# 5.3 Geology and Soils

# 5.3 GEOLOGY AND SOILS

This section evaluates the geologic and seismic conditions within the City of Lake Forest and evaluates the potential for geologic hazard impacts associated with implementation of the proposed project. Information in this section is based on the following documentation:

- *Geotechnical Investigation for Portola Center North Tentative Tract No. 17300, Lake Forest, California*, prepared by Geocon, Inc., dated April 16, 2013 (refer to Appendix 11.3, *Geotechnical Assessment*);
- *Geotechnical Investigation for Portola Center South Tentative Tract No. 15353, Lake Forest, California*, prepared by Geocon, Inc., dated July 6, 2012 (refer to Appendix 11.3, *Geotechnical Assessment*);
- *Addendum to Geotechnical Investigation for Portola Center South Tentative Tract No. 15353, Lake Forest, California*, prepared by Geocon, Inc., dated April 1, 2013 (refer to Appendix 11.3, *Geotechnical Assessment*);
- *Verdura 40/60 Retaining Wall Feasibility Design and Response to Plan Review Comments from the City of Lake Forest* (for Tentative Tract Map Number 17300), prepared by Soil Retention Designs, Inc., dated August 10, 2012 (refer to Appendix 11.3, *Geotechnical Assessment*);
- *Verdura 40/60 Retaining Wall Feasibility Design and Response to Plan Review Comments from the City of Lake Forest* (for Tentative Tract Map Number 15353), prepared by Soil Retention Designs, Inc., dated August 10, 2012 (refer to Appendix 11.3, *Geotechnical Assessment*);
- *City of Lake Forest General Plan* (June 1994); and
- *City of Lake Forest Municipal Code*.

## 5.3.1 EXISTING SETTING

### GEOLOGIC SETTING

The site is part of a larger structurally geologic complicated area of southern California. The regional structure of the area is dominated by homoclinal structure dipping to the southwest and south that involves a full range of clastic sedimentary rocks and layered volcanic rocks present from late the Jurassic to late Miocene period.

The study area comprises a part of the southwestern flank of the Santa Ana Mountains, which is a portion of the Peninsular Range province of southern California. A sequence of Tertiary-age sedimentary rocks, including the Topanga, Puente, and Capistrano Formations, as well as younger sediments, were deposited in a marine basin that was subsequently faulted and downwarped during later Miocene time into a north-trending structural trough known as the Capistrano Embayment. The embayment extended north to the Santa Ana Mountains and received a thick sequence of sediments. Broad, gentle folding, complex north-south faulting, and regional uplift in the last 4 million years then brought these bedrock units to the surface. At present, the bedrock formations are locally capped by Quaternary surficial units including Terrace Deposits, alluvium, colluvium, topsoil, landslide debris, and man-made engineered fill and undocumented fill.

The oldest rocks in the area, the Jurassic units, are exposed at the higher elevations of the Santa Ana Mountains. Often referred to as the basement complex or subjacent series, the Bedford Canyon Formation and the Santiago Peak Volcanic or Mesozoic Metavolcanic Rocks are generally mildly metamorphosed, complexly structured rocks, which supplied most of the material for the younger sedimentary formational units overlying them to the west.

Faults in the region displace rocks at least as late as the Miocene and probably younger. The Cristianitos fault extends adjacent to the western boundary of the property, and is structurally the most significant fault in the local region. However, the Cristianitos fault is considered inactive from a seismicity standpoint.

Based on review of the California Division of Mines and Geology reports and maps and reports and maps prepared by Pacific Soils Engineering, Inc.,[1] the Portola Hills area is and was underlain by several large landslide complexes. The nearest remaining large landslide to the site is located to the north within the Whiting Ranch Wilderness Park. The landslides in the local area have been heavily altered by erosion and are likely related to periods of significantly higher rainfall during the geologic time period of the Wisconsin Glacial Episode. Movement may have been initiated by seismic activity. Similar landslides in South Orange County have been dated by radiocarbon methods at 10,000 to 17,000 years before present. Most major bedrock landslides in the vicinity have failed as block-glide landslides in stratified siltstone and shale layers within the La Vida and Soquel members of the Puente Formation, and because of a regional southwest dip, most of the landslides are on west to southwesterly facing slopes.

The primary geologic unit encountered on the site is the upper Miocene-age Puente Formation which has been regionally subdivided into four members based on its type section in the Puente Hills. The basal unit is the La Vida member consisting of deep marine shale, mudstone, and thin turbidite sandstone beds. The Soquel member conformably overlies the La Vida member and consists of interfingering[2] siltstone and graded sandstone layers. The next member in the sequence is the Yorba consisting of fine-grained deposits of siltstone and mudstone. The upper member consists of the Sycamore Canyon composed of a wide variety of soils consisting of mudstone, sandstone, and conglomerate beds. The lower three members of the Puente Formation are present on the project site.

## SOIL AND GEOLOGIC CONDITIONS

Seven surficial soil types and four geologic formations have been mapped or were encountered during the geotechnical investigation. The surficial units consist of undocumented fill, previously placed engineered fill, topsoil, alluvium, colluvium, landslide debris, and Terrace Deposits. Formational units include the Oso member of the late Miocene- to early Pliocene-age Capistrano Formation, the Yorba, Soquel and La Vida members of the late Miocene-age Puente Formation, and the early Miocene-age Topanga Formation. The formational and surficial units are discussed below in order of increasing age.

[1] Pacific Soils Engineering, Inc., *Preliminary Plan Review, Vesting Tentative Tract No. 15353, Portola Hills, County of Orange, California,* November 5, 1996. This report is incorporated by reference into the Portola Center Geotechnical Investigations that were prepared by Geocon, Inc.

[2] Interfingering occurs when sedimentary rocks laterally change from one type to another in a zone with the two types for interpenetrating edges.

## Undocumented Fill (afu)

In general, the undocumented fill consists of loose, damp to moist, silt and sand with rock fragments and cobbles. In addition, scattered boulders of cemented formational material and concrete with a maximum size of 3 to 4 feet in diameter are present at the surface in the central portion of the site. In its present condition, the undocumented fill soil is not suitable for support of additional fill or structures and remedial grading will be necessary. Undocumented fill is generally suitable for reuse as compacted fill.

## Engineered Artificial Fill (afe)

Previously placed engineered fill underlies the sheet-graded areas of the site. Field investigations for the project site confirm the reported extent, depth, and suitability of the existing fill soil and geologic conditions. In general, previously placed fill consists of silty and clayey sand, silt, and clay, contains gravel- to cobble-size rock fragments, and varies from less than 5 feet to a maximum reported thickness of approximately 130 feet. The majority of the previously placed fill appears to be suitable in its present condition for the support of additional compacted fill and structural loads; however, the upper 3 to 5 feet of the soil has been disturbed due to discing, vegetation, and burrowing animals. Partial removal and recompaction of previously placed fill exists within the site.

## Topsoil (Unmapped)

Topsoil is present as a thin veneer overlying the natural, ungraded slopes, and bedrock materials across the site. The topsoil has an average thickness of approximately 2 to 3 feet based on exploratory excavations performed for the project. The topsoil consists of soft to stiff, loose to medium dense, dry to slightly moist, dark brown, porous, sandy clay to clayey sand with varying amounts of roots and rootlets. Due to the relatively thin thickness and discontinuity of these deposits, the topsoil is not shown on the Geologic Map in Appendix 11.3.

## Alluvium (Qal)

Alluvium is stream-deposited material found in the canyon drainages and generally varies in thickness depending on the size of the canyon and extent of the drainage area. The alluvium consists of firm to stiff, light to dark brown, sandy clay and loose to medium dense, silty to clayey sand. The thickness of the alluvium encountered at the site ranges from approximately 4 feet to more than 10 feet. Alluvial deposits may be deeper in the bottom of the drainages along the southern, eastern, and western margins of the site.

## Colluvium (Qcol)

Colluvium, derived from weathering of the underlying bedrock materials at higher elevations and deposited by gravity and sheet-flow, is present on the side slopes of canyons and the upper portions of the canyon drainages. The colluvium is generally stiff to hard, dry to moist, light to dark brown, sandy clay, and loose to medium dense, clayey to silty sand and clayey silt. The thickness of colluvium generally ranges from approximately 2 to 5 feet. Due to the relatively thin thickness and

discontinuity of the deposits, only the larger areas of colluvium are shown on the Geologic Map; refer to Appendix 11.3.

## Landslide Debris (Qls)

Two areas of recent landslide debris exist within the south site and five areas exist within the north site. The landslides have generally occurred within the thinly bedded siltstone and claystone layers of the La Vida and Soquel members of the Puente Formation. The landslide debris encountered during the geotechnical investigation varied from a few feet to about 16 feet thick and consisted of a mixture of discontinuous rock clasts within a matrix of silt and sand. The landslides are located along the lower portions of the canyon drainages. Landslide debris is not suitable for the support of compacted fill or structures in its present condition and may be subject to further slope instability.

