4.5 Geology and Soils

This section presents geologic, soils and seismic conditions in the Inner Harbor Specific Plan Area and evaluates the potential for the development under the Specific Plan to result in significant impacts related to exposing people or structures to unfavorable geologic hazards, soils, and/or seismic conditions. A review of the applicable regulatory framework for the Specific Plan implementation is also provided. Potential impacts are discussed and evaluated, and appropriate mitigation measures are identified where necessary. A number of site-specific reports for sites in proximity to and within the Specific Plan Area were used to compile the description of existing conditions in the Plan Area. This section also presents a project-level analysis of the Harbor View project, which is based on a site-specific reports prepared for that project site.

CEQA requires the analysis of potential adverse effects of a project on the environment. While potential effects of the environment on the project are arguably not required to be analyzed or mitigated under CEQA, this section nevertheless analyzes potential effects of the geology and soils on the Specific Plan implementation as set forth in CEQA Guidelines, Appendix G, Significance Criteria, and in order to provide information to the public and decision-makers. As such, the potential adverse effect of existing risk levels for expansive soils or landslides on proposed project residents is analyzed below.

4.5.1 Environmental Setting

Regional Setting

The Plan Area lies within the geologically complex region of California referred to as the Coast Ranges geomorphic province.[1] The Coast Ranges province lies between the Pacific Ocean and the Great Valley (Sacramento and San Joaquin valleys) provinces and stretches from the Oregon border to the Santa Ynez Mountains near Santa Barbara. Much of the Coast Range province is composed of marine sedimentary deposits and volcanic rocks that form northwest trending mountain ridges and valleys, running subparallel to the San Andreas Fault Zone. The relatively thick marine sediments dip east beneath the alluvium of the Great Valley. The Coast Ranges can be further divided into the northern and southern ranges, which are separated by the San Francisco Bay. The San Francisco Bay lies within a broad depression created from an east-west expansion between the San Andreas and the Hayward fault systems. West of the San Andreas Fault lies the Salinian Block, a granitic core that extends from the southern end of the province to north of the Farallon Islands.

The Northern Coast Ranges are comprised largely of the Franciscan Complex or Assemblage, which consists primarily of graywacke, shale, greenstone (altered volcanic rocks), basalt, chert (ancient silica-rich ocean deposits), and sandstone that originated as ancient sea floor sediments.

[1] A geomorphic province is an area that possesses similar bedrock, structure, history, and age. California has 11 geomorphic provinces.

Franciscan rocks are overlain by volcanic cones and flows of the Quien Sabe, Sonoma and Clear Lake volcanic fields (CGS, 2002a).

Project Setting

Geology and Soils

Review of geotechnical reports previously prepared for the Plan Area and nearby development shows the soils to consist of alluvial deposits overlain by a soft to very stiff marine clay deposit, locally known as “Bay Mud”. The reports record the depths of these soils from approximately 5 to 11 feet with groundwater found from approximately 3 to 12 feet. Bay Mud is considered to be a highly compressible material resulting in differential settlements. This differential settlement impacts proposed structure and infrastructure design as well as construction practices.

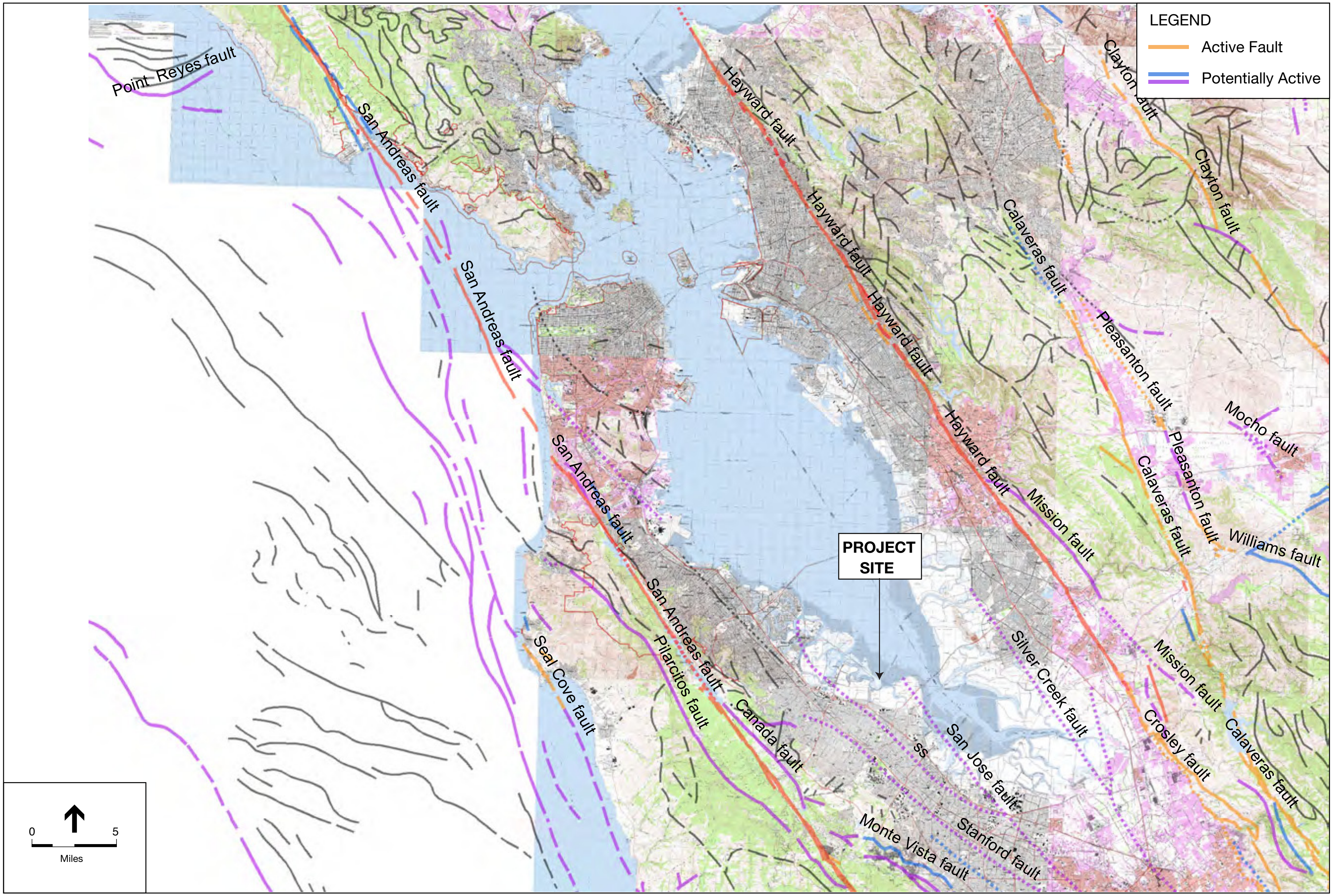
Structural loads are generally too great for the Bay Mud to support with conventional foundations. Instead, support systems comprised of driven piles is commonly recommended. Settlement across this compressible material is dependent upon the thickness of Bay Mud in conjunction with the thickness of fill at any given location. To minimize settlement in areas receiving fill a surcharge program is often utilized. Surcharging consists of placing excess fill in areas where settlement is a concern and leaving it in place a sufficient amount of time to partially pre-consolidate the material. Gravity utilities constructed in areas of Bay Mud are designed to avoid grade reversal, joint separation, and leakage. Flexible connections are used when utilities enter a building or other structure. Construction activities in areas of Bay Mud usually require the use of light grading equipment.

