be designed and constructed in compliance with the recommendations of a geotechnical engineer, consistent with implementation of Sections 91.000 through 91.7016 of the LAMC, and in conjunction with criteria established by LAHD would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury.

Operations

Impacts associated with operations would be the same as discussed above for construction.

Mitigation Measures

No mitigation is required.

Residual Impacts

Residual impacts would be less than significant.

Impact GEO-5: The proposed Program would not result in or expose people or property to a substantial risk of landslides or mudslides.

Planning Areas 2 - 4

Construction

The topography in Planning Areas 2, 3, and 4 is flat and not subject to landslides or mudflows.

Operations

Impacts associated with operations within Planning Areas 2, 3, and 4 would be the same as discussed above for construction impacts.

Impact Determination

Construction

Because the topography in the PMPU area is flat and mostly paved, new construction associated with the proposed appealable/fill projects and land use changes would not be subject to landslides or mudflows and no impacts would occur.

Operations

Operation of the proposed appealable/fill projects and land use changes would not be subject to landslides or mudflows and no impacts would occur.

Mitigation Measures

No mitigation is required.

Residual Impacts

No impacts would occur.

Impact GEO-6: The proposed Program would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from unstable soil conditions from excavation, grading, or fill.

Planning Area 2

Construction

Natural alluvial and estuarine deposits, as well as artificial fill consisting of dredged deposits or imported soils, may be encountered during excavations for utility pipeline relocation or for construction of retaining walls, manholes, and other structures. Groundwater is locally present within the PMPU area at depths as shallow as 12 feet. Excavations may locally be completed to this depth, such as for underground utility construction or vehicle maintenance pits. Materials near and below the shallow groundwater table would be relatively fluid, potentially resulting in soil collapse, which in turn could result in injury to personnel and/or damage to adjacent structures.

Proposed appealable/fill projects in Planning Area 2 that may be affected by unstable soils include Berths 187-189 Liquid Bulk Relocation and the Yang Ming Terminal Redevelopment (Berths 120-127). New construction in this planning area would include implementation of standard engineering practices regarding saturated, collapsible soils, such as dredging, dewatering wells, and other special handling procedures to facilitate excavation. For example, dewatering wells would locally increase the depth to groundwater, thus reducing the potential for collapsible soils. Various types of temporary shoring would also be used to stabilize excavations with saturated, collapsible soils. Such engineering practices would be implemented where necessary.

Dewatered groundwater would likely be discharged to the city's sewer system under an Industrial Waste Discharge Permit through the LADPW BOS. Pretreatment of the dewatered groundwater could be required. The groundwater would be conveyed to the TIWRP for further treatment prior to discharge through the facility ocean outfall. Refer to Section 3.6, Groundwater and Soils, regarding potential soil and/or groundwater contamination and treatment thereof, during construction excavations.

Operations

Impacts associated with operations within Planning Area 2 would be the same as discussed above for construction.

Planning Area 3

Construction

As discussed for Planning Area 2, natural alluvial and estuarine deposits, as well as artificial fill consisting of dredged deposits or imported soils, may be encountered during excavations for utility pipeline relocation or for construction of retaining walls, manholes, and other structures, potentially resulting in soil collapse, which in turn could result in injury to personnel and/or damage to adjacent structures. New construction in Planning Area 3 would occur in association with the Berth 300 Development Project and converting 1) the vacant uses to maritime support south of Seaside Avenue and south of Reeves Avenue; 2) existing open space to maritime support along Ferry Street; and, 3) the optional land use site at Berth 301 from maritime support to either container or liquid bulk. Materials near and below the shallow groundwater table would be relatively fluid, requiring implementation of standard engineering practices regarding saturated, collapsible soils, such as dredging, dewatering wells, and other special handling procedures to facilitate excavation. Such standard geotechnical engineering would substantially reduce the potential for soil collapse.

In addition, converting the existing ExxonMobil liquid bulk facility and the commercial fishing/industrial area near Fish Harbor to container area would create areas with fewer construction requirements and associated susceptibility to collapsible soil.

Operations

Impacts associated with operations within Planning Area 3 would be the same as discussed above for construction.

