4.6 GEOLOGY AND SOILS

4.6.1 ENVIRONMENTAL SETTING

IN THIS SECTION:

- Regulatory Setting
- Regional and Site Geology
- Seismic and Geologic Hazards
- Site Soils Conditions

The following section is based on a geotechnical review provided for the project by Dees & Associates. The review, which is included in Appendix F, provides an update to a geotechnical investigation for the project in 2008 by Pacific Crest Engineering, which also included a geologic report for the former project by Zinn Geology (2008). This section also draws from the City of Santa Cruz *General Plan 2030* EIR (SCH#2009032007), which was certified on June 26, 2013, in particular regarding the geologic and seismic conditions within the City. The General Plan EIR is incorporated by reference in accordance with section 15150 of the State CEQA Guidelines. Relevant discussions are summarized below and can be fully reviewed in the General Plan EIR on pages 4.10-4 to 4.10-15 in the Draft EIR. The General Plan EIR is available for review at the City of Santa Cruz Planning and Community Development Department (809 Center Street, Room 107, Santa Cruz, California) during business hours: Monday through Thursday, 8 AM to 12 PM and 1 PM to 5 PM. The General Plan EIR is also available online on the City's website at: http://www.cityofsantacruz.com/index.aspx?page=348.

REGULATORY SETTING

State Regulations

ALQUIST-PRIOLO EARTHQUAKE FAULT ZONING ACT

The Alquist-Priolo Earthquake Fault Zoning Act was passed by the state of California in 1972 to prevent the construction over active faults of buildings used for human occupancy. The Act requires the State Geologist to establish regulatory zones (known as Earthquake Fault Zones) around the surface traces of active faults and to issue appropriate maps. Local agencies must regulate most development projects within the zones. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed over active faults. If an active fault is found, a structure for human occupancy cannot be placed over the trace of the fault and must be set back from the fault (generally 50 feet), although local agencies can be more restrictive than state law requires (California Department of Conservation, 2007a). There are no state-delineated Alquist-Priolo fault zones in the City of Santa Cruz.

SEISMIC HAZARDS MAPPING ACT

The Seismic Hazards Mapping Act (SHMA) addresses non-surface fault rupture earthquake hazards, including strong ground-shaking, liquefaction, and seismically-induced landslides. The goal is to mitigate seismic hazards to protect public health and safety. Pursuant to the SHMA, the state Department of Conservation is directed to provide local governments with seismic hazard zone maps that identify areas susceptible to amplified shaking, liquefaction, and earthquake-induced landslides or other ground failures. Site-specific geotechnical hazard investigations are required by SHMA when construction projects fall within these areas. Neither the City of Santa Cruz nor any part of Santa Cruz County is located within a currently designated state-Seismic Hazard Mapping Program zone (California Department of Conservation, 2007b).

CALIFORNIA BUILDING CODE

Title 24 of the California Code of Regulations, contains the Building Standards Codes, including Part 2, the California Building Code (CBC), which sets forth minimum requirements for building design and construction. In the context of earthquake hazards, the CBC design standards have a primary objective of ensuring public safety and a secondary goal of minimizing property damage and maintaining function during and following a seismic event. The 2013 CBC, including section 1803, presents the requirements for geotechnical investigations. The CBC prescribes seismic design criteria for various types of structures, and provides methods to obtain ground motion inputs. The CBC also requires analysis of liquefaction potential, slope-instability, differential settlement, and surface displacement due to faulting or lateral spreading for various categories of construction. Subsection 1803.5.12 establishes seismic design categories and requires that structures in "Seismic Design Categories" D, E or F also evaluate liquefaction potential, assess liquefaction impacts and discuss mitigation measures, such as, but not limited to , ground stabilization, selection of appropriate foundation type and depths, selection of appropriate structural systems or an combination of measures. The City of Santa Cruz is located in Seismic Design categories D-F.

Local Regulations

The City's Municipal Code section 24.14.070 requires a site-specific geotechnical investigation for all development, except projects with fewer than four units, in areas identified in the General Plan as having a high liquefaction potential. Section 24.16.060 requires an erosion control plan for projects located within high erosion hazard areas as designated in the General Plan, or for development on slopes greater than 10 percent.