Corrosivity tests show the Bay Mud to be moderately corrosive to concrete and metals. Corrosivity will impact the types of underground materials and connections specified for infrastructure systems (this concern is addressed by the City’s Building Code). (Fusco, 2014)

Faults and Seismicity

The Specific Plan Area lies within a region of California that contains many active and potentially active faults and is considered an area of high seismic activity, as shown in **Figure 4.5-1**and described in **Table 4.5-1.**[2] The U.S. Geological Survey (USGS) along with the California Geological Survey and the Southern California Earthquake Center formed the

2 An “active” fault is defined by the State of California as a fault that has had surface displacement within Holocene time (approximately the last 11,000 years). A “potentially active” fault is defined as a fault that has shown evidence of surface displacement during the Quaternary (last 1.6 million years), unless direct geologic evidence demonstrates inactivity for all of the Holocene or longer. This definition does not, of course, mean that faults lacking evidence of surface displacement are necessarily inactive. “Sufficiently active” is also used to describe a fault if there is some evidence that Holocene displacement occurred on one or more of its segments or branches (Hart, 20072007).



SOURCE: Jennings, 2010

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Figure 4.5-1
Regional Fault Map

TABLE 4.5-1
ACTIVE FAULTS IN THE PROJECT SITE VICINITY

Fault	Distance and Direction from Project	Recency of Movement	Fault Classification[a]	Historical Seismicity[b]	Maximum Moment Magnitude Earthquake (Mw)[c]
San Andreas	4 miles southwest	Historic (1906; 1989 ruptures)	Active	M 7.1, 1989 M 8.25, 1906 M 7.0, 1838 Many <M 6	7.9
Hayward	15 miles northeast	Historic (1868 rupture)	Active	M 6.8, 1868 Many <M 4.5	7.1
San Gregorio	20 miles southwest	Prehistoric (Sometime prior to 1775 but after 1270 A.D.)	Active	n/a	7.3
Calaveras	22 miles east	Historic (1861 1911, 1984)	Active	M 5.6–M 6.4,1861 M 6.2, 1911, 1984	6.8
Concord–Green Valley	30 miles northeast	Historic (1955)	Active	Historic active creep	6.7
Marsh Creek–Greenville	32 miles northeast	Historic (1980 rupture)	Active	M 5.6 1980	6.9
Rodgers Creek	40 miles north	Historic	Active	M 6.7, 1898 M 5.6, 5.7, 1969	7.0

[a] See footnote 2
[b] Richter magnitude (M) and year for recent and/or large events. The Richter magnitude scale reflects the maximum amplitude of a particular type of seismic wave.
[c] Moment Magnitude (Mw) is related to the physical size of a fault rupture and movement across a fault. Moment magnitude provides a physically meaningful measure of the size of a faulting event (CGS, 2002b). The Maximum Moment Magnitude Earthquake, derived from the joint CGS/USGS Probabilistic Seismic Hazard Assessment for the State of California, 1996. (Peterson, 1996).

SOURCES: Hart, 20072007; Jennings, 20102010; Peterson, 1996; USGS, 2003.

Working Group on California Earthquake Probabilities which has evaluated the probability of one or more earthquakes of magnitude 6.7 or higher occurring in the state of California over the next 30 years beginning in 2014. The result of the most recent evaluation known as the Uniform California Earthquake Rupture Forecast (UCERF3) indicated a 72 percent likelihood that such an earthquake event will occur in the Bay Area region (USGS, 2015).

Richter magnitude is a measure of the size of an earthquake as recorded by a seismograph, a standard instrument that records groundshaking at the location of the instrument. The reported Richter magnitude for an earthquake represents the highest amplitude measured by the seismograph at a distance of 100 kilometers from the epicenter. Richter magnitudes vary logarithmically with each whole number step representing a tenfold increase in the amplitude of the recorded seismic waves. Earthquake magnitudes are also measured by their Moment Magnitude (Mw) which is related to the physical characteristics of a fault including the rigidity of the rock, the size of fault rupture, and movement or displacement across a fault (CGS, 2002b).

Ground movement during an earthquake can vary depending on the overall magnitude, distance to the fault, focus of earthquake energy, and type of geologic material. The composition of underlying soils, even those relatively distant from faults, can intensify ground shaking. For this reason, earthquake intensities are also measured in terms of their observed effects at a given locality. The Modified Mercalli (MM) intensity scale in **Table 4.5-2** is commonly used to measure earthquake damage due to ground shaking. The MM values for intensity range from I (earthquake not felt) to XII (damage nearly total), and intensities ranging from IV to X could cause moderate to significant structural damage.[3] The intensities of an earthquake will vary over the region of a fault and generally decrease with distance from the epicenter of the earthquake.

The Northern San Andreas, Hayward and Calaveras Faults pose the greatest threat of significant damage in the Bay Area according to the USGS Working Group (USGS, 2015). These three faults exhibit strike-slip orientation and have experienced movement within the last 150 years.[4] Other principal faults capable of producing significant ground shaking in the Bay Area are listed on Table 4.5-1 and include the Concord–Green Valley, Marsh Creek–Greenville, San Gregorio and Rodgers Creek Faults.

