4.5 GEOLOGY AND SOILS

INTRODUCTION

This section provides a discussion of the existing geologic and soils environment and an analysis of potential impacts from implementation of the proposed Alamitos Bay Marina Rehabilitation project. This section also addresses the potential for damage to occur to the project site due to the local geology underlying the proposed project site, as well as slope stability, ground settlement, soil conditions, and regional seismic conditions. The following geology and soils information is based on the *Geotechnical Evaluation for the Alamitos Bay Marina Improvement Project* (Geotechnical Evaluation) prepared by Ninyo and Moore (February 9, 2007) and included as Appendix E to this EIR.

4.5.1 EXISTING ENVIRONMENTAL SETTING

4.5.1.1 Regional Geology

The project site lies within the southwestern block of the Los Angeles Basin in the coastal plain of the Peninsular Ranges Geomorphic Province. The Geomorphic province encompasses an area that extends approximately 125 miles (mi) from the Transverse Ranges and the Los Angeles Basin south to the Mexican border and the tip of Baja California. The Peninsular Ranges vary in width from approximately 30 to 100 mi and are generally characterized by northwest-trending mountain ranges separated by subparallel fault zones. The major structural fault systems bounding this area include the southern onshore segment of the Newport-Inglewood Fault, located approximately 0.6 mi northwest of the site, as well as the potentially active Los Alamitos and Norwalk Fault Zones, located approximately 3 mi northeast and 10.8 mi northeast, respectively. Regional geologic mapping indicates that the project area is underlain by Holocene-age stream channel, alluvial fan, and floodplain deposits consisting of clay, silt, sand, and cobbles.

4.5.1.2 Site Geology

The Alamitos Bay Marina lies to the northwest of the San Gabriel River and south of the outlet of the Los Cerritos Channel. The San Gabriel River borders the southeastern perimeter of the Marina and trends in a northeast-southwest direction. The Los Cerritos Channel roughly trends in a northeast-southwest direction and joins the Marina at its northern tip. Published geologic maps and literature indicate that the site is underlain by artificial fill consisting of sand and silty sand.

Subsurface explorations revealed fill materials to depths ranging from approximately 7 to 15.5 feet (ft) in onshore borings. The fill materials generally consisted of medium dense, clayey sand, medium dense, silty sand, and very stiff, sandy clay with trace gravel, wood shards, and shells. Alluvial deposits were encountered beneath the fill to the explored depth of approximately 83.5 ft. The alluvial deposits generally ranged from loose to very dense silty sand and medium dense, poorly graded sand to silty sand. The clay material encountered generally ranged from very soft to hard, silty clay and sandy clay. The silt generally ranged from very loose to dense sandy silt and firm to hard clayey silt.

4.5.1.3 Structural Geology

The proposed project area is not located within an Alquist-Priolo Earthquake Fault Zone (CGS 1986). However, based on the current understanding of the geologic framework of the area, ground shaking resulting from an earthquake occurring along regional faults is the seismic hazard with the highest probability of affecting the project site. A fault is described as the area where two tectonic or continental plates meet. An "active" fault is defined by the State of California as having had surface displacement within the Holocene time (i.e., within the last 11,000 years). A "potentially active" fault is defined as showing evidence of surface displacement during the Quaternary time (i.e., during the last 1.6 million years). These terms are, however, used by the State primarily for use in evaluating the potential for surface rupture along faults and are not intended to describe possible seismic activity associated with displacement along a fault. These definitions are not applicable to blind thrust faults that have only limited, if any, surface exposures.

Because the subject site is located in a seismically active area, the potential for strong ground motion at the site is considered significant. The nearest known active fault is the Newport-Inglewood Fault, located approximately 0.6 mi northwest of the project site. Table 4.5.A lists selected principal known active faults that may affect the subject site and the maximum moment magnitude as published by the California Geological Survey.

The principal seismic hazards at the subject site are ground shaking, seismically induced liquefaction, and various manifestations of liquefaction-related hazards. A brief description of these hazards and the potential for their occurrences on site are discussed below.