The Grading Ordinance is a subset of Title 18, Buildings and Construction, of the City's Municipal Code and is included in Chapter 18.45 – "Excavation and Grading Regulations." It provides technical regulations for grading and excavation, in conjunction with the Environmental Resource Management provisions in Chapter 24.14, in order to safeguard life, health, safety, and the public welfare; protect fish and wildlife, riparian corridors and habitats, water supplies, and private and public property; and to protect the environment from the effects of flooding, accelerated erosion, and/or deposition of silt. The ordinance accomplishes this by providing guidelines, regulations, and minimum standards for clearing, excavation, cuts, fills, earth moving, grading operations (including cumulative grading), water runoff, and sediment control. In addition, the ordinance includes provisions regarding administrative procedures for issuance of permits and approval of plans and inspections during construction and subsequent maintenance. The City revised the Grading Ordinance in April 2004 in order to strengthen the ordinance regarding implementation of Best Management Practices (BMP)s, including those for erosion and sediment control.

REGIONAL AND SITE GEOLOGY

Regional Geologic Setting

The following section is summarized from the General Plan 2030 EIR (see DEIR pages 4.10-4 to 4.10-6 and Appendix F-4 prepared by Nolan Associates).

The City of Santa Cruz lies on a narrow coastal plain at the mouth of the San Lorenzo River Valley on the northern shore of the Monterey Bay. The coastal plain is bounded landward by the Santa Cruz Mountains, rising to elevations over 2,600 feet. The San Lorenzo River flows southward from the Santa Cruz Mountains and is the largest drainage in the region, with an area of about 106 square miles. The central district of the City of Santa Cruz is situated on the floodplain of the lower San Lorenzo River.

The City of Santa Cruz is situated on the southwestern slope of the central Santa Cruz Mountains, part of the Coast Ranges physiographic province of California. The northwest-southeast structural grain of the Coast Ranges is controlled by a complex of active faults within the San Andreas fault system. The geology of the City and surrounding area displays over 100 million years of geologic history. Rock units in the City are separable into three major groups: granitic intrusive rocks of Late Cretaceous age, pre-Cretaceous metasedimentary rocks, and sedimentary rocks of Tertiary and Quaternary age. The sedimentary rocks overlying the granitic and metamorphic basement, principally the Santa Margarita Sandstone, the Santa Cruz Mudstone, and the Purisima Formation, are younger Tertiary age rocks and, locally, have experienced only gentle uplift and very mild folding.

Project Site Geology

The project site is located just slightly downstream from the foot of the central Santa Cruz Mountains, where the backfilled San Lorenzo River floodplain intersects the mountains. The river valley spills out onto a large, open flood plain in this area, which has backfilled an ancestral river valley that has sliced through a series of broad ancestral marine terraces that stretch across most of Santa Cruz. It appears that the site is located astride a series of nested Pleistocene- or Holocene-aged fluvial terraces transitioning downward toward the active hydraulic boundary between the San Lorenzo River and the Pacific Ocean (Zinn Geology, January 2008).

The project site has been mapped as being underlain by Holocene-age alluvium overlapping Purisima Formation bedrock that forms the core of Beach Hill. The 2008 geologic investigation indicates that the site is also underlain by discontinuous ponds and blankets of artificial fill, which in turn are underlain by up to 36.5 feet of Holocene-age alluvium. Pliocene-age Purisima Formation sandstone bedrock underlies the surface cover, varying in depth across the site between 10 and 45 feet below the ground surface. The bedrock underlying the site is a well-sorted, fine-grained sandstone (Zinn Geology, January 2008).

