

## GEOLOGY, SOILS, AND SEISMICITY

### 4.5 GEOLOGY, SOILS, AND SEISMICITY

This chapter provides an overview of the regulatory framework and existing geologic conditions on the Project site and evaluates potential environmental impacts of the Project related to geology, soils, and seismicity.

#### 4.5.1 ENVIRONMENTAL SETTING

##### 4.5.1.1 REGULATORY FRAMEWORK

This section summarizes key State and local regulations pertaining to geology, soils, and seismicity that are applicable to the Project. There are no federal regulations relating to geology, soils, and seismicity applicable to the Project.

#### State Regulations

##### *Alquist-Priolo Earthquake Fault Zoning Act*

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting to structures used for human occupancy.<sup>1</sup> The main purpose of the Act is to prevent the construction of buildings used for human occupancy on top of active faults. The Act only addresses the hazard of surface fault rupture and is not directed toward other earthquake hazards, such as ground shaking or landslides.<sup>2</sup>

The law requires the State Geologist to establish regulatory zones (known as Earthquake Fault Zones or Alquist-Priolo Zones) around the surface traces of active faults, and to issue appropriate maps.<sup>3</sup> The maps are then distributed to all affected cities, counties, and State agencies for their use in planning and controlling new or renewed construction. Generally, construction within 50 feet of an active fault zone is prohibited.

San Leandro is listed as a city affected by Alquist-Priolo Earthquake Fault Zones.<sup>4</sup>

##### *Seismic Hazards Mapping Act*

The Seismic Hazards Mapping Act, passed in 1990, addresses non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides.<sup>5</sup> Under this Act, seismic hazard zones are mapped by the State Geologist to assist local governments in land use planning. Section 2691(c) of the

<sup>1</sup> Called the *Alquist-Priolo Special Studies Zones Act* until renamed in 1993.

<sup>2</sup> California Geological Survey, Alquist-Priolo Earthquake Fault Zones, <http://www.consrv.ca.gov/CGS/rghm/ap/Pages/Index.aspx>, accessed on July 17, 2014.

<sup>3</sup> Earthquake Fault Zones are regulatory zones around active faults. The zones vary in width, but average about ¼-mile-wide. <http://www.consrv.ca.gov/cgs/rghm/ap/Pages/main.aspx>, accessed on July 17, 2014.

<sup>4</sup> California Geological Survey, Cities and Counties Affected by Alquist-Priolo Earthquake Fault Zones as of January 2010, <http://www.conservation.ca.gov/cgs/rghm/ap/Pages/affected.aspx>, accessed on July 23, 2014.

<sup>5</sup> California Geological Survey, Alquist-Priolo Earthquake Fault Zoning Act, <http://www.consrv.ca.gov/cgs/rghm/ap/Pages/main.aspx>, accessed on July 17, 2014.

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Act states that “it is necessary to identify and map seismic hazard zones in order for cities and counties to adequately prepare the safety element of their general plans and to encourage land use management policies and regulations to reduce and mitigate those hazards to protect public health and safety.” Section 2697(a) of the Act states that “cities and counties shall require, prior to the approval of a project located in a seismic hazard zone, a geotechnical report defining and delineating any seismic hazard.”

### *California Building Code*

The California Building Code (CBC), known as the California Building Standards Code, is included in Title 24 of the California Code of Regulations. The CBC incorporates the International Building Code, a model building code adopted across the United States.

The CBC is updated every three years, and the current 2013 CBC took effect January 1, 2014. The 2013 CBC has been adopted for use by the City of San Leandro according to Chapter 7 of Title 7 of the San Leandro Municipal Code. Through the CBC, the State provides a minimum standard for building design and construction. The CBC contains specific requirements for seismic safety, excavation, foundations, retaining walls, and site demolition. It also regulates grading activities, including drainage and erosion control.

## **Local Regulations**

### *San Leandro General Plan*

The City of San Leandro General Plan contains a goal and policies to minimize the risk of natural hazards, including earthquakes and landslides, in Chapter 6, Environmental Hazards, of the General Plan. The relevant goal and policies are listed in Table 4.5-1.

### *San Leandro Municipal Code*

#### Chapter 7-12, Grading, Excavations, and Fills

Chapter 7-12, Grading, Excavations, and Fills, of the City of San Leandro Municipal Code maintains a grading ordinance to mitigate hazards associated with erosion and land stability. The ordinance establishes criteria for permits and identifies grading plan submittal and construction requirements.

### *Clean Water Program*

The Alameda County Clean Water Program facilitates local compliance with the Federal Clean Water Act. The City of San Leandro participates in the program. The Program establishes Best Management Practices (BMP's) for erosion control during and after construction. BMP's related to erosion control address preservation of existing vegetation, streambank stabilization, slope drains, and earth dikes and drainage swales, to name a few.