## Terrace Deposits (Qt)

Holocene- to Pleistocene-age, fluvial-derived Terrace Deposits are located on the southwestern portion of the site and the southeastern margins of the site. The deposits generally consist of medium dense to dense, damp to moist, brown to yellowish brown, silty sand with gravel and cobble size material. Localized areas within this unit have been reported to have cemented zones. In addition, loose sand and gravel layers are known to exist. The granular dense portions of the Terrace Deposits typically exhibit favorable shear strength and "very low" to "low" expansive characteristics (expansion index of 50 or less). The Terrace Deposits are generally suitable for the support of compacted fill and structural loads. However, layers of loose sand and gravel may be subject to raveling and erosion where exposed on slopes, and may be prone to settlement.

## Capistrano Formation-Oso Member (Tco)

Late Miocene- to early Pliocene-age Oso Member of the Capistrano Formation is located along the natural slopes on the western portion of the site and natural slopes within Whiting Ranch. The Capistrano Formation is in high-angle fault contact with the older Puente Formation along the Cristianitos Fault in the western portion of the site. The Oso Member of the Capistrano Formation generally consists of fine- to medium-grained sandstone that is white to light yellowish brown, poorly bedded to massive, and weakly to moderately cemented. In general, the sediments of the Oso Member exhibit favorable shear strength and "very low" to "medium" expansion characteristics (expansion index of 90 or less). The Capistrano Formation is suitable for the support of compacted fill and structural loads. Oversize material may be generated from this unit during excavation because of matrix cementation. The Capistrano Formation is suitable for the support of compacted fill and structural loads. Oversize material may be generated from this unit during excavation because of matrix cementation.

## Puente Formation-Yorba Member (Tpy)

The upper Miocene-age Yorba Member of the Puente Formation is exposed on the north portion of the project site at the top and along the west side of the ridge south of Glenn Ranch Road. This unit is the highest member in the sequence within the Puente Formation exposed on the site. The Yorba Member conformably overlies the older Soquel Member of the Puente Formation. The

contact between the two members is generally dipping from south to west. The Yorba Member typically consists of light olive to grayish brown, thinly bedded, moderately indurated, sandy to clayey siltstone. Some of the beds contain high concentrations of evaporate minerals such as carbonates and gypsum. A thin, light gray ash bed was also present approximately 2 inches thick.

In general, the sediments of the Yorba Member of the Puente Formation exhibit low to moderate shear strength and "medium" to "high" expansion characteristics (expansion index of 51 to 130). The Yorba Member is suitable for the support of compacted fill and structural loads. The La Vida Member contains minerals that may be corrosive to steel or concrete.

## Puente Formation-Soquel Member (Tps and Tps-slt)

The upper Miocene-age Soquel Member of the Puente Formation is exposed on the majority of the natural exposures on the site and is the middle member in the sequence. The Soquel Member conformably overlies the older La Vida Member of the Puente Formation. The contact between the two members is generally dipping from south to west. The Soquel Member consists of white to light yellowish brown, massively bedded, weakly to moderately cemented, fine- to coarse-grained (arkosic) sandstone (Tps) and thinly bedded diatomaceous shale and siltstone (Tps-slt). The sandstone portions of this unit are exposed in cut slopes along Glenn Ranch Road and on the lower portions of the natural slopes on the south and western portions of the site. Siltstone layers were observed to interfinger within this unit.

Where exposed within existing cut and natural slopes, the sandstone portions of the Soquel Member (Tps) have been stable, but have been subject to minor raveling and erosion. In general, the granular sediments of the Soquel Member exhibit favorable shear strength and "very low" to "low" expansion characteristics (expansion index of 50 or less). The Soquel Member sandstone is suitable for the support of compacted fill and structural loads. The sandstone is moderately to well cemented and oversize material may be generated in this unit during grading operations because of matrix cementation.

The siltstone portions of the Soquel Member (Tps-slt) exhibit relatively low to moderate shear strength and "medium" to "high" expansion characteristics (expansion index of 51 to 130). The siltstone unit of the Soquel Member is suitable for the support of compacted fill and structural loads; however, stability fills will be required where siltstone is exposed in cut slopes. This unit is typically prone to slope instability and has been subject to slope failures and landslides.

## Puente Formation-La Vida Member (Tplv)

The late Miocene-age La Vida Member of the Puente Formation is present on the natural slope areas on the southeastern portion of the site and east of Saddleback Ranch Road in natural and partially graded slopes. The La Vida Member is conformably overlain by the younger Soquel Member. The contact between the two siltstone members is generally dipping from south to west and is sometimes difficult to distinguish. The La Vida Member typically consists of interbedded siltstone, shale, claystone, and sandstone beds. Deeper within the formation, the siltstone beds are generally unoxidized, very dark gray, well indurated, and shaley. Some of the claystone beds encountered in the borings have been subject to bedding plane shearing and are weak. The La Vida Member is prone to slope instability and has been subject to slope failures and landsliding.

In general, the sediments of the La Vida Member of the Puente Formation exhibit low to moderate shear strength and "medium" to "high" expansion characteristics (expansion index of 51 to 130). The La Vida Member is suitable for the support of compacted fill and structural loads; however, stability fills should be constructed where the La Vida Member is exposed in cut slopes. The unit has locally been subject to deep weathering and slope creep. Deeply weathered and creep-affected areas are compressible and should be removed during remedial grading in areas to receive compacted fill or structural loads. The La Vida Member also contains minerals that may be corrosive to steel or concrete.

### Topanga Formation (Tt)

The middle Miocene-age Topanga Formation is mapped in the southeast margins of the site underlying the La Vida Member of the Puente Formation. This unit typically consists of moderately to well cemented, fine- to medium-grained sandstone.

## GEOLOGIC STRUCTURE

The geologic structure within the project area is characterized by a series of regional fault blocks within the Tertiary-age sedimentary units, which have been tilted generally to the south and west to form dipping bedding. Within the north site, bedding attitudes observed within formational materials encountered during the investigation range from 13 to 43 degrees generally dipping from south to west with most dips ranging 17 to 28 degrees from horizontal. In the south site, bedding attitudes observed within formational materials encountered during the investigation range from 2 to 33 degrees generally dipping from south to west with most dips ranging 10 to 25 degrees from horizontal. Bedding plane shear (BPS) dips and directions tend to be more variable when measured within each borings but are believed to be generally parallel to bedding when compared regionally between borings. However, BPS is commonly discontinuous between adjacent borings.

The granular portions of the sandstone formational units within the Puente and Capistrano Formations (Tps and Tco) are typically massive to poorly bedded. The interbedded siltstone and sandstone units within the Puente Formation (Tplv) and the siltstone units of the Soquel Member (Tps-slt) typically are thinly bedded (less than 2 inches) and are frequently jointed or fractured. Sheared claystone beds exist within the siltstone units, generally along bedding (referred to as bedding plane shears) and frequently with "out-of-slope" orientations. Shear zones create a possibility for slope instability.

The Cristianitos Fault extends along the western portions of the site, juxtaposing the underlying Puente Formation with the younger Oso Member of the Capistrano Formation. Dips should be expected to be considerably steeper in the vicinity of the Cristianitos Fault. Fault strands and shear zones encountered during previous grading operations at several locations on the site were mapped previously.

## GROUNDWATER

The California Division of Mines and Geology Seismic Hazard Evaluation of the El Toro 7.5 Minute Quadrangle indicates that the site is not located within a groundwater basin. The site is

located within the southern portion of Portola Hills and is underlain by bedrock units that are not considered water bearing. Groundwater information presented in this document is generated from data collected in the early 1900s to present.

With the exception of the existing debris basin and drainage structure located on the northwest portion of the site, surface water, such as seeps, springs, or phreatophytes within the existing drainages were not observed. A static groundwater table was not encountered in the exploratory excavations performed during the site investigation. However, localized layers of seepage were encountered within the exploratory borings. It is not uncommon for groundwater seepage conditions to develop where none previously existed due to the permeability characteristics of the geologic units encountered on site. During the rainy season, perched water conditions are likely to develop within the drainage areas that may require special consideration during grading operations. Groundwater elevations are dependent on seasonal precipitation, irrigation, and land use, among other factors, and vary as a result.

# GEOLOGIC HAZARDS

## Faulting

The numerous faults in Southern California include active, potentially active, and inactive faults. The criteria for these major groups are based on criteria developed by the California Division of Mines and Geology (CDMG) (now called the California Geological Survey [CGS]). By definition, an active fault is one that has had surface displacement within Holocene time (about the last 11,000 years). A potentially active fault has demonstrated surface displacement during Quaternary time (approximately the last 1.6 million years), but has had no known Holocene movement. Faults that have not moved in the last 1.6 million years are considered inactive. Based on the CGS Seismic Hazards Map, the site is not located within a State of California Earthquake Fault Zone.