SEISMIC AND GEOLOGIC HAZARDS

Regional Seismicity

The City of Santa Cruz is located in a seismically active region of California. Historical earthquakes along the San Andreas fault and its branches have caused substantial seismic shaking in Santa Cruz County in historical time. The two largest historical earthquakes to affect the area were the moment magnitude (Mw) 7.9 San Francisco earthquake of April 18, 1906, and the Mw 6.9 Loma Prieta earthquake of October 17, 1989 (corresponding to Richter magnitudes of 8.3 and 7.1). The San Francisco earthquake caused severe seismic shaking and structural damage to many buildings in the Santa Cruz Mountains. The Loma Prieta earthquake may have caused more intense seismic shaking than the 1906 event in localized areas of the Santa Cruz Mountains, although its regional effects were not as extensive. There were also major earthquakes in northern California along or near the San Andreas fault in 1838, 1865, and possibly 1890.

The City of Santa Cruz is situated between two major active faults: the San Andreas, approximately 11.5 miles to the northeast, and the San Gregorio, approximately nine miles to the southwest. The active or potentially active faults that may affect the project site are the San Andreas, Zayante-Vergeles, Monterey Bay-Tularcitos, and San Gregorio fault zones. There are no active fault zones or risk of fault rupture within the City.

Seismic Hazards

Seismic hazards which may affect the project site include ground-shaking, liquefaction and lateral spreading, and seismically-induced slope instabilities. Since the nearest known active or potentially active fault is mapped approximately 6.4 miles from the site (Monterey Bay-Tularcitos fault), the potential for ground surface fault rupture is low (Pacific Crest Engineering, Inc., January 2008). The distances between these faults and the City center are listed in Table 4.6-1, as are the maximum expected earthquake size and the approximate time interval between major earthquakes on each fault. All of these faults are considered capable of magnitude (M) 6.5 or larger earthquakes.

SEISMIC SHAKING

As indicated above, the San Andreas, Zayante-Vergeles, San Gregorio, and Monterey Bay-Tularcitos fault are considered active seismic sources by the State of California. The General Plan 2030 EIR provides description of these faults (DEIR pages 4.10-6 to 4.10-14.)

Seismic shaking at the project site is expected to be intense during the next major earthquake along local fault systems, particularly the Zayante-Vergeles fault (Zinn Geology, January 2008). The 2008 geologic report included a site-specific calculation of peak ground acceleration using two methods. The deterministic method evaluates potentially damaging earthquake sources, and then selects a suitable controlling source and seismic event. This method results in a single set of ground-shaking parameters for a site, which are summarized on Table 4.6-2. The maximum deterministic earthquake ground motion expected at the project site will be approximately 0.71g[1], based on an M_w 7.3 earthquake centered on the Monterey Bay-Tularcitos fault zone (Zinn Geology, January 2008). Expected duration of strong shaking for this event is about 16 seconds.

Table 4.6-1: Distances and Directions to Local Faults

Fault	Distance from City (miles)	Maximum Expected Earthquake Magnitude (Moment Magnitude)	Approximate Time Between Major Earthquakes (years)
San Gregorio	9.9	7.2	400
Zayante-Vergeles	7.9	7.9	8821
Monterey Bay-Tularcitos	6.5	6.5	2841
San Andreas	11.2	7.9	210

Source: Nolan Associates for City of Santa Cruz General Plan 2030 EIR

Table 4.6-2: Deterministic Ground Acceleration Data

Fault Zone	Moment Magnitude M_w[1]	Estimated Recurrence Interval (years)	Distance From Site (miles)	Estimated Mean Peak Ground Acceleration (g)[2]	Estimated Mean + Dispersion Ground Acceleration (g)[2]	Maximum Considered Earthquake Ground Motion (g)[2]
San Andreas - 1906 Segment	7.9	210	11.7	0.34	0.49	0.51
Zayante-Vergeles	7.0	10,000	8.7	0.36	0.54	0.53
Monterey Bay-Tularcitos	7.3	2,841	6.4	0.49	0.71	0.73
San Gregorio	7.0	400	9.5	0.28	0.42	0.41

Notes:
[1] The moment magnitude values in the table represent magnitude of a characteristic or maximum earthquake of a given fault.
[2] (g) = the acceleration due to gravity