An erosion and sedimentation control plan must be submitted with a grading permit application, along with a drainage plan and pollution control plan. These plans ensure that any runoff from a project site meets regional water quality standards.

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**TABLE 4.5-1 SAN LEANDRO GENERAL PLAN GOAL AND POLICIES**

Goal/Policy Number	Goal/Policy Text
<b>Chapter 6, Environmental Hazards</b>	
Goal 29	<b>Mitigation of Natural Hazards:</b> Reduce the potential for injury, property damage, and loss of life resulting from earthquakes, landslides, floods, and other natural disasters.
Policy 29.01	<b>Risk Management:</b> Minimize risks from geologic, seismic, and flood hazards by ensuring the appropriate location, site planning, and design of new development. The City’s development review process, and its engineering and building standards, should ensure that new construction is designed to minimize the potential for damage.
Policy 29.02	<b>Earthquake Retrofits:</b> Strongly encourage the retrofitting of existing structures to withstand earthquake ground shaking, and require retrofitting when such structures are substantially rehabilitated or remodeled.
Policy 29.04	<b>Code Revisions:</b> Revise and update construction codes and regulations to incorporate the latest available information and technology related to earthquake hazards.
Policy 29.05	<b>Public Awareness:</b> Promote greater public awareness of earthquake hazards, along with incentives and assistance to help property owners make their homes and businesses more earthquake-safe.

Source: San Leandro General Plan, 2002, Chapter 6, Environmental Hazards.

**4.5.1.2 EXISTING CONDITIONS**

*Geology and Soils*

Regional Geology

The Project site is in the northern portion of the Coast Ranges geomorphic province of California, which is characterized by northwest-trending mountain ranges and valleys that generally parallel the major geologic structures such as the San Andreas and Hayward faults. The oldest widespread rocks in the region are highly deformed sedimentary, metamorphic and volcanic rocks of the Franciscan Assemblage, which formed during the Mesozoic Era (225 to 65 million years ago). These rocks are in fault contact with similar age sedimentary rocks of the Mesozoic Great Valley Sequence. The Mesozoic rocks are, in turn, overlain by a diverse sequence of Cenozoic Era (younger than 65 million years) sedimentary and volcanic rocks. Since their deposition, the Mesozoic and Cenozoic rocks have been extensively deformed by repeated episodes of folding and faulting. The Bay Area experienced several episodes of uplift and faulting during late Tertiary Period (approximately 25 million to 2 million years ago), that produced the region’s characteristic northwest-trending mountain ranges and valleys, which include the eastern San Francisco Bay hills and San Francisco Bay.

Worldwide climate fluctuations during the Pleistocene age (approximately 1.8 million to 11,000 years ago) resulted in several distinct glacial periods. A lowering of sea level accompanied each glacial advance as water became stored in vast ice sheets. Melting of the continental glaciers during warm intervals caused corresponding rises in sea level. High sea levels favored rapid and widespread deposition in the bay and surrounding floodplains. Low sea levels during glacial advances steepened the gradients of streams and rivers draining to the sea, thereby encouraging erosional down-cutting. The most recent glacial interval ended approximately 11,000 years ago. Evidence suggests that during the maximum extent of this latest glaciation, sea level was approximately 300 to 400 feet below its present elevation and the valley now occupied by San Francisco Bay drained to the Pacific Ocean more than 30 miles west of the Golden Gate.

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Near the beginning of the Holocene age (approximately 11,000 years ago), the rising sea reentered the Golden Gate, and sediments accumulated rapidly beneath the rising San Francisco Bay and on the surrounding floodplains. Being geologically recent, these surface deposits are generally less dense, weaker, and more compressible than the deeper, well-consolidated Pleistocene-age soils that predate the last sea-level rise.

### Site Geology

The Project site lies along the eastern margin of San Francisco Bay on the low-lying coastal plain and adjacent filled portions of the bay. An 1878 topographic map of the area, shows that prior to fill placement the original coastline was located east of Monarch Bay Drive as illustrated on Figure 4.5-1.<sup>6</sup> The entire Project site is relatively low-lying with elevations ranging up to about 10 feet above mean sea level. Roughly, the western two-thirds of the project site, including the existing marina and the surrounding buildings, has been constructed by filling on the shallow margin of San Francisco Bay. Review of historic aerial photographs covering the time period from 1947 to 2012 indicate that some fill was placed periodically during the first half of the twentieth century. By 1947, a low levee had been constructed along the existing coastline. Some small structures were present at Mulford point at that time; however, the site was largely undeveloped. By 1959, the Marina Golf Course in the eastern portion of the site had been constructed. By the early 1960s, the existing marina fill had been placed and development began in the Marina area. By 1968, fill for the Marina Park to the south of the project site had been placed and the park was under construction.