An "active" fault is defined by the State of California as a fault that has had surface displacement within approximately the last 11,000 years. A "potentially active" fault is defined as a fault that has shown evidence of surface displacement during the last 1.6 million years, unless direct geologic evidence demonstrates inactivity for the last 11,000 years or longer. This definition does not, of course, mean that faults lacking evidence of surface displacement are necessarily inactive. "Sufficiently active" is also used to describe a fault if there is some evidence that displacement occurred in the last 11,000 years on one or more of its segments or branches. These faults are considered either active or potentially active. Inactive faults are located throughout the Bay Area. Inactive faults with a long period of inactivity do not provide any guarantee that a considerable seismic event could occur. Occasionally, faults classified as inactive can exhibit secondary movement during a major event on another active fault. However, as in the case of the Palo Alto fault which is mapped as a concealed fault relatively close to the plan area, it is not zoned as requiring further study by the State of California (Engeo, 2012).

3 The damage level represents the estimated overall level of damage that will occur for various MM intensity levels. The damage, however, will not be uniform. Not all buildings perform identically in an earthquake. The age, material, type, method of construction, size, and shape of a building all affect its performance.

4 A strike-slip fault is a fault on which movement is parallel to the fault's strike or lateral expression at the surface.

TABLE 4.5-2
MODIFIED MERCALLI INTENSITY SCALE

Intensity Value	Intensity Description	Average Peak Acceleration (% g[a])
I	Not felt except by a very few persons under especially favorable circumstances.	< 0. 17 g
II	Felt only by a few persons at rest, especially on upper floors on buildings. Delicately suspended objects may swing.	0.17-1.4 g
III	Felt noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly, vibration similar to a passing truck. Duration estimated.	0.17-1.4 g
IV	During the day felt indoors by many, outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.	1.4–3.9g
V	Felt by nearly everyone, many awakened. Some dishes and windows broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles may be noticed. Pendulum clocks may stop.	3.5 – 9.2 g
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; and fallen plaster or damaged chimneys. Damage slight.	9.2 – 18 g
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.	18 – 34 g
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.	34 – 65 g
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.	65 – 124 g
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.	> 124 g
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.	> 124 g
XII	Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted. Objects are thrown upward into the air.	> 124 g

a g (gravity) = 980 centimeters per second squared. 1.0 g of acceleration is a rate of increase in speed equivalent to a car traveling 328 feet from rest in 4.5 seconds.

SOURCE: ABAG, 2003; CGS, 2003

San Andreas Fault

The San Andreas Fault Zone is a major structural feature that forms at the boundary between the North American and Pacific tectonic plates, extending from the Salton Sea in Southern California near the border with Mexico to north of Point Arena, where the fault trace extends out into the Pacific Ocean. The main trace of the San Andreas fault through the Bay Area trends northwest through the Santa Cruz Mountains and the eastern side of the San Francisco Peninsula. As the principal strike-slip boundary between the Pacific plate to the west and the North American plate to the east, the San Andreas is often a highly visible topographic feature, such as between Pacifica and San Mateo, where Crystal Springs Reservoir and San Andreas Lake clearly mark the rupture zone. Near San Francisco, the San Andreas fault trace is located immediately off-shore near Daly City and continues northwest through the Pacific Ocean approximately 6 miles due west of the Golden Gate Bridge.

In the San Francisco Bay Area, the San Andreas Fault Zone was the source of the two major seismic events in recent history that affected the San Francisco Bay region. The 1906 San Francisco earthquake was estimated at M 7.9 and resulted in approximately 290 miles of surface fault rupture, the longest of any known continental strike slip fault. Horizontal displacement along the fault approached 17 feet near the epicenter. The more recent 1989 Loma Prieta earthquake, with a magnitude of Mw 6.9, resulted in widespread damage throughout the Bay Area. (ABAG, 2003b).

Hayward Fault

The Hayward Fault Zone is the southern extension of a fracture zone that includes the Rodgers Creek Fault (north of San Pablo Bay), the Healdsburg fault (Sonoma County), and the Maacama fault (Mendocino County). The Hayward fault trends to the northwest within the East Bay, extending from San Pablo Bay in Richmond, 60 miles south to San Jose. The Hayward fault in San Jose converges with the Calaveras fault, a similar type fault that extends north to Suisun Bay. The Hayward fault is designated by the Alquist-Priolo Earthquake Fault Zoning Act as an active fault.

Historically, the Hayward fault generated one sizable earthquake in the 1800s.[5] In 1868, a Richter magnitude 7 earthquake on the southern segment of the Hayward Fault ruptured the ground for a distance of about 30 miles. Recent analysis of geodetic data indicates surface deformation may have extended as far north as Berkeley. Lateral ground surface displacement during these events was at least 3 feet.

A characteristic feature of the Hayward fault is its well-expressed and relatively consistent fault creep. Although large earthquakes on the Hayward fault have been rare since 1868, slow fault creep has continued to occur and has caused measurable offset. Fault creep on the East Bay segment of the Hayward fault is estimated at 9 millimeters per year (mm/yr) (Peterson, et al., 1996). However, a large earthquake could occur on the Hayward fault with an estimated moment magnitude (Mw) of about Mw 7.1 (Table 4.5-2). The USGS Working Group on California Earthquake Probabilities includes the Hayward–Rodgers Creek Fault Systems in the list of those faults that have the highest probability of generating earthquakes of magnitude (M) 6.7 or greater

5 Prior to the early 1990s, it was thought that a Richter magnitude 7 earthquake occurred on the northern section of the Hayward Fault in 1836. However, a study of historical documents by the California Geological Survey concluded that the 1836 earthquake was not on the Hayward Fault (Bryant, 2000).

in the Bay Area in the next 30 years beginning 2014 at a probability of 14.3 percent (USGS, 2005.

Calaveras Fault

The Calaveras fault is a major right-lateral strike-slip fault that has been active during the last 11,000 years. The Calaveras Fault is located in the eastern San Francisco Bay region and generally trends along the eastern side of the East Bay Hills, west of San Ramon Valley, and extends into the western Diablo Range, and eventually joins the San Andreas Fault Zone south of Hollister. The northern extent of the fault zone is somewhat conjectural and could be linked with the Concord Fault.