Source: Zinn Geology, January 2008

Duration of a strong seismic shaking may be more critical than the peak acceleration for areas with liquefaction potential. Duration of strong shaking is dependent on magnitude, where a magnitude 7.3 earthquake duration is estimated at 21 seconds and a magnitude 7.9

[1] (g) – The acceleration due to gravity.

earthquake duration is estimated at 38 seconds. Considering the recurrence intervals of the San Andreas and its estimated earthquake duration, the project site is more likely to be affected by the San Andreas fault's lower value mean plus one dispersion ground acceleration (0.49g) than the Monterey Bay-Tularcitos fault's higher mean plus one dispersion ground acceleration (0.71g) (Zinn Geology, January 2008).

Probabilistic modeling – used to define the likelihood of earthquake occurrences and various outcomes for given seismic scenarios--was also developed in the 2008 geological investigation (Zinn Geology, January 2008) in accordance with the requirements of the 2007 California Building Code in effect at the time the investigation was conducted.

LIQUEFACTION AND LATERAL SPREADING

According to maps developed as part of the City's recently adopted *General Plan 2030* and included in the General Plan EIR (Figure 4.10-4), the project site is located in an area identified as being subject to liquefaction hazards. Liquefaction occurs in loose, cohesionless, granular materials that are saturated with groundwater. The effects of seismic shaking can cause this type of sediment to lose strength and flow like a liquid. Liquefaction-related ground deformation includes lurch cracking, fissuring, and lateral spreading. Liquefaction typically occurs in soils composed of loose sands and non-cohesive silts of restricted permeability.

The Purisima Formation bedrock at the project site is overlain by loose alluvial deposits consisting mainly of silty sands with some discontinuous, interbedded layers of clay and silt (Pacific Crest Engineering, Inc., January 2008). The 2008 geotechnical investigation included a quantitative analysis of liquefaction potential at the site, and estimated that the magnitude of possible seismically-induced ground surface settlement could range from 1.2 to 7.8 inches, with the worst settlement occurring in areas where the depth to bedrock was the greatest (Ibid). The 2008 investigation further indicated that, based on this analysis, there is a potential that the soil on the project can liquefy and either laterally spread toward the south (Beach Street) or surge laterally around the piers.

The 2008 geotechnical investigation was reviewed and updated for the current project by Dees & Associates. The 2013 geotechnical update (included in Appendix F of this EIR) indicated that the 2008 investigated estimated settlements to be on the order of 1.2 to 7.8 inches; however, their liquefaction analysis indicated that the zone of liquefaction extends into the sandstone bedrock and clay layers that are not susceptible to liquefaction. The geotechnical update recalculated the liquefaction potential for two of the soil profiles assuming the bedrock and clay do not liquefy and using a median plus one standard deviation of 0.71g. The updated analysis indicates the maximum settlement from liquefaction would be 7.6 inches.

SEISMICALLY INDUCED LANDSLIDING

The 2008 geotechnical investigation concluded that there is a low potential for seismically induced landsliding at the project site with the grading and design proposed at that time.

Coastal Erosion

Coastal erosion is the wearing away of coastal land. The term commonly is used to describe the horizontal retreat of the shoreline along the ocean. Coastal erosion includes both cliff or bluff erosion and beach erosion, and is a result of both winter wave attack as well as a slowly rising sea level (City of Santa Cruz, September 2007). The project site is not located on a coastal bluff that could be subject to coastal bluff erosion. The City's existing adopted Local Hazards Mitigation Plan (2007-2012) identifies the shoreline between Bay Street and East Cliff Street, which includes the project site, as not being subject to coastal erosion (Ibid). Furthermore, the project site is protected by a seawall that, in turn, protects Beach Street in front of the hotel. In the last century the seawall protected the Beach Street and the La Bahia Hotel from erosion (Zinn Geology, January 2008).