The marina construction included dredging to increase water depth and provide access for boats. Dredging was performed in the marina area and in the channel that leads to San Francisco Bay. Additional dredging has been performed periodically to maintain boating access. Currently there are three maintained channels associated with the Marina: a main access channel leading from San Francisco Bay into the Marina; an auxiliary access channel along the southern side of the southern dike leading to the boat-launching ramp; and, an interior channel leading to the boat berthing area within the marina.

Dredging and filling plans for the marina indicate that the marina fill was constructed by first constructing a series of clamshell dredged dikes (rock dikes were specified at the tips of the western and northern dikes) around the perimeter of the areas to be filled and then filling the interior with either hydraulically placed fill and/or clamshell dredged material.<sup>7</sup> The fill was placed using both hydraulic and clamshell methods and consists of material derived from Bay Mud and the underlying alluvial sediments.

West of the original coastline, the fill was placed over soft estuarine deposits referred to as Bay Mud. Borings drilled as part of the marina dredging plan development indicate that within the project site the Bay Mud is relatively thin, ranging up to about 10 feet in thickness. The Bay Mud is underlain by older, better consolidated, alluvial and estuarine deposits of Pleistocene and Holocene age.

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<sup>6</sup> Thompson and West, 1878, "Map Number Three, Alameda County Farm Map", Oakland, California.

<sup>7</sup> Indenco Engineers, 1962, San Leandro Small Craft Harbor Stage II Dredging and Filling Plans, April 9.



**Explanation**

**Fill** Area Of Manmade Fill

**Alluvium** Clay, Silt and Sand Deposited By Streams

Source: Google Maps, 2014.

Figure 4.5-1  
 Historic Shoreline and Fill Areas

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Geotechnical investigations have been conducted for construction of various buildings and other improvements (proposed and existing) on the marina fill dikes.<sup>8</sup> Borings drilled for these improvements generally encountered 5 to 13 feet of fill underlain by 3 to 16 feet of Bay Mud, which was in turn underlain by older, firmer alluvial, and estuarine deposits.

East of the historic shoreline the project site is underlain by alluvial sediments. These sediments typically consist of interbedded clay and silt with some sand. Little or no Bay Mud is likely to be present in this area.

### Liquefaction

Liquefaction is a phenomenon where loose, saturated, non-cohesive soils such as silts, sands, and gravels undergo a sudden loss of strength during earthquake shaking. The test borings performed at the site for previous developments encountered potentially liquefiable sands and silts within the alluvial sediments and in the dredged fill created from the alluvial sediments. These materials are intermixed with clays that would not normally be subject to liquefaction.

### *Regional Faulting, Seismicity, and Seismic Hazards*

#### Regional Faulting and Seismicity

Seismic activity within the Coast Ranges is generally associated with active faults of the San Andreas system, which includes major active faults both east and west of the site, as shown in Figure 4.5-2. Over the width of the San Francisco Bay Region, approximately 1.5 inches/year of relative horizontal movement occurs between the North American and Pacific Plates<sup>9</sup>. This movement is partially accommodated by creep and earthquakes occurring along active faults. The approximate distances and directions to major active Bay Area faults are summarized in Table 4.5-2.