Table 4.5.A: Nearby Active Faults

Fault	Approximate Fault to Site Distance (miles)	Maximum Moment Magnitude
Newport-Inglewood	0.6	7.1
Palos Verdes	7.9	7.3
San Joaquin Hills	10.9	6.6
Puente Hills	12.9	7.1
Whittier	16.9	6.8
Upper Elysian Park	21.4	6.4
San Jose	23.9	6.4
Raymond	25.4	6.5
Hollywood	26.3	6.4
Verdugo	26.3	6.9
San Andreas	49.5	7.8

Source: *Geotechnical Evaluation for the Alamitos Bay Marina Improvement Project* prepared by Ninyo and Moore, February 9, 2007.

Ground Motion. The Geotechnical Evaluation included an evaluation of ground shaking hazards, including a review of a probabilistic seismic hazard assessment that consisted of statewide estimates of peak horizontal ground accelerations conducted for California. In addition, a site-specific probabilistic seismic hazard analysis was performed to evaluate anticipated peak ground accelerations (PGAs). The PGA is a commonly used parameter to represent the level of observed and/or estimated ground shaking at a particular site. The probabilistic seismic hazard analysis estimates that a PGA of 0.34g (acceleration due to gravity) is applicable to the project site conditions for a 10 percent probability of exceedance in 50 years (475-year return period). The "predominant earthquake" that contributes most to the ground-shaking hazard at 10 percent probability of exceedance in 50 years is a magnitude (Mw) 7.5 event on a fault zone located within 62 mi of the project site.

Liquefaction. Soil liquefaction is a phenomenon that occurs during strong ground shaking, most commonly in generally low- to medium-density, saturated, low-cohesion soils where the soils experience a temporary loss of strength and behave essentially as a fluid. Areas most susceptible to liquefaction-induced damage are underlain by loose, water-saturated, granular sediment within 50 ft of the ground surface. Saturated conditions reduce the effective normal stress, thereby increasing the likelihood of earthquake-induced liquefaction. One of the major types of liquefaction-induced ground failures is lateral spreading of mildly sloping ground. Lateral spreading involves movement of earth materials due to ground shaking and is evidenced by near-vertical cracks with horizontal movement of the soil. Liquefaction-induced ground failure has historically been a major cause of earthquake damage in Southern California.

Due to the variability of the on-site soils, the potential for liquefaction varies across the site. The liquefaction analysis indicated that some of the granular soil layers located below the historic high groundwater level may liquefy during the design seismic event up to depths of approximately 48 ft below the ground surface (bgs) for the onshore portions of the site and to depths of approximately 14 ft bgs in the offshore portions of the site.

Lateral Spreading. Lateral spreading of the ground surface during an earthquake usually takes place along weak shear zones that have formed within a liquefiable soil layer. Lateral spread has generally been observed to take place in the direction of a free-face (i.e., retaining wall, slope, channel) but has also been observed to a lesser extent on ground surfaces with gentle slopes. For sites located in proximity to a free-face, the amount of lateral ground displacement is strongly correlated with the distance of the site from the free-face. Other factors, such as earthquake magnitude, distance from the earthquake epicenter, thickness of the liquefiable layers, and the fine content and particle sizes of the liquefiable layers also affect the amount of lateral ground displacement. Based on the Geotechnical Evaluation, seismically induced lateral spread of approximately 1–11 ft is estimated to occur.

Subsidence. The phenomenon of soil liquefaction may result in several hazards, including liquefaction-induced settlement. The amount of soil settlement during a strong seismic event depends on the thickness of the liquefiable layers and the density and/or consistency of the soils. Based on the geotechnical analysis, post-earthquake dynamic ground settlements ranging from approximately 5 to 27 inches are estimated to occur in relatively saturated soils located below the historic high groundwater to depths of up to approximately 48 ft.