Planning Area 4

Construction

Natural alluvial and estuarine deposits, as well as artificial fill consisting of dredged deposits or imported soils, may be encountered during excavations for utility pipeline relocation or for construction of retaining walls, manholes, and other structures, potentially resulting in soil collapse, which in turn could result in injury to personnel and/or damage to adjacent structures. New construction associated with the proposed appealable/fill projects and land use changes in Planning Area 4 would require implementation of standard engineering practices regarding saturated, collapsible soils, such as dredging, dewatering wells, and other special handling procedures to facilitate excavation. Such standard geotechnical engineering would substantially reduce the potential for soil collapse.

Operations

Impacts associated with operations within Planning Area 4 would be the same as discussed above for construction.

Impact Determination

Construction

Due to implementation of standard engineering practices regarding saturated, collapsible soils, people and structures would not be exposed to substantial adverse effects from construction of the proposed appealable/fill projects and land use changes under the proposed Program. As a result, impacts associated with shallow groundwater would be less than significant.

Operations

Impacts associated with operations would be the same as discussed above for construction.

Mitigation Measures

No mitigation is required.

Residual Impacts

Residual impacts would be less than significant.

Impact GEO-7: The proposed Program would not result in one or more distinct and prominent geologic or topographic features being destroyed, permanently covered, or materially and adversely modified.

Planning Areas 2 - 4

Construction

Since Planning Areas 2, 3, and 4 are relatively flat and paved, with no prominent geologic or topographic features, new construction associated with the proposed appealable/fill projects and land use changes would not result in any distinct and prominent geologic or topographic features being destroyed, permanently covered, or materially and adversely modified.

Operations

Potential destruction of distinct or prominent geologic or topographic features would only pertain to construction activities.

Impact Determination

Construction

No impacts would occur as a result of new construction associated with the proposed appealable/fill projects and land use changes in Planning Areas 2, 3, and 4.

Operations

No impacts related to operations would occur as potential destruction of distinct or prominent geologic or topographic features would only pertain to construction activities.

Mitigation Measures

No mitigation is required.

Residual Impacts

No impacts would occur.

Impact GEO-8: The proposed Program within the limits of the oil field would not result in the permanent loss of availability of any mineral resource of regional, statewide, or local significance.

Planning Area 2

Construction

With respect to aggregate potential, most of Planning Area 2 is located on dredged fill material, which is classified as MRZ-1, an area where adequate information indicates that no significant mineral deposits (i.e., aggregate deposits) are present or where it is judged that little likelihood exists for their presence. However, a small area of Quaternary sediments underlying the northwest portion of the planning area, adjacent to West Basin, has been designated as MRZ-3, which is an area containing mineral deposits, the significance of which cannot be evaluated from available data (Section 3.5.2.2.9, Mineral Resources). However, none of the proposed appealable/fill projects or land use changes would affect this area with unevaluated aggregate resource potential.

With respect to petroleum resources, the northern portion of Planning Area 2 is located within the Wilmington Oil Field. Proposed fill/appealable projects, including Berths 187-189 Liquid Bulk Relocation, Yang Ming Terminal Redevelopment (Berths 120-127), and construction of new fill at both the Yang Ming Terminal and China Shipping Terminal (Berth 102) would preclude oil and gas drilling from within individual project boundaries. However, petroleum reserves beneath those sites could be accessed from remote locations, using directional (or slant) drilling techniques.

Operations

Impacts associated with operations within Planning Area 2 would be the same as discussed above for construction.

Planning Area 3

Construction

Planning Area 3 is located on dredged fill material, which is classified as MRZ-1, an area where adequate information indicates that no significant mineral deposits (i.e., aggregate deposits) are present or where it is judged that little likelihood exists for their presence.

Planning Area 3 is not underlain by a known oil field. In the event that oil reserves are discovered beneath this planning area, projects built as a result of land use changes would potentially preclude oil and gas drilling from within individual project boundaries. However, petroleum reserves beneath those sites could be accessed from remote locations, using directional (or slant) drilling techniques.

Operations

Impacts associated with operations within Planning Area 3 would be the same as discussed above for construction.

Planning Area 4

Construction

Planning Area 4 is located on dredged fill material, which is classified as MRZ-1, an area where adequate information indicates that no significant mineral deposits (i.e., aggregate deposits) are present or where it is judged that little likelihood exists for their presence.