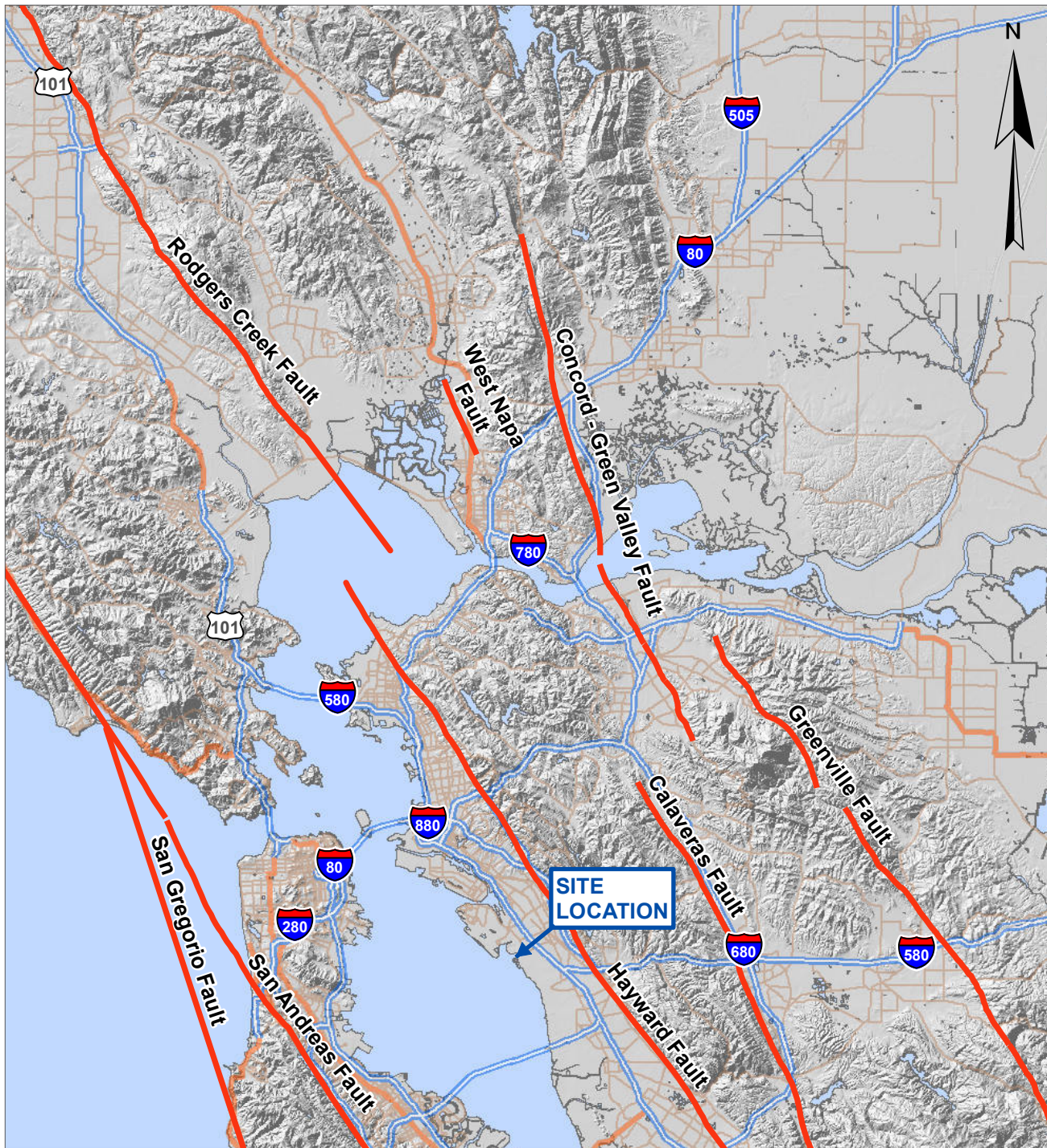
As indicated in the above table, the active fault nearest the site is the Hayward fault, which is located approximately 3.8 miles northeast of the east end of Project site. The Hayward fault is a northwest-trending zone approximately 51 miles long, which extends from southeastern San Jose, through the East Bay communities, into San Pablo Bay. Beneath San Pablo Bay, faulting generally steps right (east) to the Rodgers Creek fault. To the south, the Hayward fault merges with the Calaveras fault.

Although the City of San Leandro is listed as an area affected by the Alquist-Priolo Fault Zones, the Project site is not in one of the Alquist-Priolo Earthquake Fault Zones. The closest such zone is along the Hayward Fault approximately 3.8 miles northeast of the Project site.

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<sup>8</sup> Harding Lawson Associates, 1977, Geotechnical Investigation For Horatio's Restaurant; Gribaldo Jones & Associates, 1969, Geotechnical Investigation For Tia Maria Restaurant; Woodward, Clyde, Sherard & Associates, 1965 & 1972, Geotechnical Investigations for Marina (Blue Dolphin) Restaurant; Earth Systems Consultants, 1984, Geotechnical Investigation For Launch Ramp Restaurant, Geotechnical Investigation for Marina Launch Ramp, Treadwell and Rollo, 2005.

<sup>9</sup> Working Group on California Earthquake Probabilities (WGCEP), 2008, "The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2): 2007 – 2036. U. S. Geological Survey Open File Report 2007-1437.



Source: Alan Kropp & Associates.

— "Active" Regional Faults (Surface Displacement within the Last 11,000 years)



Sources: 1) The California Geological Survey, 2001, CD's 2001-04, 2001-05, and 2001-06: GIS Files of Official Alquist-Priolo Earthquake Fault Zones ([http://www.consrv.ca.gov/CGS/geologic\\_hazards/regulatory\\_hazard\\_zones/ap\\_cd\\_html.htm](http://www.consrv.ca.gov/CGS/geologic_hazards/regulatory_hazard_zones/ap_cd_html.htm)).  
 2) Jennings, 2010, "Fault Activity Map of California and Adjacent Areas," CDMG, Geologic Data Map No. 6.  
 3) California Division of Mines and Geology, 1997, "Maps of Known Active Fault Near-Source Zones in California and Adjacent Portions of Nevada."  
 4) Background data: USGS 10m DEM.

