4.4 GEOLOGY

This section addresses potential impacts related to geologic and seismic hazards. Specifically, it discusses the potential risk to people and structures in and around the project area resulting from a seismic event or geologic hazard. This evaluation is primarily based on site specific geotechnical feasibility studies prepared by Pacific Soils Engineering, Inc. (1999, 2005a-b, 2006a-d, 2008a-b), Group Delta Consultants, Inc. (2003) and Geotek, Inc. (2012). Additional information was also obtained from the City of Rancho Palos Verdes General Plan Natural Environment Element. The most recent geotechnical report for the project site, prepared by Geotek, Inc. (2012), is included in Appendix D of this EIR. This report presents slope stability analyses with respect to the established geotechnical setback line at the project site and the proposed project. All other referenced geotechnical reports for the site along with the Rancho Palos Verdes General Plan are available for review at the Community Development Department at the Rancho Palos Verdes City Hall, 30940 Hawthorne Boulevard, in Rancho Palos Verdes.

4.4.1 Setting

a. Regional Geology. As described in the Rancho Palos Verdes General Plan Natural Environment Element, the Palos Verdes Peninsula is underlain by a sequence of middle Miocene and younger bedded sedimentary rocks that are draped anticlinally over a core of Mesozoic schist "basement rocks." Both the schist and sedimentary rocks have been intruded by irregular masses of basaltic volcanic rocks. A series of marine terrace benches developed across the rocks of the Peninsula during late Pleistocene and Holocene geologic time (the last few hundred thousand years) and both sandy marine terrace deposits and overlying deposits of landward origin occupy these benches. The landscape in parts of the region has been significantly modified by the movement of massive landslides during the time interval between formation of the oldest terraces and the present (Rancho Palos Verdes General Plan, 1975). The peninsula has been uplifted by movement on two sub-parallel bounding faults, the Palos Verdes fault on the northeast and the San Pedro fault offshore on the southwest.

The faulting and seismicity of Southern California is dominated by the compressionary regime associated with the "Big Bend" of the San Andreas Fault Zone. The San Andreas Fault Zone separates two of the major tectonic plates that comprise the Earth's crust. The Pacific Plate lies west of the San Andreas Fault Zone and the North American Plate lies east of the San Andreas Fault Zone. The relative movement between the two plates is the chief driving force of fault ruptures in the region. The San Andreas Fault generally trends northwest-southeast. However, north of the Transverse Ranges Province, the fault trends in an east-west direction (the Big Bend), causing the fault's right-lateral strike-slip movement to produce north-south compression between the two plates. This compression has produced rapid uplift of many of the mountain ranges in Southern California. North-south compression in southern California has been estimated to be 5 to 20 millimeters per year (SCEC, 1995).

b. Site Stratigraphy. The following description of the site stratigraphy is sourced from the Group Delta Consultants, Supplemental Report Geology and Geotechnical Investigation, performed in 2003. The area which is the subject of this report is larger than the current project site but the information remains relevant. Figure 4.4-1 shows the geotechnical site conditions established by previous geotechnical studies undertaken at the site as well as the locations of geotechnical explorations (borings and trenches) on the current site development plan. Figure 4.4-1 is sourced from Plate 1, Geotechnical Map, included in the most recent geotechnical report for the site which was prepared by Geotek (March 5, 2012).

Fill. Artificial fill has been identified at the site. Artificial fill (afc) placed during grading operations for the construction of Crestridge Road is present along the southerly property boundary. These canyon fills and buttress fills are comprised of reworked bedrock and surficial soils.

Colluvium. Most of the site is covered with a thin (one to three-foot thick) layer of colluvium. The colluvial soils generally consist of a dark gray to black clay matrix with sand to cobble-size material. In most cases, the colluvium is highly expansive and should not be used as fill under structures or pavement. Since this unit is generally thin, it has not been mapped. Where the colluvium has been transported by erosion, it was mapped as slope wash.

Slope wash. Slope wash generally consists of colluvium or bedrock materials that have been eroded and carried onto the slope by rain runoff, and slope creep. The slope wash material is similar to the colluvium and consists of a clay matrix with sand and cobbles. The slope wash deposits are found on the east and west flanks of the large landslide on the descending slope below the north edge of the project.

Alluvium. A deposit of older alluvium has been identified on the high descending slope below the north property line, and above Indian Peak Road. The alluvium consists of clayey to sandy silt and indicates little or no evidence of bedding. The presence of abundant nodules of caliche indicates that this deposit may be older than Holocene.

Bedrock. The bedrock at this site consists of the upper part of the Altamira Shale member of the Monterey Formation. Common to the upper Altamira Shale are the white weathered thin beds of siliceous and phosphoric shale with interbeds of limestone, dolostone, and diatomite. Tuffaceous beds that could alter to bentonite are less commonly present within this member.