Planning Area 4 is not underlain by a known oil field. In the event that oil reserves are discovered beneath this planning area, the proposed appealable/fill projects would potentially preclude oil and gas drilling from within individual project boundaries. However, petroleum reserves beneath those sites could be accessed from remote locations, using directional (or slant) drilling techniques.

Operations

Impacts associated with operations within Planning Area 4 would be the same as discussed above for construction.

Impact Determination

Construction and Operations

Construction and operations of the proposed appealable/fill projects and land use changes within Planning Areas 2, 3, and 4 would not result in the permanent loss of availability of known mineral resources that would be of future value to the region and the residents of the state. Therefore, impacts to mineral resource would be less than significant.

Mitigation Measures

No mitigation is required.

Residual Impacts

Residual impacts would be less than significant.

Impact GEO-9: The proposed Program would not result in substantial damage to structures or infrastructure or expose people to substantial risk of injury from sea level rise.

Planning Area 2

Construction

As indicated in Table 3.5-3, predicted sea level rise in the Port through 2050 varies from 10 to 17 inches, with an average of 14 inches. Such an increase in itself would not likely inundate existing berths within Planning Area 2, which range in height from about 7.5 to 12 feet above MSL. However, such an increase could locally exacerbate flooding in the unlikely event of a tsunami or seiche. Refer to Impact GEO-2 for a discussion of potential tsunami impacts.

Operations

Impacts associated with operations within Planning Area 2 would be the same as discussed above for construction.

Planning Area 3

Construction

Predicted sea level rise in the Port would not likely inundate existing berths within Planning Area 3, which range in height from about 7.5 to 12 feet above MSL. However, such an increase could locally exacerbate flooding in the unlikely event of a tsunami or seiche. Refer to Impact GEO-2 for a discussion of potential tsunami impacts.

Operations

Impacts associated with operations within Planning Area 3 would be the same as discussed above for construction.

Planning Area 4

Construction

Predicted sea level rise in the Port would not likely inundate existing berths within Planning Area 4. However, such an increase could locally exacerbate flooding in the unlikely event of a tsunami or seiche. Refer to Impact GEO-2 for a discussion of potential tsunami impacts.

Operations

Impacts associated with operations within Planning Area 4 would be the same as discussed above for construction.

Impact Determination

Construction and Operations

Construction and operation of the proposed appealable/fill projects and land use changes would not likely expose people and structures to substantial sea level rise. Therefore, impacts would be less than significant.

Mitigation Measures

No mitigation is required.

Residual Impacts

Residual impacts would be less than significant.

3.5.5 Summary Impact Determination

Table 3.5-4 summarizes the impact determinations of the proposed Program related to geology. Identified potential impacts are based on federal, state, and City of Los Angeles significance criteria, LAHD guidance/policy, and the scientific judgment of the report preparers.

For each type of potential impact, the table describes the impact, notes the CEQA impact determination, describes applicable mitigation measures, and notes the residual impacts (i.e., the impact remaining after mitigation). All impacts, whether significant or not, are included in the table.

Table 3.5-4. Summary Matrix of Potential Impacts and Mitigation Measures for Geology Associated with the Proposed Program

Environmental Impacts	*Impacts Determination*	*Mitigation Measures*	*Impacts After Mitigation*
Construction			
GEO-1: Construction of the proposed Program would not result in substantial damage to structures or infrastructure or expose people to substantial risk of injury from seismic activity along the Palos Verdes Fault Zone or other regional faults that could produce fault ruptures, seismic ground shaking, liquefaction, or other seismically induced ground failure.	Less than significant	No mitigation is required	Less than significant
GEO-2: Construction of the proposed Program would not expose people and structures to substantial risk involving tsunamis or seiches.	Significant	**MM GEO-1: Emergency Response Planning.** Individual project operators shall work with Port engineers and Port police to develop tsunami response training and procedures to assure that construction and operations personnel will be prepared to act in the event of a large seismic event. Such procedures shall include immediate evacuation requirements in the event that a large seismic event is felt at the project site, as part of overall emergency response planning for individual projects. Such procedures shall be included in any bid specifications for construction or operations personnel, with a copy of such bid specifications to be provided to LAHD, including a completed copy of its operations emergency response plan prior to commencement of construction activities and/or operations.	Less than significant
GEO-3: Construction of the proposed Program would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from subsidence/soil settlement.	Less than significant	No mitigation is required	Less than significant