Figure 4.5-2  
**Regional Fault Map**

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**TABLE 4.5-2 APPROXIMATE ACTIVE FAULT DISTANCES AND DIRECTIONS**

<b>Active Fault</b>	<b>Approximate Distance from Project Site (Miles)</b>	<b>Approximate Direction from Project Site</b>
Hayward	3.8	Northeast
Calaveras	12.0	Northeast
San Andreas	14.5	Southwest
Concord-Green Valley	19.0	North-Northeast
San Gregorio	22.0	Southwest
Rodgers Creek	30.0	North-Northwest

Source: Allan Kropp & Associates, 2014.

Several large earthquakes have occurred throughout the region during historic times. These included several earthquakes on the Hayward fault as well as earthquakes on the San Andreas and Calaveras faults. Commonly, historic earthquakes are characterized in terms of Local Magnitude ( $M_L$ ), which has also come to be known as Richter Magnitude ( $M$ ). A brief summary of information on historic earthquakes in the area is given below.

Three earthquakes larger than  $M$  6.0 are thought to have occurred on the Hayward fault during historical time.<sup>10</sup> On October 21, 1868, an earthquake of approximately  $M$  6.8 occurred on the southern segment of the Hayward fault. This earthquake reportedly produced surface ground rupture from Oakland to the Warm Springs district of Fremont, a length of approximately 30 miles. The other two earthquakes occurred in 1858 ( $M$  6.1) and 1911 ( $M$  6.6). Both of these earthquakes were also centered in the southern portion of the Hayward fault.<sup>11</sup>

The largest historical earthquake in the Bay Area occurred on the San Andreas fault near San Francisco in 1906. That earthquake, of  $M$  8.3, caused widespread damage throughout the region. More recent earthquakes in the region include the October 17, 1989, Loma Prieta earthquake on the San Andreas fault ( $M$  7.1); the Hollister, Coyote Lake, and Morgan Hill earthquakes of 1974, 1979, and 1984, on the Calaveras fault, ( $M$  5.2,  $M$  5.9, and  $M$  6.2, respectively); the 1957 Daly City earthquake on the San Andreas fault ( $M$  5.3); two Santa Rosa earthquakes of 1969 on the Rodgers Creek fault ( $M$  5.6 and  $M$  5.7); and the South Napa earthquake in August 2014 ( $M$  6.0).

<sup>10</sup> Topozada, Tousson R., and David L. Parke, 1982. Area Damaged by the 1868 Hayward Earthquake and Recurrence of Damaging Earthquakes near Hayward, California Department of Conservation, Division of Mines and Geology Special Publication 62.

<sup>11</sup> Topozada, Tousson R., Charles R. Real, and David L. Parke, 1981. Preparation of Iseismal Maps and Summaries of Reported Effects for Pre-1900 California Earthquakes: California Department of Conservation, Division of Mines and Geology Open-File Report 81-11.



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The most recent significant earthquake in the area was the Loma Pieta earthquake of October 17, 1989. This earthquake had a magnitude of 7.1 and was centered approximately 49 miles southeast of San Leandro. Strong ground shaking occurred in the San Leandro area and property damage in the area was light to moderate.

In 2008, The Working Group on California Earthquake Probabilities (WGCEP), in conjunction with the United States Geological Survey (USGS), published an updated report evaluating the probabilities of significant earthquakes occurring in the Bay Area over the next three decades.<sup>12</sup> The WGCEP report indicates that there is a 0.63 (63 percent) probability that at least one magnitude 6.7 or greater earthquake will occur in the San Francisco Bay region before 2036. This probability is an aggregate value that considers seven principal Bay Area fault systems and unknown faults (background values). The findings of the WGCEP report are summarized in Table 4.5-3.

**TABLE 4.5-3 EARTHQUAKE PROBABILITY**

<b>Fault System</b>	<b>Probability of at Least One Magnitude 6.7 or Greater Earthquake in 2007-2036</b>
Hayward – Rodgers Creek	0.31
Calaveras	0.07
San Andreas	0.21
Concord-Green Valley	0.03
San Gregorio	0.06
Greenville	0.03
Mount Diablo Thrust	0.01
Background	0.14

Source: Working Group on California Earthquake Probabilities (WGCEP), 2008, The Uniform California Rupture Forecast, Version 2 (UCERF 2): 2007-2036. U.S. Geological Survey Open File Report 2007-1437.

The WGCEP report indicates that between 2007 and 2036 there is a 14 percent chance that an earthquake with a magnitude of greater than 6.7 may occur in the Bay Area on a fault system not characterized in the study.