Onsite, the Altamira shale member consists mostly of a white to olive gray diatomaceous shale, claystone and siltstone, with dolostone up to 2 feet thick, and banded chert layers that average from 1 to 2 inches in thickness. Light gray siliceous siltstone reported by other investigators correlate to the dolostone beds identified in this study will be addressed as dolostone in this report. Bedded bluish gray sandy volcanic ash layers and clay seams up to one-eight to one inch in thickness are found along shale beds.

c. Geologic Structure. The major structural feature on the site is a roughly east-west trending anticline that is located approximately 100 to 150 feet north of the axis of the ridgeline. The southern limb of this antiform dips at shallow to moderate angles (5-20°) to the south. The northern limb of the antiform coincides with the northerly descending natural slope. In general, this limb of the anticline forms a dip slope condition with bedding angles ranging from 5 to 25°. There is evidence that many small folds are located on the north limb, probably as a result of movement due to contemporaneous settlement during deposition, drag folding from tectonic deformation, gravity creep along bedding, and may also have possibly been affected by

movement of the ancient landslide when it was active. Bedrock joints are well developed along the ridge area of the site and trend in a general east-west and north-south direction, with dips ranging from 70 degrees to vertical. Minor "inactive" faults have previously been observed in trenches excavated on the northerly facing natural slope and on the cut slopes westerly of Crenshaw Boulevard (Group Delta Consultants, 2003). These faults are not interpreted as continuous features and are likely near-surface phenomena resulting from creep affected bedrock.

No large scale or active faulting has been observed on the project site (Group Delta Consultants, 2003). Two inactive faults were mapped in the parcel along Crenshaw Boulevard by Pacific Soils Engineering, Inc. (2000). In addition, a large zone of tension cracks was also exposed in a westerly-facing cut slope made during grading of the adjacent Belmont property to the west of the site (Group Delta Consultants, 2003). This tension feature was located about 240 feet north of Crestridge Road and was confined to a zone about 15 to 20 feet wide. The cracks were infilled with black colluvium material with bedrock particles throughout. Since the exposure was not fully exposed, the depth of the tension cracks could not be determined. These tension features may correlate with the north Crestridge graben fault, which generally lines up with two inactive faults mapped by Pacific Soils Engineering (2000) along Crenshaw Boulevard.

d. Topography. The approximately 9.76-acre project site slopes from south to north from Crestridge Road up to the ridgeline above, including the ridge and a portion of the slope beyond as it descends towards Indian Peak Road. Slopes on the site range from approximately 10% to 40%. Topographically the highest elevation on the site is roughly 1228 feet ± msl located along the apex of the natural ridgeline to a low of approximately 980 feet ± msl toward the northeastern corner of the property (Geotek, 2012).

From the north side of the site an approximately 200+ foot high slope descends down from the property to Indian Peak Road. The majority of this slope is natural and has inclinations ranging from about 3 horizontal to 1 vertical to 2 to 1, and locally as steep as 1 to 1. A 40-foot high cut slope descends from the ridge to the Mirandela Senior Apartments site located adjacent to Crenshaw Boulevard. On the south, existing 12-foot to 40-foot high cut and buttressed fill slopes descend from the ridge down to the level of Crestridge Road.

e. Landslides. Three landslides have been mapped north of the site (Pacific Soils Engineering, 2005). A large ancient landslide complex is present along the northern property line near the center of the site. The landslide is located on the 200+ foot-high descending slope that extends down to Indian Peak Road. The landslide covers about 4.3-acres (Group Delta Consultants, 2003). Previous investigations indicate the landslide is about 25 to 30 feet deep and has failed along bedding on the north-dipping limb of the large anticline located north of the ridgeline (Converse Consultants, 1998). The bottom of the slide is a thin clay seam located at or near the base of a siliceous siltstone bed that dips about 10 to 26 degrees to the northwest. Just above Indian Peak Road, at a depth of about 30 feet, a previously drilled borehole encountered a thin soil layer that the landslide overrides (Group Delta Consultants, 2003). In their 2003 report, Group Delta Consultants noted that the road cut at the bottom of the landslide, just above Indian Peak Road, has developed deep erosion rills.

A bedrock landslide, about 2 to 3 acres in area, was also discovered below the western end of the site above Indian Peak Road, during previous investigations (Group Delta Consultants, 2003). This landslide is about 25 feet thick and has slid over an older alluvial deposit near the toe. This is likely also an ancient feature. Years of farming have rounded off the topography of the ridge and slope, obscuring any surficial expression of the landside.

This ancient landslide sits about 100 feet below the project site. Group Delta Consultants (2003) observed long cracks in the sidewalk along Indian Peak Road at the toe of the landslide that parallel the landslide toe and Indian Peak Road. In addition, at the time they observed that some of the power poles appeared to show some tilt in a downslope direction. The sidewalk cracks had up to an inch of displacement and were confined to the sidewalk. No distress or cracks were noticed on Indian Peak Road.