The fault separates rocks of different ages, with older rocks west of the fault and younger sedimentary rocks to the east. The location of the main, active fault trace is defined by youthful geomorphic features (linear scarps and troughs, right-laterally deflected drainage, sag ponds) and local groundwater barriers. The Calaveras fault is designated as an Alquist-Priolo Earthquake Hazard Zone. There is a distinct change in slip rate and fault behavior north and south of the vicinity of Calaveras Reservoir. North of Calaveras Reservoir, the fault is characterized by a relatively low slip rate of 5-6 mm/yr and sparse seismicity. South of Calaveras Reservoir, the fault zone is characterized by a higher rate of surface fault creep that has been evidenced in historic times. The Calaveras Fault has been the source of numerous moderate magnitude earthquakes and the probability of a large earthquake (greater than M6.7) hashas been estimated at 7.4 percent over the next 30 years (USGS, 2015). However, this fault is considered capable of generating earthquakes with upper bound magnitudes ranging from Mw magnitude 6.6 to magnitude 6.8.

Seismic Hazards

Surface Fault Rupture

Seismically induced ground rupture is defined as the physical displacement of surface deposits in response to an earthquake's seismic waves. The magnitude, sense, and nature of fault rupture can vary for different faults or even along different strands of the same fault. Ground rupture is considered more likely along active faults, which are referenced in Table 4.5-1.

The site is not within an Alquist-Priolo Fault Rupture Hazard Zone, as designated through the Alquist-Priolo Earthquake Fault Zoning Act, and no mapped active faults are known to pass through the immediate project region. Therefore, the risk of ground rupture at the site is very low.

Ground Shaking

Strong ground shaking from earthquakes generated by active faults in the Bay Area is a significant hazard to the Plan Area and could affect the project site during the next 30 years. During the life of the Project, the proposed improvements are likely to be subjected to at least one moderate to severe earthquake that would cause strong ground shaking.

The severity of ground shaking at the site resulting from a specific earthquake would depend on the characteristics of the generating fault, distance to the energy source, the magnitude of the event, and the site-specific geologic conditions. Earthquakes on the active faults (listed in Table 4.5-1) are expected to produce a range of ground shaking intensities at the project site. Ground shaking may affect areas hundreds of miles distant from the earthquake's epicenter. Historic earthquakes have caused strong ground shaking and damage in the San Francisco Bay Area, the most recent being the M 6.9 Loma Prieta earthquake in October 1989. The epicenter was approximately 50 miles south of the project site, but this earthquake nevertheless caused strong ground shaking for about 20 seconds and resulted in varying degrees of structural damage throughout the Bay Area.

Liquefaction

Liquefaction is the sudden temporary loss of shear strength in saturated, loose to medium-density granular sediments subjected to ground shaking. It generally occurs when seismically-induced ground shaking causes the pressure of the water between the granules to increase to a point equal to the pressure of the soil overburden. When this occurs, the soil can move like a fluid, hence the term liquefaction. Liquefaction can cause foundation failure of buildings and other facilities due to the reduction of foundation bearing strength. Lateral spreading is related to liquefaction and is characterized by the horizontal displacement of surficial blocks of sediments resulting from liquefaction in a subsurface layer that occurs on slopes ranging between 0.3 and 3 percent and can displace the surface by several feet up to tens of feet.

The potential for liquefaction depends on the duration and intensity of earthquake shaking, particle size distribution of the soil, density of the soil, and elevation of the groundwater. Areas at risk due to the effects of liquefaction are typified by a high groundwater table and underlying loose to medium-density granular sediments, particularly younger alluvium and artificial fill sediments and other reclaimed areas along the margin of San Francisco Bay. The project site is mapped within an area that has been identified as highly susceptible to liquefaction as identified by the State of California Seismic Hazard Zonation Program (Engeo, 2012). Maps prepared by the Associations of Bay Area Governments also indicate that the site has a very high potential for liquefaction. However, the geotechnical evaluation conducted for the San Mateo County Replacement Jail site concluded that placement of engineered fill for other purposes to raise site grades, could be thick enough to resist upward pressure from the relatively thin liquefiable lenses found onsite (Engeo, 2012). However, other geotechnical measures such as use of deep foundation systems or treatment of liquefiable soils are other viable solutions to overcome liquefaction hazards.

Differential Settlement

Earthquake shaking can produce compaction and densification of dry, uniformly graded, granular, and loose soil material. The amount of compaction across an area can vary due to differences in soil types, producing differential settlement. Artificial fill may also be susceptible to differential settlement. Differential settlement can affect existing and proposed foundations, slabs, and pavements. Given the geologic setting of the project area, this area could be subjected to earthquake-induced settlement.

Other Geologic Hazards

Expansive Soil

Expansive soils exhibit a “shrink-swell” behavior. Shrink-swell is the cyclic change in volume (expansion and contraction) that occurs in fine-grained clay sediments from the process of wetting and drying. Structural damage may result over an extended period of time, usually as the result of inadequate soil and foundation engineering or the placement of structures directly on expansive soils. Typically, soils that exhibit expansive characteristics comprise the upper five feet of the surface. The effects of expansive soils could damage foundations of above-ground structures, paved roads and streets, and concrete slabs. Expansion and contraction of soils, depending on the season and the amount of surface water infiltration, could exert enough pressure on structures to result in cracking, settlement, and uplift.

Settlement

Settlement can occur from immediate settlement, consolidation, shrinkage of expansive soil, and liquefaction (discussed below). Immediate settlement occurs when a load from a structure or placement of new fill material is applied, causing distortion in the underlying materials. This settlement occurs quickly and is typically complete after placement of the final load. Consolidation settlement occurs in saturated clay from the volume change caused by squeezing out water from the pore spaces. Consolidation occurs over a period of time and is followed by secondary compression, which is a continued change in void ratio under the continued application of the load.

Soils tend to settle at different rates and by varying amounts depending on the load weight or changes in properties over an area, which is referred to as differential settlement. The project site is underlain by poorly engineered artificial fill that varies in depth and thickness. Compressible Bay Mud and marsh deposits underlies the fill and is up to 50 feet thick.

Soil Erosion

Soil erosion is the process whereby soil materials are worn away and transported to another area either by wind or water. Rates of erosion can vary depending on the soil material and structure, soil placement, and human activity. Excessive soil erosion can eventually lead to damage of building foundations and other improvements. Erosion is most likely on sloped areas with exposed soil, especially when unnatural slopes are created by cut and fill activities. Soil erosion rates can therefore be higher during the construction phase. Typically, the soil erosion potential during construction is reduced by using modern construction practices; and once an area is graded and covered with concrete, structures, asphalt, or vegetation, the soil erosion potential is nearly eliminated.