Active or potentially active faults with the potential for surface fault rupture are not known to pass directly beneath the site. Therefore, the potential for surface rupture due to faulting occurring beneath the site during the design life of the project site is considered low. However, the project site is located in the seismically active Southern California region, and could be subjected to moderate to strong ground shaking in the event of an earthquake on one of the many active Southern California faults.

The San Joaquin Hills Thrust, located approximately 5½ miles west of the site, is the closest known active fault. The San Joaquin Hills Thrust is a recently discovered blind thrust fault (fault with no surface expression) having an expected maximum earthquake magnitude (Mw) of 7.1. The fault extends roughly between Huntington Beach and Dana Point, is not exposed at the ground surface, and is typically identified at depths greater than 3 kilometers. This fault and other blind thrust faults are not exposed at the surface and do not present a potential surface fault rupture hazard; however, these active features are capable of generating future earthquakes and ground shaking.

The Cristianitos Fault has been mapped extending along the western margins of the site. The fault was encountered within the fault trench (FT-1) excavated as a part of the Geotechnical Investigations; refer to Appendix 11.3. The fault offsets the Oso Member of the Capistrano Formation and the Soquel Member of the Puente Formation. The fault trends roughly north and

dips at high-angles to nearly vertical. Continuous "A" and "AB" topsoil units extend across the fault trace with no evidence of offset. A fault trench performed north of Glenn Ranch Road in Portola Center North encountered the Cristianitos Fault as a zone of faulting approximately 80 feet wide composed of approximately nine thin fault strands offsetting beds within the Soquel Member of the Puente Formation. Evidence was not observed within the recent and previous fault trenches, and no evidence is present in the literature that suggests the fault offsets Holocene-age material. The Cristianitos Fault is locally overlain by Quaternary terrace deposits ranging in age from an estimated 34,000 to 120,000 years before present and has not been offset by faulting. The onshore portion of the Cristianitos Fault is considered "inactive" by the State Geologist.

## Seismicity

Based on USGS data, 27 known active faults are located within a radius of 50 miles from the project site.[3] The San Joaquin Hills Thrust, located approximately 5½ miles west of the site, is the nearest known active fault and is the dominant source of potential ground motion. Earthquakes that might occur on the San Joaquin Hills Thrust or other faults within the southern California and northern Baja California area are potential generators of significant ground motion at the site. The estimated maximum earthquake magnitude and peak ground acceleration for the San Joaquin Hills Thrust are 7.1 and 0.40g, respectively. Table 5.3-1, *Deterministic Spectra Site Parameters*, lists the estimated maximum earthquake magnitude and peak ground acceleration for the 10 most dominant faults in relation to the site location.

**Table 5.3-1**
**Deterministic Spectra Site Parameters**

| Fault Name | Distance from Site (miles) | Maximum Earthquake Magnitude (Mw) | Peak Ground Acceleration | | |
|---|---|---|---|---|---|
| | | | Boore-Atkinson 2008 (g) | Campbell-Bozorgnia 2008 (g) | Chiou-Youngs 2008 (g) |
| San Joaquin Hills Thrust | 5½ | 7.1 | 0.28 | 0.38 | 0.40 |
| Chino | 10 | 6.8 | 0.21 | 0.19 | 0.21 |
| Elsinore | 11 | 7.85 | 0.26 | 0.21 | 0.28 |
| Newport Inglewood | 15 | 7.5 | 0.20 | 0.15 | 0.19 |
| Puente Hills (Coyote Hills) | 20 | 6.9 | 0.13 | 0.13 | 0.12 |
| Puente Hills | 22 | 7.1 | 0.13 | 0.13 | 0.14 |
| Puente Hills (Santa Fe Springs) | 28 | 6.7 | 0.09 | 0.09 | 0.07 |
| Palos Verdes | 29 | 7.3 | 0.12 | 0.08 | 0.08 |
| Palos Verdes Connected | 29 | 7.7 | 0.14 | 0.10 | 0.12 |
| San Jose | 29 | 6.7 | 0.09 | 0.07 | 0.06 |

Source: Geocon, Inc., *Geotechnical Investigation for Portola Center North Tentative Tract No. 17300*, April 16, 2013 and *Geotechnical Investigation for Portola Center South Tentative Tract No. 15353*, July 6, 2012.

[3] Geocon Inc., *Geotechnical Investigation for Portola Center North Tentative Tract No. 17300*, April 16, 2013 and *Geotechnical Investigation for Portola Center South Tentative Tract No. 15353*, July 6, 2012.

In the event of a major earthquake on the referenced faults or other significant faults in the southern California and northern Baja California area, the project site could be subjected to moderate to severe ground shaking. With respect to this hazard, the site is considered comparable to others in the general vicinity. Ground motion for a 10 percent probability of exceedance in a 50-year period based on an average of several attenuation relationships is depicted in Table 5.3-2, *Probabilistic Site Parameters for Selected Faults California Geologic Survey*.

**Table 5.3-2**
**Probabilistic Site Parameters for Selected Faults California Geologic Survey**

| Calculated Acceleration (g) Firm Rock | Calculated Acceleration (g) Soft Rock | Calculated Acceleration (g) Alluvium |
|---|---|---|
| 0.34 | 0.36 | 0.39 |

Source: Geocon, Inc., *Geotechnical Investigation for Portola Center North Tentative Tract No. 17300*, April 16, 2013 and *Geotechnical Investigation for Portola Center South Tentative Tract No. 15353*, July 6, 2012.

### Liquefaction

Liquefaction typically occurs when a site is subjected to strong seismic shaking, on-site soils are cohesionless or are silt and clay with low plasticity, groundwater is encountered within 50 feet of the surface, and soil relative densities are less than about 70 percent. If the four criteria are met, a seismic event could result in a rapid pore water pressure increase from the earthquake-generated ground accelerations. According to mapping produced by the State of California, there are no areas susceptible to liquefaction mapped at the site.

## 5.3.2 REGULATORY SETTING

### FEDERAL

The purpose of the Federal Soil Protection Act is to protect or restore the functions of the soil on a permanent sustainable basis. Protection and restoration activities include prevention of harmful soil changes, rehabilitation of the soil of contaminated sites and of water contaminated by such sites, and precautions against negative soil impacts. If impacts are made on the soil, disruptions of its natural functions as an archive of natural and cultural history should be avoided, as far as practicable. In addition, the requirements of the Federal Water Pollution Control Act (also referred to as the Clean Water Act [CWA]) through the National Pollution Discharge Elimination System (NPDES) provide guidance for protection of geologic and soil resources.

### STATE

### California Building Code

California building standards are published in the California Code of Regulations, Title 24, known as the California Building Code (CBC). The 2010 CBC applies to all applications for building permits. The 2010 CBC contains administrative regulations for the California Building Standards

Commission and for all State agencies that implement or enforce building standards. Local agencies must ensure that development complies with the guidelines contained in the 2010 CBC. Cities and counties have the ability to adopt additional building standards beyond the 2010 CBC.

## Seismic Hazards Mapping Act

The *Seismic Hazards Mapping Act* became effective in 1991 to identify and map seismic hazard zones for the purpose of assisting cities and counties in preparing the safety elements of their general plans and to encourage land use management policies and regulations that reduce seismic hazards. The recognized hazards include strong groundshaking, liquefaction, landslides, and other ground failure. These effects account for approximately 95 percent of economic losses caused by earthquakes. The Act has resulted in the preparation of maps delineating Earthquake-Induced Liquefaction and Landslide Zones of Required Investigation. The map for El Toro Quadrangle, which encompasses the project area, was issued by the CGS in 2001. The map shows that the creeks and washes within the project area contain Liquefaction Hazard Zones and that there are scattered Landslide Hazard Zones, mostly in the eastern portion of the El Toro Quadrangle.

The CGS provides guidance with regard to Seismic Hazard Zones. Under CGS's Seismic Hazards Mapping Program, seismic hazard zones are identified and mapped to assist local governments in land use planning. The intent of this Act is to protect the public from the effects of strong groundshaking and other hazards caused by earthquakes. In addition, CGS's 2008 Special Publication 117, *Guidelines for Evaluating and Mitigating Seismic Hazards in California*, provides guidance for the evaluation and mitigation of earthquake-related hazards for projects in the designated zones of required investigations. Because the project area contains state-designated hazard areas for liquefaction and landsliding, the City would require site-specific investigations to address the actual soils conditions at each development site and to provide appropriate treatment of those conditions as part of the construction design.

# LOCAL

## City of Lake Forest General Plan

### Safety and Noise Element

The Safety and Noise Element of the Lake Forest *General Plan* is concerned with providing a comprehensive analysis of seismic factors, among other issues, to reduce loss of life, injuries, damage to property, and social and economic impacts resulting from future earthquakes. The Element focuses on current developmental policies, as well as the allocation of future land uses, and its purpose is to serve as a guide for future development such that development will be responsive to seismic safety considerations. To provide a general direction for development in the City, goals, policies, and implementation programs regarding seismic safety are presented in the Element. The goal and policy applicable to the proposed project are:

**Goal 1.0** Reduction in the risk to the community from hazards associated with geologic conditions, seismic activity, and flooding.