### 4.5.2 STANDARDS OF SIGNIFICANCE

The Project would result in a significant geology, soils, and seismicity impact if it would:

1. Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

<sup>12</sup> Working Group on California Earthquake Probabilities (WGCEP), 2008. "The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2): 2007 – 2036. U. S. Geological Survey Open File Report 2007-1437.

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- Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. Refer to Division of Mines and Geology Special Publication 42.
  - Strong seismic ground shaking.
  - Seismic-related ground failure, including liquefaction.
  - Landslides.
2. Result in substantial soil erosion or the loss of topsoil.
  3. Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.
  4. Be located on expansive soil, as defined in Table 18-1-b of the Uniform Building Code (1994), creating substantial risks to life or property.
  5. 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.

### 4.5.3 IMPACT DISCUSSION

This section analyzes potential project-specific and cumulative impacts to geology and soils.

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<b>GEO-1</b>	<b>The Project could expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving strong seismic ground shaking; seismic-related ground failure; including liquefaction and lateral spreading.</b>
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Large earthquakes could generate strong to violent ground shaking at the Project site and could cause damage to structures and threaten public safety. San Leandro lies within a seismically active region that includes much of western California. Several active faults are present in the region, including the Hayward, Calaveras, and San Andreas faults. These faults are capable of generating large earthquakes that could produce strong to violent ground shaking at the Project site. WGCEP has estimated that there is a 63 percent chance of a large earthquake (magnitude 7 or greater) in the Bay Area by the year 2036.<sup>13</sup> At present, it is not possible to predict precisely when or where earthquakes will occur on these faults.

During an earthquake, seismic risk to a structure would depend on the distance to the earthquake epicenter, the characteristics of the earthquake, the subsurface conditions underlying the structure and its immediate vicinity, and the characteristics of the structure. The Project site is located on relatively thick, alluvial deposits that could cause amplification of ground shaking. In addition, a thin layer of soft Bay Mud overlies the alluvium in the western portion of the Project site and could increase the shaking

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<sup>13</sup> Working Group on California Earthquake Probabilities (WGCEP), 2008. "The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2): for 2007-2036," U.S. Geological Survey Open File Report 2007-1437; CGS Special Report 203; and SCEC Contribution #1138..

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amplification. This is considered a *significant* impact. Impacts and related mitigations for potential liquefaction hazards are addressed in Impact GEO-3.

The Project site is flat; there is no potential for landslide impacts.

**Impact GEO-1:** The Project could expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving strong seismic ground shaking, seismic-related ground failure, including liquefaction and lateral spreading.

**Mitigation Measure GEO-1:** Require geotechnical reports for all development within the Project site, as required by the San Leandro Municipal Code Section 7-12. The geotechnical reports shall consider the potential earthquake related impacts of strong ground shaking amplification due to the soft underlying sediments, as identified in this DEIR. Seismic ground motion parameters shall be provided in the geotechnical reports in accordance with CBC requirements. The building plans shall incorporate all design and construction criteria specified in the report(s). The geotechnical engineer shall sign the improvement plans and approve them as conforming to their recommendations prior to issuance of building permits. The geotechnical engineer shall also assume responsibility for inspection of the work and shall certify to the City, prior to acceptance of the work that the work performed is adequate and complies with its recommendations. The geotechnical engineer of record shall prepare letters and as-built documents to document their observances during construction and to document that the work performed is in accordance with the project plans and specifications. As required by the City of San Leandro, all construction activities shall meet the CBC regulations for seismic safety (i.e. reinforcing perimeter and/or load bearing walls, bracing parapets, etc.).<sup>14</sup> In addition, all project-related grading, trenching, backfilling and compaction operations shall be conducted in accordance with the City of San Leandro Engineering Department's Standard Plans. All improvements shall conform to regulations for seismic safety contained in the CBC.

**Significance After Mitigation:** Less than significant.

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### GEO-2      The Project could result in substantial soil erosion or the loss of topsoil.

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#### Soil Erosion or Loss of Topsoil

Proper drainage and control of runoff is important in controlling erosion and flooding both during and after construction. Surface drainage ditches and storm drains must be regularly maintained to continue functioning as designed. In addition, proper drainage and erosion control during grading is necessary to

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<sup>14</sup> Seismic design provisions of the CBC generally prescribe minimum lateral forces, applied statistically to the structure and combined with the gravity forces of dead and live loads. The CBC-prescribed lateral forces generally are substantially smaller than the expected peak forces that would be associated with a major earthquake. Therefore, when built according to CBC standards, structures are anticipated to (1) resist minor earthquakes without damage; (2) resist moderate earthquakes without structural damage but with some nonstructural damage; and (3) resist major earthquakes without collapse but with some structural as well as nonstructural damage. Conformance to the current building code standards does not guarantee that significant structural damage will not occur in the event of a maximum magnitude earthquake; but it is reasonable to expect that a well-designed and well-constructed structure would not collapse or cause loss of life in a major earthquake.