Landslides

Landslides are dependent on the slope and geology of an area as well as the amount of rainfall, excavation, and seismic activity. A landslide or slope failure is a mass of rock, soil, and debris displaced downslope by sliding, flowing, or falling. Steep slopes and downslope creep of surface materials characterize landslide-susceptible areas Landslides can occur on slopes of 15 percent or less, however, the probability is greater on steeper slopes. The plan area is relatively flat and has a very low potential for slope failure.

4.5.2 Regulatory Setting

Federal Regulations

Earthquake Hazards Reduction Act

The Earthquake Hazards Reduction Act was enacted in 1997 to "reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards and reduction program." To accomplish this, the Act established the National Earthquake Hazards Reduction Program (NEHRP). This program was significantly amended in November 1990 to refine the description of agency responsibilities, program goals, and objectives.

NEHRP's mission includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improvement of building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improvement of mitigation capacity; and accelerated application of research results. The NEHRP designates the Federal Emergency Management Agency (FEMA) as the lead agency of the program and assigns it with several planning, coordinating, and reporting responsibilities. Programs under NEHRP help inform and guide planning and building code requirements such as emergency evacuation responsibilities and seismic code standards.

Occupational Safety and Health Administration (OSHA) Regulations

Excavation and trenching are among the most hazardous construction activities. OSHA's Excavation and Trenching standard, Title 29 of the Code of Federal Regulations (CFR), Part 1926.650, covers requirements for excavation and trenching operations. OSHA requires that all excavations in which employees could potentially be exposed to cave-ins be protected by sloping or benching the sides of the excavation, supporting the sides of the excavation, or placing a shield between the side of the excavation and the work area.

State Regulations

California Building Code

The California Building Code (CBC) has been codified in the California Code of Regulations (CCR) as Title 24, Part 2. Title 24 is administered by the California Building Standards Commission, which by law, is responsible for coordinating all building standards. Under State law, all building standards must be centralized in Title 24 or they are not enforceable. The purpose of the CBC is to establish minimum standards to safeguard the public health, safety, and general welfare through structural strength, means of egress facilities, and general stability by regulating and controlling the design, construction, quality of materials, use and occupancy, location, and maintenance of all building and structures within its jurisdiction. The 2013 CBC is based on the 2012 International Building Code (IBC) published by the International Code Conference. In addition, the CBC contains necessary California amendments, which are based on reference standards obtained from various technical committees and organizations such as the American Society of Civil Engineers (ASCE), the American Institute of Steel Construction (AISC), and the American Concrete Institute (ACI). ASCE Minimum Design Standards 7-05 provides requirements for general structural design and includes means for determining earthquake loads as well as other loads (e.g., flood, snow, wind, etc.) for inclusion into building codes. The provisions of the CBC apply to the construction, alteration, movement, replacement, and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures throughout California.

The earthquake design requirements take into account the occupancy category of the structure, site class, soil classifications, and various seismic coefficients, which are used to determine a Seismic Design Category (SDC) for a project as described in Chapter 16 of the CBC. The SDC is a classification system that combines the occupancy categories with the level of expected ground motions at the site and ranges from SDC A (very small seismic vulnerability) to SDC E (very high seismic vulnerability and near a major fault). Design specifications are then determined according to the SDC in accordance with Chapter 16 of the CBC. Chapter 16, Section 1613 provides earthquake loading specifications for every structure, and portion thereof, including nonstructural components that are permanently attached to structures and their supports and attachments, which shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE 7-05.

Chapter 18 of the CBC covers the requirements of geotechnical investigations (Section 1803), excavation, grading, and fills (Section 1804), load-bearing of soils (1805), as well as foundations (Section 1808), shallow foundations (Section 1809), and deep foundations (Section 1810). Chapter 18 also describes analysis of expansive soils and the determination of the depth to groundwater table. For Seismic Design Categories D, E, and F, Chapter 18 requires analysis of slope instability, liquefaction, and surface rupture attributable to faulting or lateral spreading, plus an evaluation of lateral pressures on basement and retaining walls, liquefaction and soil strength loss, and lateral movement or reduction in foundation soil-bearing capacity. It also addresses mitigation measures to be considered in structural design, which may include ground stabilization, selecting appropriate foundation type and depths, selecting appropriate structural systems to accommodate anticipated displacements, or any combination of these measures. The potential for liquefaction and soil strength loss must be evaluated for site-specific peak ground acceleration magnitudes and source characteristics consistent with the design earthquake ground motions.

Construction General Permit

The California Construction Storm Water Permit (Construction General Permit)[6], adopted by the State Water Resources Control Board (SWRCB), regulates construction activities that include

6 *General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities,* Order No. 2009-0009-DWQ, as amended by Order No. 2010-0014-DWQ, National Pollutant Discharge Elimination System No. CAS000002.

clearing, grading, and excavation resulting in soil disturbance of at least one acre of total land area. The Construction General Permit authorizes the discharge of storm water to surface waters from construction activities. It prohibits the discharge of materials other than storm water and authorized non-storm water discharges and all discharges that contain a hazardous substance in excess of reportable quantities established at 40 Code of Federal Regulations 117.3 or 40 Code of Federal Regulations 302.4, unless a separate NPDES Permit has been issued to regulate those discharges.

The Construction General Permit requires that all developers of land where construction activities will occur over more than one acre do the following:

- Complete a Risk Assessment to determine pollution prevention requirements pursuant to the three Risk Levels established in the General Permit;
- Eliminate or reduce non-storm water discharges to storm sewer systems and other waters of the Nation;
- Develop and implement a Storm Water Pollution Prevention Plan (SWPPP), which specifies best management practices (BMPs) that will reduce pollution in storm water discharges to the Best Available Technology Economically Achievable/Best Conventional Pollutant Control Technology standards; and
- Perform inspections and maintenance of all BMPs.

In order to obtain coverage under the NPDES Construction General Permit, the Legally Responsible Person must electronically file all permit registration documents with the SWRCB prior to the start of construction. Permit registration documents must include:

- Notice of Intent;
- Risk Assessment;
- Site Map;
- SWPPP;
- Annual Fee; and
- Signed Certification Statement.

Typical BMPs contained in SWPPPs are designed to minimize erosion during construction, stabilize construction areas, control sediment, control pollutants from construction materials, and address post construction runoff quantity (volume) and quality (treatment). The SWPPP must also include a discussion of the program to inspect and maintain all BMPs.