**Policy 1.1** Reduce the risk of impacts from geologic and seismic hazards.

**Recreation and Resources Element**

The Recreation and Resources Element of the Lake Forest *General Plan* deals with community goals to protect environmental resources and open space, while providing opportunities for economic development and growth. Resource issues addressed in the Element include parks and other open space, natural resources and features, historic and archaeological resources, and paleontological resources. The Element addresses continued development and enhancement of public involvement in civic activities with relation to these resource issues. To provide a general direction for such development, goals, policies, and implementation programs regarding resource issues are presented in the Element. The mineral resources goal and policies applicable to the Proposed Project are:

**Goal 3.0** Extraction of mineral resources and reclamation of mined land, while preserving the City's plans for future use as described in the Land Use Element.

**Policy 3.1** Provide for the conservation and development of significant identified mineral resource sites within Lake Forest.

**Policy 3.2** Provide for the reclamation of mineral resource sites in concert with future use as described in the Land Use Element and required environmental mitigation.

**Policy 3.3** Regulate mineral extraction activities to minimize hazards and conflicts with other land uses by the issuance of sand and gravel site permits.

**Policy 3.4** Address and mitigate the significant environmental effects of surface mining operations.

## Lake Forest Municipal Code

Site development in the City of Lake Forest is required to comply with the CBC and all state and City requirements pertaining to construction and occupation hazards. As such, the 2010 CBC has been adopted as the base document of the Lake Forest Building Code. The CBC, discussed above under state regulations, is adopted by the City in Title 8, *Buildings and Construction*, of the Municipal Code. The Building Code, as adopted, includes amendments and modifications to the CBC as set forth in Chapter 8.02, *California Building Code*, of Title 8. Chapter 8.30, *Lake Forest Grading and Excavation Code*, of Title 8 contains specific regulations to safeguard life, limb, property, and the public welfare by regulating grading on private property in the City.

The provisions of the City's Building Code are legal requirements: the investigation and treatment of geologic, soils, and seismic conditions through the use of site-specific suitability analyses conducted to establish design criteria for appropriate foundation type and support, are standard. The important information for the City as lead agency is not the specific location and exact extent of unsuitable conditions at each potential construction location, but the knowledge that such conditions have been identified in the project area, that standard techniques are available for avoiding or correcting them, and that oversight responsibility for them is vested in the lead agency.

# 5.3.3 IMPACT THRESHOLDS AND SIGNIFICANCE CRITERIA

## CEQA SIGNIFICANCE CRITERIA

The environmental analysis in this section is patterned after the Modified Initial Study Checklist, and is contained in Appendix 11.1 of this EIR. The Initial Study Checklist includes questions relating to geology and seismic hazards. The issues presented in the Initial Study Checklist have been utilized as thresholds of significance in this section. Accordingly, a project may create a significant environmental impact if it would:

- 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? Refer to Division of Mines and Geology Special Publication 42; refer to Section 8.0, *Effects Found Not To Be Significant*.
    - Strong seismic ground shaking; refer to Section 8.0, *Effects Found Not To Be Significant*.
    - Seismic-related ground failure, including liquefaction; refer to Impact Statement GEO-1.
    - Landslides; refer to Impact Statement GEO-2.
- Result in substantial soil erosion or the loss of topsoil; refer to Section 8.0, *Effects Found Not To Be Significant*.
- 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; refer to Impact Statement GEO-3.
- 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; refer to Impact Statement GEO-4.
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water; refer to Section 8.0, *Effects Found Not To Be Significant*.

Based on these standards, the effects of the proposed project have been categorized as either a "less than significant impact" or a "potentially significant impact." Mitigation measures are recommended for potentially significant impacts. If a potentially significant impact cannot be reduced to a less than significant level through the application of mitigation, it is categorized as a significant unavoidable impact.

# 5.3.4 OVERVIEW OF OSA PEIR GEOLOGY, SOILS, AND MINERAL RESOURCES ANALYSIS

The OSA PEIR analyzed the potential for development in the OSA area to have impacts on geological resources, such as mineral extraction, as well as the as well as the potential for local and regional geological, seismic, and soil conditions.

*Alquist-Priolo Earthquake Fault Zone*. The OSA PEIR (Page 3.6-20) determined that no part of the OSA area is in a known Earthquake Fault Zone as defined by the ***Alquist-Priolo Earthquake Fault Zoning Act of 1994***. As there are no known active faults traces in the OSA area, fault rupture is not anticipated, and there would be no impact in this regard.

*Ground Shaking*. For impacts related to ground shaking, page 3.6-21 of the OSA PEIR indicates that since other active and potentially active faults in Southern California are capable of producing seismic shaking in the OSA area, it is anticipated that the building sites would experience ground acceleration caused by small and moderate magnitude earthquakes on active distant faults. The projects studied in the OSA PEIR are required to apply the California Building Code (CBC) Seismic Zone 4 Standards as the minimum seismic-resistant design for all proposed facilities; include additional seismic-resistant earthwork and construction design criteria, based on the site-specific recommendations of a California Certified Engineering Geologist in cooperation with the project's California-registered geotechnical and structural engineers; and conduct engineering analyses that demonstrate satisfactory performance of any unsupported cut or fill slopes, and of colluvium and/or fill where they form part or all of the support for structures, foundations and underground utilities; and an analysis of soil expansion potential and appropriate remediation (compaction, removal-and-replacement, etc.) prior to using any expansive soils for foundation support. Compliance with these regulatory requirements would reduce potential impacts of seismically induced ground shaking in the OSA to a less than significant level.

*Liquefaction*. As identified on page 3.6-21 of the OSA PEIR, the potential for liquefaction is present in the OSA and the proposed residential and public facilities could experience liquefaction-related damages in the event of a moderate or large earthquake. To reduce the risks associated with seismically induced liquefaction and the associated hazards of seismically induced lateral spreading or subsidence, the same considerations of location and type of subsurface materials are required when designing or retrofitting foundations and structures for a particular site. By monitoring and enforcing the requirements of the Building Code, the City would ensure the structural integrity of the completed project. The OSA PEIR determined that compliance with these regulatory requirements would reduce seismically induced ground failures to a less than significant level.

*Landslides*. As discussed in the OSA PEIR (page 3.6-22), portions of Site 2 (the project site) are underlain by hillside deposits (colluvium) that contain active and dormant landslide features, and alluvium that, in its natural state, could respond poorly to loading during seismic ground motion. State-designated Landslide Hazards Zones occur on the project site. The OSA PEIR concluded that the potential effects of seismically induced landslides would be reduced to less than significant following compliance with the regulatory framework.

*Erosion*. Page 3.6-23 of the OSA PEIR determined that development would expose areas of soil to erosion by wind or water during the construction process. Specific erosion impacts would depend largely on the effectiveness of the required erosion control programs for the sites and the length of time soils would be subject to conditions that would be affected by erosion processes. Earth-disturbing activities associated with demolition and construction would be temporary and would be regulated by the NPDES permitting process. The addition of paved and landscaped areas would, over the long term, decrease the potential for erosion because fewer exposed soils would exist at the sites.

All construction activities associated with the OSA would be required to comply with Chapter 33 of the CBC, which regulates excavation activities and the construction of foundations and retaining walls. Appendix Chapter 33 of the CBC regulates grading activities, including drainage and erosion control. The OSA PEIR concluded that compliance with the NPDES permit process and the CBC requirements would minimize effects from erosion. The City's monitoring and enforcing the requirements of the NPDES permit and the Building Code would ensure the control of potential erosion.

*Unstable Geologic Unit*. The OSA PEIR (page 3.6-24) identified the existence of slightly to moderately compressible, corrosive, and expansive soils within the OSA sites. As part of the construction permitting process, the City requires completed reports of soil conditions at the specific construction sites to identify potentially unsuitable soil conditions including liquefaction, subsidence, and collapse. The City's monitoring and enforcing the requirements of the Building Code, would ensure that unstable soils or geologic units were stabilized or removed and replaced prior to their being used for foundation support. The standards of the City's Building Code would be required to be met prior to project construction. As a result, the OSA PEIR concluded that the potential hazards posed by unstable soils or geologic units would be regulated and reduced to a less than significant level.

*Expansive Soil*. The OSA PEIR (page 3.6-25) states that the existence of slightly to moderately expansive soils at the OSA raises concerns about foundation stability for public facilities, dwellings, roads, and utilities. An acceptable degree of soil stability would be achieved for expansive soils by the required incorporation of soil treatment programs in the excavation and construction plans to address site-specific soil conditions. The City's monitoring and enforcing the requirements of the Building Code would ensure that expansive soils were stabilized or removed and replaced prior to their being used for foundation support. The OSA PEIR concludes that compliance with the City's Building Code would reduce the potential hazards posed by expansive soils to a less than significant level.