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control erosion. Typically, erosion impacts are greatest in the first two years after construction, the time generally required to reestablish a good vegetation cover on areas of disturbed soil.

### Coastal Erosion

The San Leandro shoreline is exposed to wave attack. The coastline within the vicinity of the Project site is armored with rip-rap to control erosion. No areas of significant coastal erosion were observed within the Project site. The existing erosion protection may require periodic maintenance to maintain effective erosion control.

**Impact GEO-2:** The Project could result in substantial soil erosion or the loss of topsoil.

**Mitigation Measure GEO-2A:** The Project civil engineer shall prepare an erosion control plan. The erosion control plan shall be submitted to the City as a part of building and/or grading plan submittal. The erosion control plan shall conform to the guidelines of the Clean Water Program and Utilize BMP's detailed under section "C6 CASQA - BMPs Erosion Control" of the Program Resources.

**Mitigation Measure GEO-2B:** The existing rip-rap providing coastal erosion protection shall be periodically refurbished to maintain effective erosion control. This may include local replacement of rip-rap boulders as well as periodic re-building of rip-rap armament sections degraded by wave attack and/or long-term erosion.

**Significance After Mitigation:** Less than significant.

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<b>GEO-3</b>	<b>The Project could result in a significant impact related to development on unstable geologic units and soils or result in lateral spreading, subsidence, liquefaction, or collapse.</b>
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### Liquefaction

Given the Project site is located in a seismically active region, future earthquakes are likely during the life of the Project and the risk of liquefaction could be significant.

Potential liquefaction at the Project site would likely be settlement of the ground surface and the localized expulsion of sand and water onto the ground surface (i.e., sand boils). Liquefaction could also result in excessive settlement of improperly designed foundations and possibly lateral spreading (the lateral spreading hazard to be discussed in subsequent section). Depending on the amount of ground or foundation settlement, damage to the planned buildings could be moderate. Other areas such as parking lots and landscape areas could also undergo settlement and ground deformation as a result of liquefaction. This is considered to be a *significant* impact.

**Impact GEO-3A:** The Project could result in a significant impact related to development on unstable geologic units and soils or result in lateral spreading, subsidence, liquefaction, or collapse.

**Mitigation Measure GEO-3A:** Project-specific geotechnical reports shall be prepared in accordance with the City's grading permit regulations. The recommendations for both special foundations and

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other geotechnical engineering measures specified in project specific geotechnical reports shall be implemented during design and construction. These measures include use of deep foundations engineering and removal or improvement of potentially liquefiable soils. Documentation of the methods used shall be provided in the required design-level geotechnical report(s).

**Significance After Mitigation:** Less than significant.

### Lateral Spreading

Lateral spreading is a phenomenon in which relatively flat land areas undergo sudden lateral movement generally toward a slope or channel margin during an earthquake. Lateral spreading occurs most frequently where there is laterally continuous liquefiable layer or layers present extending to or near a slope. Within the Project site lateral spreading could be a risk along the channel margins created by the dredged channels both inside and outside of the marina and adjacent fill dikes. This is considered to be a *significant* impact.

**Impact GEO-3B:** The Project could result in a significant impact related to development on unstable geologic units and soils or result in lateral spreading.

**Mitigation Measure GEO-3B:** The potential for lateral spreading shall be evaluated as a part of the required geotechnical reports. Where necessary, corrective measures shall be included in the required design-level geotechnical report(s) and implemented during construction. These measures could include retaining structures to stabilize channel margins, use of deep foundations, removal or improvement of liquefiable soils, and/or the use of relatively rigid foundations.

**Significance After Mitigation:** Less than significant.

### Settlement (Subsidence, Collapse)

Settlement, also referred to as subsidence and/or collapse, is a process in which compressible soils undergo a reduction in volume in response to an increase in pressure. This pressure can be the result of the addition of soil material or structures. Soils most susceptible to settlement are soft, saturated clays and silts such as the Bay Mud dredged fill materials that underlies the area west of the original shoreline. The existing fills were placed more than 50 years ago by placing soil and rock material over the underlying Bay Mud. Since that time the Bay Mud and fill has consolidated under the load exerted by the existing fills and it is likely that the potential for additional settlement under existing conditions is low. However, the Project would include construction of new structures, which would place a load on their foundations and the underlying materials as well as potentially the placement of some new fill. For buildings constructed with shallow foundations such as slabs or spread footings, the new load would be applied directly to the existing fill materials. Larger buildings would likely be constructed using deep foundations such as driven piles, which apply the load to the alluvial materials beneath the Bay Mud, which are firmer and less prone to settlement. If not properly engineered, buildings could undergo excessive settlement. Parking areas, underground utilities and/or other non-building improvements could also be impacted by new fill placement. This is considered to be a *significant* impact.