Local Regulations

Redwood City General Plan

The *Public Safety Element* of the Redwood City General Plan describes the following policies regarding geological resources, adopted for the purpose of avoiding or mitigating an environmental effect, and that apply to the Specific Plan and/or the Harbor View project. Policies listed below that are also considered land use policies are addressed in Section 4.9*, Land Use and Planning*, of this Draft EIR.

- Policy PS-6.1: Identify structural types, land uses, and sites that are highly sensitive to earthquake activity and other geological hazards, and seek to abate or modify them to achieve acceptable levels of risk, and
- Policy PS-6.3: Work to ensure that structures and the public in Redwood City are exposed to reduced risks from seismic and geological events.

4.5.3 Project Baseline

Baseline conditions reflect the setting in the Specific Plan Area as they existed at the time the Notice of Preparation for the Specific Plan was issued on November 6, 2014, as described above in the Environmental Setting. Information regarding site conditions is based on geotechnical investigations conducted as part of past projects within the Plan Area.

4.5.4 Significance Criteria

Based on California Environmental Quality Act (CEQA) Guidelines Appendix G, a project would cause adverse impacts related to geology and soils if it would:

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

    1. 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;
    2. Strong seismic ground shaking;
    3. Seismic-related ground failure, including liquefaction;
    4. Landslides;

b) Result in substantial soil erosion or the loss of topsoil;

c) 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;

d) 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; or

e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste disposal systems where sewers are not available for the disposal of wastewater.

f) Conflict with any applicable plan, policy, or regulation adopted by the City of Redwood City for the purpose of avoiding or mitigating an adverse geotechnical or soils impact.

Approach to Analysis

Inner Harbor Specific Plan

The analysis of the Specific Plan in this document is based on proposed planned development occurring anywhere within the Plan Area and pays particular attention to underlying site conditions as site specific conditions typically dictate the range and scope of geotechnical and seismic hazards that may be present.

Harbor View Project

The analysis of the Harbor View project in this document is based on the conditions that are likely present as estimated from nearby geotechnical investigations. Due to the project site's close proximity to the Bay shoreline, the proposed project would likely be faced with relatively similar conditions to the broader Plan Area and thus would not differ greatly from analysis used for the Specific Plan.

Cumulative

Regarding the assessment of cumulative impacts, a project's contribution to cumulative impacts to geology, soils, and seismicity should be considered significant if the project's contribution to past, present and future projects would combine to be significant.

Topics Considered and Determined No Impact

The following topics are considered to have no impact to the Inner Harbor Specific Plan or the Harbor View project based on the proposed project plan, its geographical location, and underlying conditions according to several geotechnical investigations that have occurred within the Plan Area. No impact discussion is provided for these topics for the following reasons:

- *Fault Rupture (Criteria a.1)*. The faults most susceptible to earthquake rupture are active faults, which are faults that have experienced surface displacement within the last 11,000 years. There are no active faults that cross the project area, and the nearest active fault to the project site is approximately 4 miles away. Therefore, the potential for fault rupture to affect the proposed project is very low and not discussed further.

- *Landslides (Criteria a.4)*. The project site does not contain slopes that are susceptible to landslides or slope failure. The relatively flat topography of the area makes the potential for landslides or slope failure at the site very low and is therefore not discussed further.

- *Wastewater Disposal (Criteria e)*. The project site is located within an urban area where all development would be able to tie into existing wastewater infrastructure. Therefore, none of the development or redevelopment would require the use of septic or other alternative disposal wastewater systems. Therefore no impact is associated with this hazard.

- *Conflict with Redwood City Plan, Policy, or Regulation (Criteria f)*. Implementation of the plan would not present any conflict with any applicable plan, policy, or regulation related to geotechnical or soils issue areas. Future development within the plan would require site specific geotechnical evaluation and seismic design to overcome the geotechnical hazards that are present, as further discussed below, but likely within industry standards commonly employed for similar locations located near the bay shoreline.

4.5.5 Program-Level Impacts of the Inner Harbor Specific Plan

Impacts

Impact GEO-1.SP: Development under the Specific Plan could expose people or structures to seismic hazards such as ground shaking and seismic-related ground failure such as liquefaction, differential settlement, collapse, or lateral spreading (Criteria a.2 and a.3). (Less than Significant)

The Plan Area is located in a seismically active region that contains a number of active faults. In 2013, estimates by the Working Group on Earthquake Probabilities indicated a 72 percent chance that a magnitude 6.7 or greater earthquake would occur in the Bay Area region over the following 30 years, beginning 2014 (USGS, 2015). If not designed appropriately, a 6.7 or greater magnitude earthquake on one of these regional active faults could produce significant groundshaking at the plan area causing damage to structures. The presence of artificial fill and soft compressible Bay Mud deposits in the Plan Area that likely includes liquefiable layers, indicates that the area is especially susceptible to seismic hazards.

Earthquakes are unavoidable hazards although the resultant damage can be minimized through appropriate seismic design and engineering. The City requires that all construction meet the latest standards of the California Building Code (CBC) for construction which considers proximity to potential seismic sources and the maximum anticipated groundshaking possible. The proposed construction associated with any future development in the Plan Area would be in accordance with applicable City ordinances and policies and consistent with the most recent version of the CBC, which requires structural design that can accommodate ground accelerations expected from known active faults. In addition, the investigations would be prepared by a California registered Geotechnical Engineer or Engineering Geologist and include "recommendations" for final design parameters for the walls, foundations, foundation slabs, and surrounding related improvements (utilities, roadways, parking lots and sidewalks). Project-specific Geotechnical investigations are required by law and while the design parameters are, in practice, referred to as recommended, they are required be incorporated into a project design specifications in order for the project to receive final approval of a building permit under the CBC. Compliance with these building safety design standards would reduce potential impacts associated with ground shaking to less than significant levels.

The presence of loose unconsolidated soils and shallow groundwater beneath proposed improvements could potentially be susceptible to liquefaction. Liquefaction at the site could result in loss of bearing pressure, lateral spreading, sand boils (liquefied soil exiting at the ground surface), and earthquake-induced settlement. Future earthquakes could potentially produce damaging effects at the site, if proposed improvements are not adequately designed.