*Corrosive Soils*. As discussed in the OSA PEIR (page 3.6-24), the existence of slightly to moderately compressible, corrosive, and expansive soils at the OSA sites makes it necessary to ensure the soils used for foundation support are sound. The OSA PEIR concluded that compliance with the City's Building Code requirements would ensure that the potential hazards posed by unstable soils or geologic units would be regulated and reduced to a less than significant level.

*Septic Tanks*. Page 3.6-25 of OSA PEIR identifies that development in the OSA would be served by existing wastewater treatment facilities. Therefore, no known septic systems or alternative wastewater disposal systems would be installed, and there would be no impact in this regard.

*Mineral Resources*. According to the OSA PEIR (page 3.6-25 and 3.6-25), mineral resource recovery operations occur on Site 4 (gravel mining). However there are no mineral resources identified on Site 2 (the project site). The OSA PEIR concluded that implementation of the OSA PEIR project would not alter the County's projected aggregate production or consumption and therefore no impact would occur.

The OSA PEIR also included Standard Conditions of Approval that require the preparation of precise grading plans, provisions for surface and storm drainage, future geotechnical investigations, structural design recommendations, and infrastructure improvements. Standard Condition of Approval G3 requires site-specific geotechnical investigations for the entire site. This measure has been complied with, as Geocon, Inc. has prepared the following site specific studies: *Geotechnical Investigation for Portola Center North Tentative Tract No. 17300*, dated April 16, 2013 and *Geotechnical Investigation for Portola Center South Tentative Tract No. 15353*, dated July 6, 2012 (Geotechnical Investigations); refer to Appendix 11.3. Standard Condition of Approval G4 requires compliance with the South Coast Air Quality Management District's nuisance and fugitive dust control rules (Rules 402 and 403). The requirements within Standard Condition of Approval G4 are included in Mitigation Measures 3.3-1 through 3.3-7 in Section 5.6, *Air Quality*.

## 5.3.5 IMPACTS AND MITIGATION MEASURES

### SEISMIC-RELATED GROUND FAILURE

#### GEO-1 THE PROPOSED PROJECT WOULD NOT EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS ASSOCIATED WITH SEISMICALLY INDUCED GROUND FAILURE, INCLUDING LIQUEFACTION.

***Impact Analysis:*** According to the OSA PEIR (page 3.6-21) the potential for liquefaction is present in the OSA and the proposed residential and public facilities could experience liquefaction-related damages in the event of a moderate or large earthquake. To reduce the risks associated with seismically induced liquefaction and the associated hazards of seismically induced lateral spreading or subsidence, the same considerations of location and type of subsurface materials are required when designing or retrofitting foundations and structures for a particular site. The OSA PEIR determined that by monitoring and enforcing the requirements of the Building Code, the City would ensure the structural integrity of the completed project. Due to the regulatory requirements, the OSA PEIR determined that seismically induced ground failures would be reduced to a less-than-significant level.

**Liquefaction**

As described above, liquefaction typically occurs when a site is subjected to strong seismic shaking, on-site soils are cohesionless or are silt and clay with low plasticity, groundwater is encountered within 50 feet of the surface, and soil relative densities are less than about 70 percent. If the four criteria are met, a seismic event could result in a rapid pore water pressure increase from the earthquake-generated ground accelerations.

According to mapping produced by the State of California[4], there are no areas susceptible to liquefaction mapped at the site. The potential for liquefaction is considered to be very low due to the presence of drained compacted fill, dense formational units, and the absence of a permanent groundwater table in the upper 50 feet. Therefore impacts would be less than significant in this regard.

**Soil Creep and Lateral Spreading**

The Geotechnical Investigations determined that the planned compacted fill slopes would possess a factor of safety of at least 1.5 for surficial conditions; refer to Appendix 11.3. The surficial condition assumes the soil would be saturated in the upper 3 feet from the slope face. To help mitigate slope creep from occurring, plants with variable root depth would be installed soon after the construction of the slopes. In addition, to avoid surficial slope failure from saturation and loose soil due to gopher holes, rodent abatement would be implemented as part of the slope maintenance. The planned buildings and structures would be setback in accordance with the CBC.

A deformation analysis was performed to address lateral movement and concluded that the slope deformations from the analyses would be greater than the lateral expansion deformations. In addition, the Mechanically Stabilized Earth (MSE) retaining walls would be backfilled with sandy material that possesses a "very low" expansion potential and lateral fill extension from expansion is considered negligible for the MSE walls.

The soil creep zone is usually isolated to the outer 3 to 5 feet of the slope face. The planned residential structures and improvements are not planned within this zone. Foundation recommendations for walls located adjacent to slopes are provided in the Geotechnical Investigations in Appendix 11.3. However, if planned retaining walls or similar improvements that are prone to creeping are proposed at the top of slopes, the Geotechnical Investigations recommend that deepened footings should be incorporated to reduce the effect of lateral fill extension are recommended. Additional Mitigation Measure GEO-1 requires compliance with all recommendations in the Geotechnical Investigations. With implementation of Additional Mitigation Measure GEO-1, impacts would be less than significant in this regard.

***Standard Conditions of Approval:***

G1 Prior to the issuance of precise grading permits, the applicant shall prepare and submit a final (precise) grading plan to the Building Division of the Development Services Department showing building footprints, new and revised pads and elevations of finished grades, drainage routes, retaining walls, erosion control, slope easements, structural best management practices conforming to the approved water quality management plan, and other pertinent information.

G2 Prior to the issuance of precise grading permits, the applicant shall in a manner meeting the approval of the City Engineer:

[4] California Division of Mines and Geology (CDMG), *State of California Seismic Hazard Zones, El Toro Quadrangle,* January 17, 2001.

- Design provisions for surface drainage.
- Design all necessary storm drain facilities extending to a satisfactory point of disposal for the proper control and disposal of storm runoff.
- Dedicate the associated easements to the City of Lake Forest, if determined necessary by the City Engineer.
- Prior to the issuance of any certificates of use and occupancy said improvements shall be constructed in a manner meeting the approval of the City Engineer.

~~G3 Prior to approval of the final design plans and issuance of a grading permit, the applicant shall conduct a site-specific geotechnical investigation for the entire site and prepare a report that fully assesses the geologic and soil conditions of the site. As part of the report preparation, soil sampling and any geotechnical testing will be completed at each location where structures are to be erected. The report shall provide grading and structural design recommendations for avoiding liquefaction, subsidence or collapse for each of the proposed structures. The recommendations shall be implemented by the Project Applicant.~~ *(Standard Condition of Approval G3 is deleted as Geotechnical Investigations have been prepared for the proposed project.)*

~~G4 During project grading and construction activities, the following measures shall be implemented by the applicant as monitored by the Director of Development Services and Director of Public Works/City Engineer.~~

~~A. Normal watering procedures or other dust palliative measures shall be followed during earth moving and construction operations to minimize fugitive dust emissions in compliance with SCAQMD Rule 403. Soil binders shall be spread on site, unpaved roads, and parking area in compliance with Rule 403.~~

~~B. Where practical, heavy duty construction equipment shall be kept on site when not in operation to minimize exhaust emissions associated with vehicles entering and exiting the project site.~~

~~C. Restrict traffic speeds on all unpaved road to 15 miles per hour or less, and provide a flag person to properly guide traffic and ensure safety at the construction site.~~

~~D. Suspend all grading operations when wind speeds exceed 25 miles per hour and during second stage smog alerts.~~

~~E. Comply with SCAQMD Rules 402 and 403 which state that no dust impacts off-site sufficient to be called a nuisance are created and restrict visible emissions from construction and grading, respectively.~~

~~F. Use low emission mobile construction equipment (i.e., tractors, scrapers, dozers, etc.) where practical. Shut off engines when not in use.~~

~~G. Maintain construction equipment in peak operating condition to reduce operating emissions.~~

- ~~Use low sulfur fuel for equipment to the extent feasible.~~
- ~~Use electric equipment whenever practicable.~~
- ~~Moisten soil to grading to 12% soil moisture.~~

- ~~Water exposed surfaces at least twice daily under calm conditions and as often as needed on windy days when winds are less than 25 miles per hour or during dry weather in order to maintain a surface crust and prevent the release of visible emissions from the construction site.~~
- ~~Treat any area that will be exposed for extended periods with a soil conditioner to stabilize soil or temporarily plant with vegetation.~~
- ~~Wash mud-covered tires and under-carriages of any trucks leaving construction sites.~~
- ~~Provide for street sweeping, as needed, on adjacent roadways to remove dirt dropped by construction vehicles or mud, which would otherwise be carried off by trucks departing project sites.~~
- ~~Provide for permanent sealing of all graded areas, as applicable, at the earliest practicable time after soil disturbance.~~

*(Standard Condition of Approval G4 is deleted as these requirements are included in Mitigation Measures 3.3-1 through 3.3-7 in Section 5.6, Air Quality.)*