Slope Hazards

The project site is located at the southern flank of Beach Hill, where the hill descends into the beach along Beach Street. The project site gently slopes from north to south, with a narrow band of 30-to-50+ percent slopes in the central portion of the site. According to maps developed as part of the City's recently adopted *General Plan 2030* and included in the General Plan EIR (Figure 4.10-5), the project site contains slopes of 30-to-50+percent. It appears that the onsite slope, in part, was created as the result of past grading to create level areas in the upper portion of the site. City regulations exempt minor sculpted landforms from compliance with City slope regulations. The project proposes grading the northern portion of the site to construct an underground parking garage. The area of the 30-to-50+ percent slopes likely would be re-graded, thus eliminating any construction on steep slopes, although a grading plan has not yet been prepared.

SITE SOILS CONDITIONS

Previous geotechnical reports indicate that the soils at the site consist of a thin layer of fill over native silty sand over sandstone bedrock, with the exception of the soil adjacent to Beach Drive at the base of the slope, where interbedded clays and sands were encountered above the bedrock (Dees & Associates, October 2013). Soil borings and laboratory testing conducted in 2001 were reviewed as part of the 2008 geotechnical report. The borings encountered fill or native soils underlain by Purisima Formation sandstone at depths that varied from 11 to 44 feet below the existing ground surface with a general downward trend to the east-southeast (Ibid.). The geotechnical update conducted for the current project proposal indicates that the depth to bedrock is typically 18 to 24 feet across most of the site and dips steeply to the east about 60 feet west of the east property line. Bedrock is 22 to 44 feet deep at the eastern property line (Ibid.). Soil borings drilled at a property about 65 feet to the east of the project site encountered bedrock at a higher elevation than the bedrock at the eastern property line of the La Bahia site. This indicates there is likely a bowl-shaped depression in the vicinity of Westbrook Street. Review of the borings at the La Bahia site and the borings at 301 Beach Street across Westbrook Street indicate that the inter-bedded clays are located in the southeast corner of the La Bahia site and the clays extend further inland at 301 Beach Street (Ibid.).

Silty sands were encountered in all borings, except for one that encountered interbedded clays and sands. Fill was encountered in two borings ranging in depth from two to eight feet. The artificial fill present on the site appears to be derived from alluvium on the site or from a nearby location. Based on the age, genesis, and geotechnical analysis, the fill appears to be non-engineered (Pacific Crest Engineering, Inc., January 2008).

Groundwater was encountered in most of the soils borings, perched above the bedrock at depths below the ground surface, varying from 9.5 to 24 feet (Dees & Associates, October 2013), with an average depth of 12.8 feet (Pacific Crest Engineering, Inc., January 2008). However, these depths may not be reflective of stabilized[2] groundwater level. Based on data from two monitoring wells (one located on Beach Street about 75 feet east of the wharf entrance, and the other located on Cliff Street), Pacific Crest Engineering conservatively estimated the highest expected stabilized groundwater level at the project site to be at a depth of five feet (Pacific Crest Engineering, Inc., January 2008).

4.6.2 RELEVANT PROJECT ELEMENTS

The proposed La Bahia Hotel project consists of demolition of the existing 44-unit La Bahia apartment complex, with the exception of a portion of the existing bell tower building in the southeastern portion of the site, and construction of a 165-room hotel. The new building would cover the entire block bound by Beach, Westbrook, First, and Main Streets. Demolition would result in removal of approximately 2,750 tons of material. Grading activities would result in excavation of 22,250 cubic yards of soil, all of which would be exported offsite.

In order to provide mitigation for potential liquefaction hazards, the project geotechnical consultant has indicated that in-situ densification of the ground using vibro-displacement may be used to densify the soil, increase bearing capacity, and provide liquefaction mitigation. Vibro-displacement using stone columns is a ground improvement technique that constructs dense aggregate columns by means of a crane-supported downhole vibrator. Stone columns need to penetrate the liquefiable soil and be embedded at least one foot into sandstone bedrock. Preliminary estimates indicate that most stone columns would be less than 10 feet deep and spaced approximately every 10 feet.