According to mapping from the Seismic Hazard Zonation Program, the Plan Area is located in an area deemed highly susceptible to liquefaction hazards (CGS, 2015). A geotechnical investigation for the San Mateo County Replacement Jail site determined that the relatively thin liquefiable layers present at the site could be addressed through the placement of additional fill materials at the surface (Engeo, 2012) . However, other geotechnical approaches such as use of deep foundation systems or treatment of liquefiable soils could be viable in other areas where the potential for liquefaction is greater. Adherence to building code requirements and proven required geotechnical design measures would minimize the potential for liquefaction, differential settlement, lateral spreading or collapse through foundation design, treatment of site soils and/or replacement of liquefiable soils with engineered fills.

Therefore, with implementation of the seismic design requirements into construction specification in accordance with building code requirements discussed above, the impacts associated with the effects associated with ground shaking and seismic-related ground failure such as liquefaction, differential settlement, collapse, or lateral spreading would be reduced to less-than-significant levels.

Mitigation: None Required

Impact GEO-2.SP: Adoption and development under the Specific Plan could potentially cause soil erosion or loss of topsoil during construction and operation of development under the Specific Plan (Criterion b) (Less than Significant)

Construction activities associated with new development would involve earthwork activities, including grading and stockpiling of soils. Disturbance of soils formerly protected with vegetation or covered by asphalt or concrete can become exposed to winds and water flows that result in soil erosion or the loss of topsoil. Development under the Specific Plan would be required to implement the construction best management practices (BMPs), as detailed in the Storm Water Pollution Prevention Plan (SWPPP) as required by the Construction General Permit from the National Pollution Discharge Elimination System program. Although these measures are intended to prevent sedimentation from entering runoff from the site, they generally prevent soil erosion and loss of topsoil occurring at a construction site. Thus, with adherence to the required BMPs, potential construction-related erosion would be minimized. Following completion of construction activities, disturbed areas would be either revegetated through landscaping or covered by impervious surfaces such as structures or asphalt which limits the potential for erosion. Thus, operation of development under the Specific Plan would not result in significant soil erosion impacts. For further discussion of soil erosion and sedimentation, see also Section 4.8, *Hydrology and Water Quality*, in this document.

Mitigation: None Required

Impact GEO-3.SP: Development under the Specific Plan could potentially be located on a geologic unit or soil that is unstable, or that would become unstable as a result of development under the Plan, and potentially result in on or off-site landslide, lateral spreading, subsidence, liquefaction or collapse (Criterion c). (Less than Significant)

The Plan Area is underlain by artificial fill materials, Bay Mud and marsh deposits which are known to be generally insufficient to support substantive improvements without appropriate site preparations and/or incorporation of foundation design measures such as deep foundation systems that can be anchored in more competent materials at depth. If not engineered appropriately, improvements could be susceptible to subsidence, liquefaction, or differential settlement. The Plan Area is however, as described above, relatively level, and not susceptible to landslide.

Detailed, site-specific geotechnical analyses would be required for all proposed improvements, as detailed in Impact GEO-1.SP, which would include an evaluation of the potential for subsidence, liquefaction and differential settlement. A final design level geotechnical report would provide detailed recommendations and corrective grading plans to depict any specific geotechnical design measures necessary to ensure that site preparations such as the import of imported fill or recompaction of onsite soils. These design measures would be in accordance with CBC requirements.

As described earlier, development under the Specific Plan would be required to adhere to City building code requirements which include the preparation of a site specific geotechnical investigation by a state licensed geotechnical engineer for each proposed improvement within the plan area. The required geotechnical report for any new development would determine the susceptibility of the subject site to subsidence (settlement), liquefaction, and differential settlement and include appropriate engineering techniques for reducing any hazards that are identified. Where settlement and/or differential settlement is predicted, site preparation measures—such as use of engineered fill, surcharging, wick drains, deep foundations, structural slabs, hinged slabs, flexible utility connections, and utility hangers—could be used. These measures would be evaluated and the most effective, feasible, and economical measures recommended in a geotechnical report and incorporated into site design in accordance with building code requirements. Engineering recommendations included in the engineering and design plans of development under the Specific Plan would be reviewed and approved by the City. Therefore, with adherence to building code requirements the potential for unstable soils to adversely affect proposed improvements would be reduced to less than significant levels.

Mitigation: None Required

Impact GEO-4.SP: Proposed improvements from the adoption and development under the Specific Plan could be located on expansive or corrosive soils creating substantial risks to life or property (Criterion d). (Less than Significant.)

Expansive soils increase in volume when their moisture content becomes elevated. Structures built on expansive soils could experience foundation cracking as a result of seasonal expanding and contracting of soils over time. According to the geotechnical investigation for the county correctional facility, the Plan Area contains soils that were found to have a moderate to high potential for expansion (Engeo, 2012). However, building damage due to volume changes associated with expansive soils can be reduced through proper foundation design. Replacement of native soils with engineered fill or addition of soil amendments are effective means of mitigating expansive soils. As a requirement of the California Building Code, as discussed in Impact GEO-1.SP, any development under the Specific Plan would be required to complete a final geotechnical investigation that includes site-specific recommendations for the mitigation of potentially expansive soils.

Final geotechnical specifications would also include measures to prevent other geologic hazards such as corrosivity from causing significant damage. Geotechnical recommendations include preventing corrosive soils from coming in contact with vulnerable materials. Generally, industry standard practices minimize corrosivity through both the type of materials used for underground improvements and selective use of the engineering characteristics of backfill materials. The site-specific analysis of site foundation soils guides the recommended building foundation design, such that damage from geologic hazards such as expansive and corrosive soils is minimized and reduced to levels that can be accommodated by the final design. Therefore, implementation of standard geotechnical engineering practices and adherence to building code requirements would reduce potential impacts from expansive soils and other adverse soil properties to less-than-significant levels.

Mitigation: None Required

4.5.6 Project-Level Impacts of the Harbor View Project

Impact GEO-1.HV: Construction of the Harbor View project could expose people or structures to seismic hazards such as ground shaking and seismic-related ground failure such as liquefaction, differential settlement, collapse, or lateral spreading (Criteria a.2 and a.3). (Less than Significant)

As described above, the Plan Area, which generally includes the Harbor View project site, is located in a seismically active region that contains a number of active faults. In 2013, estimates by the Working Group on Earthquake Probabilities indicated a 72 percent chance that a magnitude 6.7 or greater earthquake would occur in the Bay Area region over the following 30 years, beginning 2014 (USGS, 2015). If not designed appropriately, a 6.7 or greater magnitude earthquake on one of these regional active faults could produce significant groundshaking at the Harbor View project causing substantial damage. However, damage can be minimized through appropriate seismic design and engineering. The City requires that all construction meet the latest standards of the California Building Code (CBC) for construction which considers proximity to potential seismic sources and the maximum anticipated groundshaking possible. The proposed construction would be in accordance with applicable City ordinances and policies and consistent with the most recent version of the CBC, which requires structural design that can accommodate ground accelerations expected from known active faults. Final design parameters for the walls, foundations, foundation slabs, and surrounding related improvements (utilities, roadways, parking lots and sidewalks) would similarly be included in the final report. Compliance with these building safety design standards would reduce potential impacts associated with ground shaking to less than significant levels.