G5 This project necessitates the construction of public and/or private infrastructure improvements. Prior to the issuance of preliminary or precise grading permits or approval of a Final 'A' or 'B' Map, the applicant shall construct, or enter into an agreement and post security, in a form and amount acceptable to the City Engineer, guaranteeing the construction of public and/or private improvements associated with the grading permit or map, in conformance with applicable City standards and the City's Capital Improvement Policy, including but not limited to:

a. Street improvements including, but not limited to: pavement, curb and gutter, medians, sidewalks, drive
b. Traffic signal systems, interconnect traffic signal preemption devices and other traffic control and management devices
c. Storm drain facilities
d. Subdrain facilities
e. Landscaping and computerized irrigation control system (for all public streets, parks and public areas).
f. Sewer, reclaimed and/or domestic water systems, as required by the appropriate sewer and water districts as well as the Orange County Fire Authority when appropriate.
g. Riding, hiking and bicycle trails adjacent to or through the project site.
h. Undergrounding of existing overhead and proposed utility distribution lines.
i. Transit-related improvements depicted on the approved tentative map

Plans for improvements, including proposed and relocated utility lines, shall be approved by the Public Works Director/City Engineer based on the City's ordinances, standards, and policies, including, but not limited to, those design and construction standards adopted by the City or otherwise reasonably determined by the Director to be applicable to the project. Plans for signing, striping, and other traffic control devices shall be approved by the City Traffic Engineer. Water improvement plans shall be approved by the Fire Marshal, the local water district, and the Public Works Director/City Engineer. The water distribution system and appurtenances shall conform to the applicable laws and

adopted regulations enforced by the Orange County Health Department. Public sewer and reclaimed water improvement plans shall be approved by the local sewering agency and the Public Works Director/City Engineer. The requirement for the reclaimed water line for irrigation is contingent upon an existing line within reasonable proximity to the site. Construction of improvements shall be under the inspection of the Public Works Department.

G6 Prior to issuance of any permit, any easement that lies within or crosses rights-of-way proposed to be deeded or dedicated to the City, shall be subordinated by the applicant to the City prior to City acceptance of the rights-of-way, unless otherwise exempted by the Director of Public Works/City Engineer based on the City's ordinances, standards, and policies, including, but not limited, to those design and construction standards adopted by the City or otherwise reasonably determined by the Director to be applicable to the project.

G7 Prior to issuance of a grading permit, a recordable instrument providing for reciprocal ingress and egress access easements between and among the parcels with access via private drives shall be submitted by the applicant to the City of Lake Forest for review and approval of the City Attorney, Director of Development Services and the Director of Public Works/City Engineer. The instrument shall be approved if it is appropriate recordable form, and adequately provides for reciprocal access in a manner consistent with the City's ordinances, standards, and policies, including, but not limited, to those public design and construction standards adopted by the City or otherwise reasonably determined by the Directors to be applicable to the project.

***Applicable OSA Mitigation Measures:*** No OSA PEIR Mitigation Measures are applicable to this topical area.

***Additional Mitigation Measures:***

GEO-1 Concurrent with submittal of the 40-scale grading plans, the project applicant shall submit a Final Geotechnical Engineering Report for review and approval by the City's Engineer. The Final Geotechnical Engineering Report shall be prepared by a professional engineer and certified engineering geologist licensed by the State of California, in consultation with a corrosion engineer, and demonstrate compliance with the recommendations identified in the Geotechnical Investigations prepared for the project (*Geotechnical Investigation for Portola Center North Tentative Tract No. 17300* [dated April 16, 2013] and *Geotechnical Investigation for Portola Center South Tentative Tract No. 15353* [dated July 6, 2012]), the retaining wall recommendations prepared by Soil Retention Designs Inc. (*Verdura 40/60 Retaining Wall Feasibility Design and Response to Plan Review Comments from the City of Lake Forest* [for Tentative Tract Map Numbers 17300 and 15353, dated August 10, 2012]) and any additional recommendations identified by the City's Engineer. The Geotechnical Investigations and retaining wall recommendations are included in Appendix 11.3, *Geotechnical Investigation*, of this EIR and are incorporated by reference into this mitigation measure.

***Level of Significance After Mitigation:*** Less Than Significant Impact With Mitigation Incorporated.

# LANDSLIDES

## GEO-2 THE PROPOSED PROJECT WOULD NOT EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL LANDSLIDES.

***Impact Analysis:*** As discussed in the OSA PEIR (page 3.6-22), portions of Site 2 (the project site) are underlain by hillside deposits (colluvium) that contain active and dormant landslide features, and alluvium that, in its natural state, could respond poorly to loading during seismic ground motion. State-designated Landslide Hazards Zones occur on the project site. The OSA PEIR concluded that the potential effects of seismically induced landslides would be reduced to less than significant following compliance with the regulatory framework.

Based on field reconnaissance and the subsurface investigation documented within the project geotechnical investigations, five areas of recent landslide deposits exist at the northern site and two areas of recent landslide deposits exist at the southern site, originating in the La Vida Member and the siltstone portions of the Soquel Member of the Puente Formation. The approximate limits and dimensions of the landslides are depicted in Appendix 11.3.

During prior investigations conducted by Pacific Soils Engineering Inc., a landslide was encountered 350 feet north of the West Pad at its closest point within the Whiting Ranch Wilderness Park.[5] Geologic cross-sections are provided within Appendix 11.3 to illustrate the relationship between the existing landslide and the proposed project. This landslide, in its present orientation, does not pose a geologic hazard to proposed development of the site in the current configuration or if the offsite landslide were to re-activate. Previous mapping indicates that several large areas of landslide debris previously existed at the site prior to development. According to a review of the prior geotechnical investigations by Pacific Soils Engineering, these landslides have been removed during the previous grading operations.

The surficial soil (consisting of undocumented artificial fill, the upper 3 to 5 feet of previously placed fill, topsoil, colluvium, alluvium, landslide debris, creep-affected formational material, and loose Terrace Deposits) are not considered suitable for the support of fill or structural loads in its present condition and will require remedial grading in the form of removal, moisture conditioning as necessary, and compaction within the limits of grading. The majority of the previously placed fill, the Terrace Deposits, and formational materials of the Puente and Capistrano Formations are suitable for the support of structures and compacted fill.

Remedial grading operations are generally not planned to extend beyond the limits of grading presented on the tentative tract map with the exception small areas along the west, south, and east portions of the site generally at the toes of slopes and where removal of landslide debris and alluvium would extend to the property line.

Siltstone portions of the Puente Formation contain out-of-slope bedding orientations and bedding plane shears and are prone to slope instability. The landslide deposits observed at the site should be

[5] Pacific Soils Engineering, Inc., *Preliminary Plan Review, Vesting Tentative Tract No. 15353, Portola Hills, County of Orange, California,* November 5, 1996. This report is incorporated by reference into the Portola Center Geotechnical Investigations that were prepared by Geocon, Inc.

removed in the areas of proposed development. With implementation of Additional Mitigation Measure GEO-2, the potential for future landslides is low. Additional Mitigation Measure GEO-2 includes requirements for removal and compaction of landslide debris and for stabilization of proposed slopes. Compliance with Standard Conditions of Approval G1 through G7 and Additional Mitigation Measures GEO-1 and GEO-2 would ensure that potential impacts associated with landslides would be reduced to a less than significant level.

***Standard Conditions of Approval:*** Refer to Standard Conditions of Approval G1 through G7.

***Applicable OSA Mitigation Measures:*** No OSA PEIR Mitigation Measures are applicable to this topical area.

***Additional Mitigation Measures:*** Refer to Additional Mitigation Measure GEO-1 and the following Additional Mitigation Measure:

GEO-2 During grading, the removal of landslide debris and surficial soil shall be evaluated by a qualified geologist to determine the actual depth of removal necessary. Topsoil, colluvium, alluvium, landslide debris, undocumented fill, and the unsuitable portions of previously placed fill and formational materials within the limits of grading shall be removed to expose firm, formational materials or moist, dense previously placed fill. Removals shall be required beyond the toe of slope and extend to the property line to remove landslide debris. The bottom of the excavation should be scarified at least one foot, moisture conditioned as necessary, and compacted prior to the placement of fill material. These recommendations shall be stipulated in the construction contracts, grading plans, and specifications. The project grading plans and specifications shall be subject to review and approval by the City of Lake Forest Department of Public Works.

***Level of Significance After Mitigation:*** Less Than Significant Impact With Mitigation Incorporated.

## UNSTABLE GEOLOGIC UNITS

### GEO-3 DEVELOPMENT OF THE PROPOSED PROJECT WOULD NOT BE LOCATED ON A GEOLOGIC UNIT OR SOIL THAT IS UNSTABLE, OR THAT WOULD BECOME UNSTABLE AS A RESULT OF THE PROJECT.

***Impact Analysis:*** The OSA PEIR (page 3.6-24) identified the existence of slightly to moderately compressible, corrosive, and expansive soils within the OSA sites. As part of the construction permitting process, the City requires completed reports of soil conditions at the specific construction sites to identify potentially unsuitable soil conditions including liquefaction, subsidence, and collapse. The City's monitoring and enforcing the requirements of the Building Code, would ensure that unstable soils or geologic units were stabilized or removed and replaced prior to their being used for foundation support. The requirements of the City's Building Code would be required to be met prior to project construction. As a result, the OSA PEIR concluded that the potential hazards posed by unstable soils or geologic units would be regulated and reduced to a less than significant level.