4.5.2 METHODOLOGY

This section addresses the potential for structural damage due to the local geology underlying the proposed project area, as well as slope instability, ground settlement, unstable soil conditions, and regional seismic conditions. Geologic/geotechnical conditions affecting the site are summarized from compiled information and analyses, including referenced documents/publications and the site-specific Geotechnical Evaluation (Ninyo and Moore 2007), included in Appendix F of this EIR.

4.5.3 THRESHOLDS OF SIGNIFICANCE

The impact significance criteria used for this analysis are based primarily on Appendix G of the State CEQA Guidelines. Project implementation may be considered to have a significant effect related to geology and soils if it would result in one or more of the following:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death, involving 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, strong seismic ground shaking, and seismic-related ground failure, including liquefaction or landslides
- Substantial soil erosion or the loss of topsoil
- 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-site or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code, creating substantial risks to life or property, or
- Be incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater

4.5.4 IMPACTS AND MITIGATION MEASURES

The following impacts of the proposed project have been identified based on project characteristics and the significance thresholds defined above.

4.5.4.1 Less Than Significant Impacts

The following impacts that could result from implementation of the proposed project were evaluated and determined to be less than significant.

Wastewater Disposal. The proposed project would utilize the existing sewer system. The project does not include the use of septic tanks or alternative methods for disposal of wastewater into the subsurface soils. The project area is currently, and will continue to be, sewered by the City of Long Beach (City). Wastewater is transported via underground lines to treatment plants. Therefore, no soil or subsurface impacts related to this issue would occur, and no mitigation is required.

Landslides. The project area is surrounded by flat developed areas, and site topography is relatively level; therefore, the possibility of a seismically induced landslide is not possible. Additionally, the site is not located near any known historical landslides. According to the California Department of Conservation's Seismic Hazard Zones Map for the *Long Beach, Seal Beach, and Los Alamitos, California* quadrangles, the project area does not fall within any earthquake-induced landslide zones. Therefore, impacts from slope instability and/or landslides are not expected and are considered less than significant. No mitigation is required.

4.5.4.2 Potentially Significant Impacts

The following impacts that could result from implementation of the proposed project were evaluated and determined to be potentially significant.

Erosion Potential. The majority of construction involves the replacement of Marina dock facilities in the water and does not involve significant disruption of land side soils. However, there is the potential for soil erosion to occur at the site during project implementation. Construction of the proposed project includes excavation of land side soils to develop the open space/habitat mitigation site, minor grading of land side soils associated with repaving of parking areas, trenching for utilities, and reconstruction of the restrooms.

The project includes the replacement of the paved parking lot surfaces in Basins 1, 2, 3, 4, 6-North (6-N), and 6-South (6-S). The existing asphalt surface would be demolished, broken down, and reused, to the extent possible, as fill for the base course under the new asphalt paving. Repaving areas total approximately 930,622 square feet. However, in order to accommodate the Marina operations, no more than 1 acre of parking lot pavement area would be replaced at any one time. No landscaped islands within the parking lot areas would be removed or altered in size.

All excavation, trenching, and compaction activities would be performed under the observation of a qualified engineer. The project would be required to adhere to all applicable construction standards with regard to erosion control. Erosion control measures typically identify how all construction materials, wastes, or demolition debris, etc., shall be properly covered, stored, and secured to prevent transport into local drainages or coastal waters by wind, rain, tracking, tidal erosion, or dispersion.

In addition, the project would be subject to the Storm Water Pollution Prevention Plan (SWPPP) requirements for erosion and sedimentation control during construction (refer to Section 4.7, Hydrology and Water Quality). Best management practices (BMPs) would be undertaken to control runoff and erosion from any earthmoving activities such as excavation and compaction. The objective of erosion control BMPs is to achieve no net change in the amount of sediments that could impact water quality. Mitigation measures as included in this EIR are required to reduce fugitive dust and transport of soil (refer to Section 4.2, Air Quality, and Section 4.7, Hydrology and Water Quality, respectively). With implementation of these standard control and mitigation measures, soil erosion potential related to construction activities will be reduced to less than significant levels.