According to mapping from the Seismic Hazard Zonation Program, the Harbor View project site is located in an area deemed highly susceptible to liquefaction hazards (CGS, 2015). Only a site specific geotechnical investigation could verify whether liquefiable materials are present beneath this project site. However, regardless, required geotechnical investigations would be able to identify any potential liquefiable materials and adherence to building code requirements and proven geotechnical design measures would minimize the potential for liquefaction, differential settlement, lateral spreading or collapse through foundation design, treatment of site soils and/or replacement of liquefiable soils with engineered fills.

Therefore, with implementation of the seismic design requirements into construction specification in accordance with building code requirements, as discussed above and in Impact GEO-1.SP, the impacts associated with the effects associated with ground shaking and seismic-related ground failure such as liquefaction, differential settlement, collapse, or lateral spreading would be reduced to less-than-significant levels.

Mitigation: None Required

Impact GEO-2.HV: Construction of the Harbor View project could potentially cause soil erosion or loss of topsoil during construction and operation of the project (Criteria b). (Less than Significant)

Just as described above for the Specific Plan in Impact GEO-1.SP, all construction activities associated with this project would be required to implement BMPs, as detailed in the Storm Water Pollution Prevention Plan (SWPPP) as part of the Construction General Permit from the National Pollution Discharge Elimination System program. Although these measures are intended to prevent sedimentation from entering runoff from the site, they generally prevent soil erosion and loss of topsoil occurring at a construction site. Thus, with adherence to the required BMPs, potential construction-related erosion would be minimized to less than significant levels.

Mitigation: None Required

Impact GEO-3.HV: Construction of the Harbor View project could potentially 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 (Criteria c). (Less than Significant)

The project site is generally underlain by artificial fill materials (likely undocumented), Bay Mud and marsh deposits which are known to be generally insufficient to support substantive improvements without appropriate site preparations and/or incorporation of foundation design measures such as deep foundation systems that can be anchored in more competent materials at depth. If not engineered appropriately, improvements could be susceptible to subsidence, liquefaction, or differential settlement. The project site is however, as described above, relatively level, and not susceptible to landslide.

A detailed, site-specific geotechnical analyses would be required prior to approval of a building permit and would include an evaluation of the potential for subsidence, liquefaction and differential settlement. A final design level geotechnical report would provide detailed recommendations and corrective grading plans to depict any specific geotechnical design measures necessary to ensure that site preparations such as the import of imported fill or recompaction of onsite soils. These design measures would be in accordance with CBC requirements as well as any City building code amendments. Engineering recommendations included in the project engineering and design plans would be reviewed and approved by the City. Therefore, with adherence to building code requirements as described above (and in Impacts GEO-1.SP and GEO-1.HV), the potential for unstable soils to adversely affect proposed improvements would be reduced to less than significant levels.

Mitigation: None Required

Impact GEO-4.HV: Construction of the Harbor View project could be located on expansive or corrosive soils creating substantial risks to life or property (Criteria d). (Less than Significant.)

Expansive soils increase in volume when their moisture content becomes elevated. Structures built on expansive soils could experience foundation cracking as a result of seasonal expanding and contracting of soils over time. However, building damage due to volume changes associated with expansive soils can be reduced through proper foundation design. Replacement of native soils with engineered fill or addition of soil amendments are effective means of mitigating expansive soils. As a requirement of the California Building Code, the project would be required to complete a final geotechnical investigation that includes site-specific recommendations for the mitigation of potentially expansive soils, if present. The site-specific analysis of site foundation soils guides the recommended building foundation design, such that damage from geologic hazards such as expansive and corrosive soils is minimized and reduced to levels that can be accommodated by the final design. Therefore, implementation of the standard geotechnical engineering practices and adherence to building code requirements as above (and in Impacts GEO-1.SP and GEO-1.HV) would reduce potential impacts from expansive soils and other adverse soil properties to less-than-significant levels.

Mitigation: None Required

4.5.7 Cumulative Impacts

Impact GEO-1.CU: Development under the Specific Plan and/or the Harbor View project, combined with cumulative development in the Plan Area and citywide, including past, present, existing, approved, pending, and reasonably foreseeable future development, would not result in significant cumulative impacts with respect to geology, soils or seismicity. (Less than Significant)

The geographic scope for cumulative impacts on geology and soils is the entire Bay Area region which is considered an area of high seismic activity and susceptible to seismic events that could occur anywhere within the region. Cumulative projects considered are those in the Specific Plan vicinity that would also involve construction activity, including those in the development forecasts conducted for this EIR based on the countywide transportation model and the US 101/SR84 (Woodside Road) Interchange Improvement Project and other approved, pending, and reasonably foreseeable future projects citywide, including the nearby San Mateo County Replacement Jail and several recent, existing, and anticipated projects underway in downtown Redwood City under the Downtown Precise Plan (see Section 4.0.4 *Cumulative Analysis* in this chapter for detail).

The Plan Area and project site are located in a seismically active area and future project development could expose additional people and structures to potentially adverse effects associated with earthquakes including seismic ground shaking and seismic related ground failure. However, site-specific geotechnical studies required by the City would determine how future development projects could be designed to minimize exposure of people to these impacts. Therefore future development would be constructed to more current standards which could potentially provide greater protection than those of older structures within the region.

The impact of the risks associated with exposure to potential geological and soils hazards is generally localized because of the dependence on site specific conditions and would not affect the immediate vicinity surrounding the proposed project area. Development under the Specific Plan, and the Harbor View project would all be constructed in accordance with the most recent version of the California Building Code seismic safety requirements and recommendations contained in the project area specific geotechnical reports. Therefore, potential exposure to geological and soils hazards resulting from construction and operation of development under the Specific Plan and the Harbor View project would not have a cumulatively considerable contribution to a cumulative impact. No significant cumulative impact is identified.

Mitigation: None Required.

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