4.6.3 IMPACTS AND MITIGATION MEASURES

CRITERIA FOR DETERMINING SIGNIFICANCE

In accordance with the California Environmental Quality Act (CEQA); State CEQA Guidelines (including Appendix G); City of Santa Cruz plans, policies, and/or guidelines; and agency and professional standards, a project impact would be considered significant if the project would:

[2] To obtain a stabilized groundwater level, the groundwater must be allowed to stabilize for more than a few hours after a borehole is drilled. Stabilized groundwater level may be lower or higher than the initial measurements.

6a Expose people or structures to potential substantial adverse effects including the risk of loss, injury, or death resulting from the rupture of a known earthquake fault, seismic ground-shaking, landslides, or seismic-related ground failure, including liquefaction, which cannot be mitigated through the use of standard engineering design techniques;

6b 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 an onsite or offsite landslide or slope failure/ instability;

6c Result in substantial soil erosion or the loss of topsoil and subsequent sedimentation into local drainage facilities and water bodies; or

6d Be located on an expansive soil, as defined by the Uniform Building Code (1997), or subject to other soil constraints that might result in deformation of foundations or damage to structures, creating substantial risks to life or property.

IMPACT ANALYSIS

As described in the Initial Study (see Appendix A), the project would not be exposed to non-seismic geologic hazards (6b), would result not in substantial soil erosion (6c), and would not be located on expansive soils (6d). The following impact analyses address exposure of people or structures to seismic and geologic hazards (6a).

Impact 4.6-1 Exposure to Seismic Hazards.
The project site will be exposed to strong ground-shaking during a major earthquake on any of the nearby faults, resulting in the exposure of people and/or structures to strong seismic shaking and liquefaction. This is a *significant* impact.

As described in the Environmental Setting section, the project site is located in the seismically active region of California, and would be subject to intense seismic shaking during the next major earthquake along local faults. There are no active fault zones or risk of fault rupture within the City; therefore, fault rupture through the site is not anticipated. The project would be subject to both seismic shaking and liquefaction hazards. There is a low potential for seismically-induced landsliding on the site, as the project design would be a series of level floors stepped up from a number of ground floors starting at the lowest point adjacent to Beach Street, with supporting retaining walls to the north, west, and east (Pacific Crest Engineering, Inc., January 2008).

The project applicant would be required to design and construct the proposed project in conformance with requirements established in the California Building Code (CBC), which includes seismic design parameters. Structures built in accordance with the latest edition of the California Building Code have the potential for experiencing relatively minor damage which should be repairable (Pacific Crest Engineering, Inc., January 2008). The geotechnical update prepared for the project provides updated seismic design parameters. The *General Plan 2030* EIR also concludes that with adherence to existing regulations and standards, including the CBC, harm to people and structures from adverse seismic events would be minimized.

The project site is located in an area classified as having a high potential for liquefaction, and onsite soils consist mostly of loose alluvial deposits consisting mainly of silty sands, with some discontinuous, interbedded layers of clay and silt, underlain by the Purisima Formation bedrock at a typical depth of 18 to 24 feet across most of the site (Dees & Associates, October 2013). Perched groundwater was observed from 9.5 to 24 feet below existing grade. The updated liquefaction analysis estimates that seismically-induced ground surface settlement could range from 1.2 to 7.6 inches (Ibid.).

To mitigate liquefaction settlement and lateral spreading, the 2008 geotechnical investigation provided recommendations to penetrate the liquefiable soils with drilled piers embedded into sandstone bedrock. Drilled piers would support the structure and mitigate liquefaction-induced settlement and lateral spreading. Piers would support the structure, but the soils around the piers may settle. This can result in damage to utilities, pavements, walkways, and any other improvements not supported by the piers (Dees & Associates, October 2013). The current project geotechnical engineer has recommended vibro-displacement stone columns as an alternative to drilled piers, which can be used to densify the soil, increase bearing capacity, and provide liquefaction mitigation. This would eliminate the need for deep piers, reduce the volume of soil that has to be hauled off the site, eliminate settlement and lateral loads from liquefaction, and eliminate the need to incorporate utilities into the foundation of the structure. The use of flexible connections for utilities at the boundary of the stone columns is still recommended, as utilities located offsite still will be susceptible to liquefaction-induced settlements and lateral displacements (Ibid.).