Operation of the Marina facilities would not create a potential for soil erosion because the primary use of the project is for waterside recreation in the harbor waters. The repaving of the parking lot areas and reconstruction/remodeling of the restrooms would not result in any

increase in or new impervious areas; the existing landscaped islands within the parking lot areas would not be removed or altered in size. Therefore, long-term operations on site would not result in any soil erosion impacts, and no mitigation is required.

Seismic Considerations. The project site is not located within a currently designated Alquist-Priolo Earthquake Fault Zone, nor is it currently identified by the regulatory community as being located within zones of either primary or secondary co-seismic surface deformation (e.g., pressure ridges, escarpments, or fissures). Therefore, the site is not expected to experience primary surface fault rupture or related ground deformation.

However, since the site is located approximately 0.6 mi northwest of the Newport-Inglewood Structural Zone, significant ground shaking or secondary seismic ground deformation effects could occur at the site should a major seismic event occur along the Newport-Inglewood Structural Zone. A peak ground acceleration of 0.34g can be expected at the site, with a 10 percent chance of exceeding that rate in 50 years. The "predominant earthquake" that contributes most to the ground-shaking hazard at 10 percent probability of exceedance in 50 years is an Mw 7.1 event on the nearby portion of the Newport-Inglewood Fault Zone. This strong ground-motion potential could result in significant seismic ground shaking. As with most areas in Southern California, damage to Marina facilities and infrastructure could be expected as a result of significant ground shaking during a strong seismic event in the region. However, due to the nature of the project being floating docks and slips, impacts to the dock facilities due to earthquakes are expected to be minimal. In addition, one of the project's primary objectives is to renovate the deteriorating Marina facilities in accordance with current codes and seismic requirements.

The project would not change the existing uses on site and would not affect any habitable structures; no new buildings are proposed other than the replacement/remodeling of several restroom structures. The restroom structures will be designed and built in conformance with the adopted California Building Code (CBC), including seismic safety standards. All structures must comply with the seismic requirements of the CBC and the recommended engineering design measures. The project would incorporate current codes and seismic requirements in the replacement and/or renovation of the docks, dock bulkhead landings/ platforms, pilings, Marina restrooms, parking lots, and sea wall repairs. Although compliance with these standard measures is anticipated to limit hazards from seismic ground shaking to less than significant levels, Mitigation Measure 4.5-1 has been proposed to ensure that potential seismic ground-shaking impacts are reduced to less than significant levels.

Liquefaction. Damage from earthquakes may result from liquefaction, which occurs when loose, unconsolidated, water-laden soils are subject to shaking, causing the soils to lose cohesion, and the soil behaves as a fluid for a short period of time. Liquefaction is known generally to occur at depths shallower than 50 ft bgs.

The Geotechnical Evaluation for the proposed project determined that due to the variability of the on-site soils, the potential for liquefaction that would vary across the site. The evaluation indicates that some of the granular soil layers located below the historic high groundwater level (8 ft below the existing ground surface) may liquefy during a seismic event[1] at depths of up to approximately 48 ft bgs for the onshore portions of the site and to depths of approximately 14 ft bgs in the offshore portions of the site. Liquefaction-induced ground settlement is estimated to be in the range of approximately 5–27 inches in the upper 48 ft of the onshore areas of the project site.

As stated above, the proposed project would be designed and implemented in accordance with the City's design standards and all applicable building codes, including the seismic requirements of the CBC and the recommended engineering design measures. Since no habitable structures would be constructed (other than the restroom structures), applicable regulations would primarily involve soil compaction and piling design requirements. Although compliance with these standards is anticipated to limit hazards from seismic liquefaction to less than significant levels, implementation of Mitigation Measure 4.5-1, requiring incorporation of engineering recommendations into final design plans, would ensure that potential seismic ground failure, including liquefaction hazards, is reduced to less than significant levels.