The Geotechnical Investigations evaluated the proposed slope configurations to calculate both surficial and global stability based on the current geologic information. Adverse geologic conditions including out-of-slope-bedding, bedding plane shears, and weak discontinuous claystone layers exist within the Yorba and La Vida Members of the Puente Formation (Tpy and Tplv) and the siltstone portions of the Soquel Member (Tps-slt). Slopes composed of siltstone formational material are considered potentially unstable if weak layers or adverse bedding orientations are present. Proposed cut slopes within the granular sandstone units of the Puente (Tps) and Capistrano (Tco) Formations should be stable. Overall, the proposed cut and fill slopes could be constructed as planned; however, due to the discontinuous nature of the weak layers within the siltstone portions of the formational materials, predicting or locating isolated layers is difficult. Fill slopes, typically containing integrated MSE retaining walls, are proposed to maximum heights of approximately 100 feet throughout the development. Buttress and stability fills, soil nails and/or shear pins would be required during grading operations where out-of-slope bedding orientations or bedding plane shears detrimentally affect the stability of the proposed slopes.

The slope stability analyses performed for the project site determined that stability fills would be required along cut slopes exposing siltstone units with bedding plane shears and out-of-slope bedding orientations. The approximate shear key widths for the proposed buttress slopes are presented on the Geologic Maps in Appendix 11.3. With incorporation of the recommendations for grading and drainage within the Geotechnical Investigations, the proposed slopes would be stable and would not be impacted from shallow sloughing conditions. Buttress grading plans showing proposed subdrain locations, tie-in and outlet points, and bottom and subdrain elevations would be prepared once the 40-scale grading plans and improvement plans are available to detail this information.

Buttress fills would be required as evaluated using the Cross-Sections within the Geotechnical Investigations (B-B', C-C', E-E', D-D', G-G', H-H', J-J', L-L', N-N', Q-Q', R-R', S-S', T-T', U-U', V-V', and W-W'). Shear pins would be required on the lower slope of Lots 22 through 25 as presented in the calculations for Cross-Sections Q-Q', R-R', T-T', and EE-EE'; refer to Appendix 11.3.

The slope stability analysis (refer to Appendix C within the Geotechnical Investigations [Appendix 11.3]) presents the approximate location of the buttresses. In addition, the approximate widths of the buttresses are presented on the Geologic Map and the Geologic Cross-Sections in Appendix 11.3. Additionally, some areas would possess a fill thickness differential due to the excavation of backcuts for the planned buttresses. The Geotechnical Investigations recommends a review of the limits of the buttresses prior to construction of the project and the settlement potential for the fill differential after the 40-scale grading plans have been prepared.

Cut slope excavations including buttresses and shear keys would be required to be observed full time during grading operations by a Certified Engineering Geologist to check that soil and geologic conditions do not differ significantly from those expected. During the construction of buttresses and during landslide removals, there is a risk for temporary backcut slopes to become unstable. This risk can be reduced by grading the buttress fill in short segments and/or flattening the inclination of the temporary slopes. These excavations would be backfilled as soon as possible after establishing the shear key; refer to Additional Mitigation Measure GEO-3 and GEO-4.

The slope located above Lots 17 through 22 on TTM 17300 (West) would require stabilization that may include one row of shear pins with a buttress below the pin, two rows of shear pins, or soil nails. This area is also affected by surficial slope creep. The shear pins or soil nails would be installed after the zone of the slope creep is removed and replaced by properly compacted fill.

The proposed site design consists of multiple retaining walls located within the westerly, southerly, and easterly perimeter slopes and within internal slopes of the project site. Proposed walls consist of both single and double-tier walls positioned within 2:1 slopes which reach overall heights of up to 120 feet. Individual wall heights reach a maximum of 30 feet. Terraced walls are designed with 2:1 separation slopes or level areas between the walls typically 20 to 30 feet in horizontal distance.

Preliminary information for the planned MSE walls are provided in the slope stability analyses of the Geotechnical Investigations. The reinforcement geogrid type, length, and spacing presented on the slope stability analyses are the estimated minimum requirements for the required factor of 1.5 and 1.1 for static and seismic conditions, respectively. Additional Mitigation Measure GEO-5 requires review of the retaining wall plans by a qualified geotechnical consultant after the walls have been designed. Compliance with Standard Conditions of Approval G1 through G7 and Additional Mitigation Measures GEO-1 through GEO-5 would ensure that potential impacts associated with unstable geologic units would be reduced to a less than significant level.

***Standard Conditions of Approval:*** Refer to Standard Conditions of Approval G1 through G7.

***Applicable OSA Mitigation Measures:*** No OSA PEIR Mitigation Measures are applicable to this topical area.

***Additional Mitigation Measures:*** Refer to Additional Mitigation Measure GEO-1, GEO-2, and the following Additional Mitigation Measures:

GEO-3 During grading, cut slope excavations including buttresses and shear keys shall be observed full time by a Certified Engineering Geologist to confirm that soil and geologic conditions do not differ significantly from those expected. This requirement shall be stipulated in the construction contracts, grading plans, and specifications. The project grading plans and specifications shall be subject to review and approval by the City of Lake Forest Department of Public Works.

GEO-4 Prior to the issuance of any grading permit, the City Engineer shall confirm that all grading plans and specifications require that buttress fill is graded in short segments and/or the inclination of the temporary slopes is flattened to ensure stability of backcut slopes.

GEO-5 Concurrent with submittal of the 40-scale grading plans, the final retaining wall plans shall be reviewed by a qualified geotechnical consultant. Review of the final retaining wall plans shall ensure that the reinforcement geogrid type, length, and spacing presented on the slope stability analyses are the estimated minimum requirements for the required factor of 1.5 and 1.1 for static and seismic conditions, respectively. The review shall also verify that all applicable recommendations from the project Geotechnical Investigations are incorporated.

***Level of Significance After Mitigation:*** Less Than Significant Impact With Mitigation Incorporated.

## EXPANSIVE SOILS

### GEO-4 THE PROPOSED PROJECT WOULD NOT BE LOCATED ON EXPANSIVE SOIL CREATING SUBSTANTIAL RISKS TO LIFE OR PROPERTY.

***Impact Analysis:*** The OSA PEIR states (page 3.6-25) that the existence of slightly to moderately expansive soils at the OSA raises concerns about foundation stability for public facilities, dwellings, roads, and utilities. An acceptable degree of soil stability would be achieved for expansive soils by the required incorporation of soil treatment programs in the excavation and construction plans to address site-specific soil conditions. The City's monitoring and enforcing the requirements of the Grading Code would ensure that expansive soils were stabilized or removed and replaced prior to their being used for foundation support. The OSA PEIR concludes that compliance with the City's Grading Code would reduce the potential hazards posed by expansive soils to a less than significant level.

Based on the project Geotechnical Investigations, the on-site geologic units possess physical and chemical characteristics that may adversely affect the proposed project in their present condition. The analyses within the Geotechnical Investigations expect the soil within the upper five feet of proposed grade to be "expansive" (Expansion Index [EI] greater than 20) as defined by 2010 CBC Section 1803.5.3. Table 5.3-3, *Soil Classification Based on Expansion Index*, presents soil classifications based on the expansion index.

**Table 5.3-3**
**Soil Classification Based on Expansion Index**

| Expansion Index (EI) | Expansion Classification | 2010 CBC Expansion Classification |
|---|---|---|
| 0 – 20 | Very Low | Non-Expansive |
| 21 – 50 | Low | Expansive |
| 51 – 90 | Medium | |
| 91 – 130 | High | |
| Greater Than 130 | Very High | |

Source: Geocon, Inc., *Geotechnical Investigation for Portola Center North Tentative Tract No. 17300*, April 16, 2013 and *Geotechnical Investigation for Portola Center South Tentative Tract No. 15353*, July 6, 2012.

Laboratory Expansion Index testing indicates the on-site material is expected to possess an Expansion Index of 130 or less corresponding to a "very low" to "high" expansion potential. Therefore, additional testing for expansion potential should be performed during grading once final grades are achieved; refer to Additional Mitigation Measure GEO-6. Additionally, excavated soil with an expansion index greater than 90 should be kept at least 4 feet below finish grade in areas of the structural fill, where possible.

### Hydroconsolidation

Hydroconsolidation is the tendency of unsaturated soil structure to collapse upon saturation resulting in the overall settlement of the affected soil and overlying foundations or improvements supported thereon. Potentially compressible surficial soil underlying the proposed structures and existing fill is typically removed and recompacted during remedial site grading. However, if compressible soil is left in-place, a potential for settlement due to hydroconsolidation of the soil exists.