Table 3.5-4. Summary Matrix of Potential Impacts and Mitigation Measures for Geology Associated with the Proposed Program

Environmental Impacts	*Impacts Determination*	*Mitigation Measures*	*Impacts After Mitigation*
GEO-4: Construction of the proposed Program would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from soil expansion.	Less than significant	No mitigation is required	Less than significant
GEO-5: Construction of the proposed Program would not result in or expose people or property to a substantial risk of landslides or mudslides.	No impact	No mitigation is required	No impact
GEO-6: Construction of the proposed Program would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from unstable soil conditions from excavation, grading, or fill.	Less than significant	No mitigation is required	Less than significant
GEO-7: Construction of the proposed Program would not result in one or more distinct and prominent geologic or topographic features being destroyed, permanently covered, or materially and adversely modified.	No impact	No mitigation is required	No impact
GEO-8: Construction of the proposed Program within the limits of the oil field would not result in the permanent loss of availability of any mineral resource of regional, statewide, or local significance.	Less than significant	No mitigation is required	Less than significant
GEO-9: Construction of the proposed Program would not result in substantial damage to structures or infrastructure or expose people to substantial risk of injury from sea level rise.	Less than significant	No mitigation is required	Less than significant

Table 3.5-4. Summary Matrix of Potential Impacts and Mitigation Measures for Geology Associated with the Proposed Program

Environmental Impacts	*Impacts Determination*	*Mitigation Measures*	*Impacts After Mitigation*
Operations			
GEO-1: Operation of the proposed Program would not result in substantial damage to structures or infrastructure or expose people to substantial risk of injury from seismic activity along the Palos Verdes Fault Zone or other regional faults that could produce fault ruptures, seismic ground shaking, liquefaction, or other seismically induced ground failure.	Less than significant	No mitigation is required	Less than significant
GEO-2: Operation of the proposed Program would expose people and structures to substantial risk involving tsunamis or seiches.	Significant	**MM GEO-1: Emergency Response Planning.** Individual project operators shall work with Port engineers and Port police to develop tsunami response training and procedures to assure that construction and operations personnel will be prepared to act in the event of a large seismic event. Such procedures shall include immediate evacuation requirements in the event that a large seismic event is felt at the project site, as part of overall emergency response planning for individual projects. Such procedures shall be included in any bid specifications for construction or operations personnel, with a copy of such bid specifications to be provided to LAHD, including a completed copy of its operations emergency response plan prior to commencement of construction activities and/or operations.	Less than significant
GEO-3: Operation of the proposed Program would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from subsidence/soil settlement.	Less than significant	No mitigation is required	Less than significant

Table 3.5-4. Summary Matrix of Potential Impacts and Mitigation Measures for Geology Associated with the Proposed Program

Environmental Impacts	*Impacts Determination*	*Mitigation Measures*	*Impacts After Mitigation*
GEO-4: Operation of the proposed Program would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from soil expansion.	Less than significant	No mitigation is required	Less than significant
GEO-5: Operation of the proposed Program would not result in or expose people or property to a substantial risk of landslides or mudslides.	No impact	No mitigation is required	No impact
GEO-6: Operation of the proposed Program would not result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury from unstable soil conditions from excavation, grading, or fill.	Less than significant	No mitigation is required	Less than significant
GEO-7: Operation of the proposed Program would not result in one or more distinct and prominent geologic or topographic features being destroyed, permanently covered, or materially and adversely modified.	No impact	No mitigation is required	No impact
GEO-8: Operation of the proposed Program within the limits of the oil field would not result in the permanent loss of availability of any mineral resource of regional, statewide, or local significance.	Less than significant	No mitigation is required	Less than significant
GEO-9: Operation of the proposed Program would not result in substantial damage to structures or infrastructure or expose people to substantial risk of injury from sea level rise.	Less than significant	No mitigation is required	Less than significant

3.5.6 Significant Unavoidable Impacts

No significant unavoidable impacts to geology would occur as a result of implementation of the proposed Program.

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