Lateral Spreading and Subsidence. The renovation and replacement of the Marina dock facilities will be undertaken in their present location, where they have been in operation for approximately 50 years. As stated above, land side grading consists of minor disturbance associated with the removal of parking lot pavement and the excavation of soils to develop the open space/habitat mitigation site. For this step of the process, and impacts related to unstable soil conditions are not anticipated. Although there are no geologic units or soils that would become unstable as a result of the proposed project, the Geotechnical Evaluation determined that a seismically induced lateral spread of approximately 1–11 ft could occur during an earthquake event and that with implementation of the engineering design recommendations and compliance with the CBC, the proposed project is feasible. Therefore, Mitigation Measure 4.5-1, requiring compliance with the recommendations contained in the Geotechnical Evaluation, has been proposed to ensure that potential impacts related to unstable soils are reduced to less than significant levels.

Expansive Soils. The soils underlying the project site include sand, clay, and silt. The clay material, which is considered expansive, ranges from very soft to hard silty clay and sandy clay. However, because groundwater levels are historically 8 ft bgs at the project site, the

[1] The design seismic event evaluated in the Geotechnical Report was a 7.5 magnitude earthquake with a peak ground acceleration of 0.34g.

soils are anticipated to remain relatively wet, which would reduce the potential effects of the expansive soils on site. In addition, the project primarily involves waterside construction; land side improvements are limited to shallow excavation of paved areas and construction of the restroom buildings, which are the only structural components of the project. The Geotechnical Report concluded that the restroom structures can be designed on shallow footings with proper preparation on compacted fill.

As stated previously, the Geotechnical Evaluation determined that with implementation of the engineering design recommendations and compliance with the CBC, the proposed project is feasible. Mitigation Measure 4.5-1, requiring compliance with the recommendations contained in the Geotechnical Evaluation, requires the City to review final design plans for structural engineering compliance and to approve the plans prior to the development of the structural components of the proposed project, such as the restroom facilities. Therefore, with implementation of Mitigation Measure 4.5-1, potential impacts related to hazards from geologic and soil conditions will be reduced to less than significant levels.

4.5.4.3 Mitigation Measure

Implementation of the following mitigation measure will ensure that potential geological and soil impacts resulting from project implementation would be reduced to less than significant levels.

4.5-1 Prior to issuance of building permits, the Marine Bureau Manager shall demonstrate to the satisfaction of the Director of Development Services, or designee, that recommendations contained in the Geotechnical Evaluation prepared for the proposed project (Ninyo and Moore, February 2007) have been incorporated into final construction drawings. Design and grading construction shall be performed in accordance with the most current California Building Code in use by the City of Long Beach, the most current local grading regulations, and recommendations of the project geotechnical consultant.

4.5.5 CUMULATIVE IMPACTS

The cumulative study area for Geology and Soils is the project site and the immediately adjacent properties that physically abut the project site. The study area is essentially the area that could be affected by proposed project activities and the areas affected by other projects whose activities could directly or indirectly affect the geology and soils of the proposed project site. The project site encompasses several areas throughout the harbor; however, the majority of the project site is isolated from areas of potential development. In addition, there are no other known activities or projects with activities that would affect the geology and soils at the project site (e.g., projects requiring significant structural blasting or drilling, high vibration activities, deep excavation).

As discussed above, there are no geotechnical conditions on site that will prohibit construction, and no activities associated with the project that would contribute to any incremental effects such as risk of ground failure, slope failure, or settlement problems in the project vicinity. Implementation of Mitigation Measure 4.5-1 ensures that the proposed project complies with recommendations in the Geotechnical Evaluation and that the project would have a less than significant impact on Geology and Soils. Therefore, with implementation of the proposed mitigation, the project's geological impacts are considered less than cumulatively considerable.

4.5.6 LEVEL OF SIGNIFICANCE AFTER MITIGATION

The mitigation measure described above will reduce potential geologic, seismic, and soil-related impacts to below a level of significance. Therefore, there are no significant unavoidable adverse impacts of the proposed project related to Geology and Soils.