According to the geotechnical update, the use of vibro-displacement stone columns is a ground improvement technique that constructs dense aggregate columns by means of a crane-supported downhole vibrator. The placement of stone into the ground displaces the adjacent soil, creating denser soil conditions between the columns. Stone columns provide additional load-bearing capacity and mitigate excessive pore pressures that lead to soil liquefaction. Stone columns need to penetrate the liquefiable soil and be embedded at least one foot into sandstone bedrock. Assuming the garage floor slab is at an elevation of about 14 feet, most of the stone columns would be less than 25 feet in depth. The bedrock along the east and south edges of the site is much deeper and stone column depths up to 45 feet should be anticipated in these areas (Dees & Associates, October 2013). The stone column design has not been developed; however, the project geotechnical engineer has estimated that 30-inch diameter stone columns with a triangular center-to-center spacing of 10 feet may be needed. The subsequent design process would include development of construction specifications and inspection requirements.

Structures located over stone columns could be supported on structural mat foundations or a grid of reinforced spread footings. The top three feet of soil will need to be removed and replaced as compacted engineered fill reinforced with geotextile fabric equivalent to Mirafi 500X to accommodate mat slab or spread footing foundations. Specific recommendations for foundations founded upon stone columns should be developed in conjunction with the design of the stone columns (Dees & Associates, October 2013).

The project geotechnical engineer also has indicated that there are other alternative liquefaction mitigation measures for both the existing structures to be retained and the new proposed structures, which can be used to modify the soil without causing excess vibrations to the retained buildings, such as compaction grouting, jet grouting and deep soil mixing (Dees & Associates, December 2013). Compaction grouting consists of staged injection of low slump grout into the ground to densify the soil. Jet grouting consists of mixing cement with the soil to form "soilcrete" columns placed in a grid pattern, but does not densify the soil to the same extent as compaction grouting although some compaction is achieved. Jet grouting is primarily used to transfer loads to more competent ground below the potentially liquefiable soil layers and could be performed under the existing buildings in the same manner as compaction grouting (Ibid.).

Deep soil mixing consists of mixing cement with soil to create walls of "soilcrete" that forms a lattice type structure beneath the ground surface, which forms boxes that contain liquefiable soil to prevent lateral spreading and provide vertical load support. Deep soil mixing to mitigate liquefaction is an emerging technology and is not well understood at this time, although there are multiple case studies where soil mixing was effective in mitigating damage to structures overlying liquefiable soils (Dees & Associates, December 2013). Deep soil mixing does not appear to be practical below existing structures but could be used under new structures (Ibid.).

It is also noted that, according to the 2008 geotechnical investigation, there is a potential to encounter groundwater, necessitating implementation of a dewatering plan. Additionally, temporary shoring during construction will need to be developed, given the excavation depths required on the north and west sides of the project. The 2008 geotechnical report includes recommendations for developing a dewatering program, temporary shoring during construction, and retaining wall designs.

The geotechnical update concluded that the recommendations presented in the Pacific Crest Engineering, Inc., report dated January 28, 2008, and the revisions and addendums presented in the Dees & Associates update (October 4, 2013) may be used for design and construction of the proposed improvements (Dees & Associates, October 2013).

Mitigation Measures

Implementation of Mitigation Measure 4.6-1 below will reduce impacts of exposure to seismic hazards, including liquefaction, and other soil constraints to a less-than-significant level.

> 4.6-1: Require implementation of all recommendations set forth in the "Geotechnical Investigation and Geology Report for La Bahia Hotel" prepared by Pacific Crest Engineering (January 2008), as updated by the Dees & Associates (October 5, 2013) "Update to Geotechnical Investigation by Pacific Crest Engineering, Inc., dated January 28, 2008" and December 3, 2013 review, including foundation and structural design recommendations. These recommendations include, but are not limited to, use of vibro-displacement stone columns to mitigate exposure to liquefaction, and construction of a building foundation system that consists of structural mat foundation or grid of reinforced spread footings for structures located over stone columns.