**Impact GEO-3C:** The Project could result in a significant impact related to development on unstable geologic units and soils or result in subsidence or collapse.

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**Mitigation Measure GEO-3C:** Settlement of the existing fill and Bay Mud could have adverse effects on shallow foundations, underground utilities, pavements, and other improvements. Options to mitigate these effects include use of shallow ridged foundations for smaller structures, supporting larger structures with deep foundations such as driven piles, and installing flexible connections for utilities. Pre-loading consolidation (surcharging) prior to construction of new improvements could also be considered. The recommendations for both special foundations and other geotechnical engineering measures specified in project specific geotechnical reports shall be implemented during design and construction.

**Significance After Mitigation:** Less than significant.

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<b>GEO-4</b>	<b>The Project could create substantial risks to property as a result of its location on expansive soil, as defined by Section 1803.5.3 of the California Building Code.</b>
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### Expansive Soils

The fill and native soils that cover the Project site east of the historic shoreline are moderately to highly expansive. Expansive soils undergo a significant volume change as a result of wetting or drying. This volume change could cause damage to improperly designed foundations and pavements. Where buildings are constructed in areas containing expansive soils this impact can be effectively mitigated through use of appropriate foundations, by capping expansive soils with a layer of non-expansive fill, or by lime treatment. Typical mitigation measures for pavements include special pavement design, lime treatment of subgrade soils and/or sub-excavation of expansive soils and replacement with non-expansive fill. This is considered to be a *significant* impact.

**Impact GEO-4:** The Project could create substantial risks to property as a result of its location on expansive soil, as defined by Section 1803.5.3 of the California Building Code.

**Mitigation Measure GEO-4:** The Project geotechnical engineer shall make specific recommendations for mitigation of expansive soils under pavements and structures, including techniques such as capping expansive soils with a layer of non-expansive fill, or by lime treatment. Typical mitigation measures for pavements could include special pavement design, lime treatment of subgrade soils and/or sub-excavation of expansive soils and replacement with non-expansive fill. These recommendations shall be based on testing of the in-site fill materials. The recommendations shall be submitted to the City as a part of building and/or paving plan submittal.

**Significance After Mitigation:** Less than significant.

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<b>GEO-5</b>	<b>The Project would not 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.</b>
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Development at the Project site would not require the use of septic tanks or alternative wastewater disposal systems. Wastewater will be discharged into the existing public sanitary sewer system, which is

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serviced by the City of San Leandro, that provides wastewater collection and treatment services to the City's residents. Wastewater is eventually conveyed to the City's Water Pollution Control Plant located at 3000 Davis Street, San Leandro. As such, there would be *no impact* from implementation of the Project where soils might otherwise not be capable of supporting the use of septic tanks or alternative wastewater disposal systems.

**Significance Before Mitigation:** No impact.

### 4.5.4 CUMULATIVE IMPACTS

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**GEO-6            The Project, in combination with past, present, and reasonably foreseeable projects, would result in less than significant cumulative impacts with respect to geology and soils.**

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The following cumulative analysis considers the Project site in the context of the City of San Leandro as well as other past, present, and foreseeable projects in the vicinity. The City of San Leandro is largely built out. However, as remaining development proceeds within the City, the number of structures that may be subject to risks from geologic and seismic hazards is likely to increase. All new development in the City of San Leandro would be subject to CBC requirements, as well as the requirements embedded in the City's building permit process (e.g., requirement for geotechnical reports prior to grading permit, as required by Municipal Code Section 7-12). Compliance with CBC requirements, and the requirements of the Clean Water Program for erosion-control BMPs, along with compliance with the City's Municipal Code Chapter 7-12, as described in the Regulatory Framework of this draft EIR, would result in a *less than significant* cumulative impacts associated with soil erosion, loss of topsoil, and development-related impacts that pertain to seismically induced ground-shaking, liquefaction, and expansive soils.

Given the distance of known active faults from the Project site, the risk of primary fault rupture is judged to be low. Although the Project could be located on an unstable geologic unit(s) its development would not contribute to an associated cumulative impact given the site-specific nature of impacts related to geology and soils. The cumulative impacts associated with implementation of the Project, together with other past, present, and reasonably foreseeable projects in the surrounding area, would therefore result in a *less-than-significant* cumulative impact with respect to geology and soils.

**Applicable Regulations:**

- San Leandro General Plan
- San Leandro Municipal Code

**Significance Before Mitigation:** Less than significant.

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