Based on the project Geotechnical Investigations, the results of the laboratory consolidation tests for the fill materials indicate a range of 0.8 percent swell to about 1.3 percent collapse with an average of zero consolidation when water is added. An approximate average degree of saturation of 80 percent on the samples obtained during the investigation was calculated. Therefore, based on the results of the laboratory tests and the calculated degree of saturation of the existing fill materials, settlement due to hydroconsolidation would not affect the proposed project. Compacted fill generally settles up to about 0.4 percent of the fill thickness. Based on the results of the settlement monument readings that were performed roughly 11 to 19 years after fill placement, the average percentage of settlement is about 0.04 percent over a four year period with a near flat settlement average rate of 0.12 inches per year. Therefore, the settlement is near completion for the fill already placed. Impacts in this regard would be less than significant.

***Standard Conditions of Approval:*** Refer to Standard Conditions of Approval G1 through G7.

***Applicable OSA Mitigation Measures:*** No OSA PEIR Mitigation Measures are applicable to this topical area.

***Additional Mitigation Measures:*** Refer to Additional Mitigation Measure GEO-1 and the following Additional Mitigation Measure:

GEO-6 During the grading phase, additional testing for expansion potential shall be performed once final grades are achieved. Excavated soil with an expansion index greater than 90 shall be kept at least 4 feet below finish grade in areas of the structural fill, where possible. These recommendations shall be stipulated in the construction contracts, grading plans, and specifications. The project grading plans and specifications shall be subject to review for expansive soils and approval by the City of Lake Forest Department of Public Works.

***Level of Significance After Mitigation:*** Less Than Significant Impact With Mitigation Incorporated.

## CORROSIVE SOILS

### GEO-5 DEVELOPMENT OF THE PROPOSED PROJECT WOULD NOT ENCOUNTER CORROSIVE SOILS POTENTIALLY RESULTING IN DAMAGE TO FOUNDATIONS AND BURIED PIPELINES.

***Impact Analysis:*** As discussed in the OSA PEIR (page 3.6-24), the existence of slightly to moderately compressible, corrosive, and expansive soils at the OSA sites makes it necessary to

ensure the soils used for foundation support are sound. The OSA PEIR concluded that compliance with the City's Grading Code requirements would ensure that the potential hazards posed by unstable soils or geologic units would be regulated and reduced to a less than significant level.

The Geotechnical Investigations performed laboratory tests on samples of the site materials to evaluate the percentage of water-soluble sulfate content. The results indicate that the on-site materials at the locations tested possess "moderate" to "severe" sulfate exposure to concrete structures. Table 5.3-4, *Requirements for Concrete Exposed to Sulfate-Containing Solutions*, presents a summary of concrete requirements set forth by 2010 CBC Section 1904.3 and American Concrete Institute (ACI) *Building Code Requirements for Structural Concrete*, Standard 318. The presence of water-soluble sulfates is not a visually discernible characteristic; therefore, other soil samples from the site could yield different concentrations. Additionally, landscaping activities (i.e., addition of fertilizers and other soil nutrients) may affect the concentration over time.

**Table 5.3-4**
**Requirements for Concrete Exposed to Sulfate-Containing Solutions**

| Sulfate Exposure | Exposure Class | Water-Soluble Sulfate Percent by Weight | Cement Type | Maximum Water to Cement Ratio by Weight | Minimum Compressive Strength (psi) |
|---|---|---|---|---|---|
| Not Applicable | S0 | 0.00-0.10 | -- | -- | 2,500 |
| Moderate | S1 | 0.10-0.20 | II | 0.50 | 4,000 |
| Severe | S2 | 0.20-2.00 | V | 0.45 | 4,500 |
| Very Severe | S3 | > 2.00 | V+ Pozzolan or Slag | 0.45 | 4,500 |

Source: Geocon, Inc., *Geotechnical Investigation for Portola Center North Tentative Tract No. 17300*, April 16, 2013 and *Geotechnical Investigation for Portola Center South Tentative Tract No. 15353*, July 6, 2012.

The Geotechnical Investigations selected samples to perform potential of hydrogen (pH), resistivity, and water-soluble chloride testing to help evaluate the corrosion potential of the planned improvements. Future studies should evaluate corrosion test results and incorporate the necessary precautions to avoid premature corrosion on buried metal pipes and concrete structures in direct contact with the soils. Therefore, Additional Mitigation Measure GEO-7 requires a registered corrosion engineer to be consulted during preparation of the Final Geotechnical Engineering Report. Compliance with the Building Code and Additional Mitigation Measure GEO-7 would reduce potential impacts associated with corrosive soils to a less than significant level.

***Standard Conditions of Approval:*** No Standard Conditions of Approval are applicable to this topical area.

***Applicable OSA Mitigation Measures:*** No OSA PEIR Mitigation Measures are applicable to this topical area.

***Additional Mitigation Measures:*** Refer to Additional Mitigation Measure GEO-1 and the following Additional Mitigation Measure:

GEO-7 Concurrent with submittal of the 40-scale grading plans, the City's Engineer shall confirm that the project's Final Geotechnical Engineering Report includes recommendations from a corrosion engineer for proper protection of buried metal pipes at the project site.

***Level of Significance After Mitigation:*** Less Than Significant With Mitigation Incorporated.

## 5.3.6 CUMULATIVE IMPACTS

Table 4-1, *Cumulative Projects List*, identifies the related projects and other possible development in the area determined as having the potential to interact with the proposed project to the extent that a significant cumulative effect may occur. The following discussions are included per topic area to determine whether a significant cumulative effect would occur.

### SEISMICALLY INDUCED HAZARDS, UNSTABLE GEOLOGIC UNITS, EXPANSIVE SOILS, AND CORROSIVE SOILS

- **THE PROPOSED PROJECT, COMBINED WITH OTHER RELATED CUMULATIVE PROJECTS, WOULD NOT EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS ASSOCIATED WITH SEISMICALLY INDUCED GROUND FAILURE, INCLUDING LIQUEFACTION.**

- **THE PROPOSED PROJECT, COMBINED WITH OTHER RELATED CUMULATIVE PROJECTS, WOULD NOT EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS ASSOCIATED WITH SEISMICALLY INDUCED LANDSLIDES.**

- **THE PROPOSED PROJECT, AND OTHER RELATED CUMULATIVE PROJECTS, WOULD NOT BE LOCATED ON A GEOLOGIC UNIT OR SOIL THAT IS UNSTABLE, OR THAT WOULD BECOME UNSTABLE AS A RESULT OF THE PROJECT.**

- **THE PROPOSED PROJECT, AND OTHER RELATED CUMULATIVE PROJECTS, WOULD NOT BE LOCATED ON EXPANSIVE SOIL CREATING SUBSTANTIAL RISKS TO LIFE OR PROPERTY.**

- **THE PROPOSED PROJECT, AND OTHER RELATED CUMULATIVE PROJECTS, WOULD NOT ENCOUNTER CORROSIVE SOILS POTENTIALLY RESULTING IN DAMAGE TO FOUNDATIONS AND BURIED PIPELINES.**

***Impact Analysis:*** According to mapping produced by the State of California[6], there are no areas susceptible to liquefaction mapped at the site and the potential for liquefaction is considered to be low. Additionally, project-related impacts from lateral spreading, landslides, unstable geologic units, and expansive/corrosive soils would be reduced to a less than significant level with implementation of Additional Mitigation Measures GEO 1 through GEO-7. The geotechnical characteristics of

[6] California Division of Mines and Geology (CDMG), *State of California Seismic Hazard Zones, El Toro Quadrangle,* January 17, 2001.

each cumulative project site would be evaluated on a project-by-project basis, and appropriate mitigation measures would be required, as necessary to reduce potential impacts to a less than significant level. Further, all development within the City would be required to comply with the City's Building Code and the CBC.

The proposed project would be required to conform to applicable City criteria, adhere to standard engineering practices, and incorporate standard practices of the CBC. Standard Conditions of Approval G1 through G7 and Additional Mitigation Measures GEO-1 through GEO-7 would require the project to incorporate all engineering recommendations contained within the project Geotechnical Investigations to reduce impacts associated with seismically induced hazards, unstable geologic units, expansive soils, and corrosive soils. Therefore, the project would not contribute to cumulative impacts and impacts in this regard are not cumulatively considerable.

***Standard Conditions of Approval:*** Refer to Standard Conditions of Approval G1 through G7.

***Applicable OSA Mitigation Measures:*** No OSA PEIR Mitigation Measures are applicable to this topical area.

***Additional Mitigation Measures:*** Refer to Additional Mitigation Measures GEO-1 through GEO-7.

***Level of Significance After Mitigation:*** Less Than Significant Impact With Mitigation Incorporated.

## 5.3.7 SIGNIFICANT UNAVOIDABLE IMPACTS

No significant impacts related to Geology and Soils have been identified following implementation of the recommended Standard Conditions of Approval and Additional Mitigation Measures GEO-1 through GEO-7 and compliance with the applicable Federal, State, and local regulatory requirements.