Another smaller ancient landslide, less than an acre in area, was identified near the north west corner of the site during previous investigations (Group Delta Consultants, 2003). This landslide is about 15 feet deep and the slide plane has a one to two inch thick layer of sheared green-gray clay. The rock in the landslide is highly fractured with abundant carbonate deposits along fractures. Past farming has obscured any surface expression of this feature.

Minor surficial soil failures and evidence of soil creep are also present on the north facing natural slope. These failures appear to be 10 feet or less in thickness and are located along the edge of the large landslide and in the slopewash deposits. These minor failures seem to correlate with the edge of the large landslide (Group Delta Consultants, 2003).

f. Groundwater. No seepage or groundwater was encountered in any borings or trenches during previous investigations at the site, with the exception of groundwater encountered in Boring GDC-9 (Group Delta Consultants, 2003). This borehole was located on the north facing slope below the site about 20 feet above Indian Peak Road. In their report, Group Delta Consultants concluded that the groundwater was locally confined within the more permeable sandstone layer, and likely collected behind the fault which projects across this area of the slope.

g. Seismic Setting. The project area is located within the Peninsular Ranges Geomorphic Province, a seismically active area of Southern California. The Peninsular Ranges are characterized by northwest-trending blocks of mountain ridges and thick sequences of sediment-floored valleys cut longitudinally by young northwest trending fault zones and local low angle thrust faults. Numerous active faults occur within this region as shown on Figure 4.4-2.

The site is located approximately three miles west of the Holocene dextral strike-slip Palos Verdes Fault and approximately 5 miles south to south west of the Compton-Los Alamitos Blind Thrust Fault system. These faults have the potential to generate a maximum credible earthquake of Mw 7.1 and Mw 6.8, respectively.

Other seismogenic faults capable of generating high ground motions at the site include the Los Angeles Basin segment of the Newport-Inglewood Fault Zone, located approximately 10 miles

northeast of the site, and the Elysian Park Blind Thrust system, located approximately 19 miles to the north. These faults have the potential for a maximum credible earthquake of Mw 6.9 and Mw 6.7, respectively. The Cucamonga Fault, which is about 44 miles from the site, is the closest type A fault to the site.

The project area is bound to the north by the southern branch of the Silver Spur Graben normal fault. This fault dips at a high angle to the north and is located north of Indian Peak Road. The fault location has been mapped by Dibblee (1999) as being along or below Indian Peak Road.

Near the south end of the site, the northern branch of the Crestridge Graben normal fault could be present. A fault mapped by Pacific Soils Engineering, Inc. (2000) may correlate with the northern Crestridge Graben fault. The fault mapped by Pacific Soils Engineering dips at about 83 degrees to the south and was mapped during the evaluation of a small senior housing project proposed along Crenshaw Boulevard. A tensional feature was also uncovered during grading of the Belmont Complex to the west that trends in the direction of the faulting mapped by Pacific Soils Engineering along Crenshaw Boulevard. Since this feature was not fully excavated, it could not be determined to be a fault. At that time, the faulting and tension feature was not determined to be active or a fault rupture hazard.

The Cabrillo Fault is located less than 1 mile to the east of the site. The Cabrillo Fault (though mapped as a major structure in the Palos Verdes Hills) is not considered active at this time by the California Geological Survey.

h. Seismic Hazards. Faults generally produce damage in two ways: groundshaking and surface rupture. Seismically induced groundshaking covers a wide area and is greatly influenced by the distance of the site to the seismic source, soil conditions, and depth to groundwater. Surface rupture is limited to very near the fault. Other hazards associated with seismically induced groundshaking include earthquake-triggered landslides and tsunamis. Tsunamis and seiches are associated with ocean surges and inland water bodies, respectively. Neither of these hazards would affect the project area

Ground Rupture. The project area is located outside an Alquist-Priolo Earthquake Fault Zone as defined by the Alquist-Priolo Special Studies Zone Act of 1972 (now the Alquist-Priolo Earthquake Fault Zoning Act), which regulates development near active faults. Thus, as discussed in the Initial Study for the proposed project, the potential for ground rupture to the project area from an active fault is low.

Seismically Induced Ground Shaking. Holocene surface displacement can be recognized by the existence of cliffs in alluvium, terraces, offset stream courses, fault troughs and aligned saddles, sag ponds, and the existence of steep mountain fronts. Potentially active faults are those that have had surface displacement during Quaternary time, within the last 1.6 million years. Inactive faults have not had surface displacement within the last 1.6 million years.

Seismically induced ground acceleration is the shaking motion that is produced by an earthquake. The 1994 Northridge earthquake showed how peculiarities in basin effects could play a significant role in ground accelerations at particular areas. For instance, ground accelerations exceeding 1.0 g were recorded at areas far from the epicenter of the Northridge earthquake.

Probabilistic modeling was completed by Group Delta Consultants (2003) to predict future ground accelerations. The closest active fault to the site is the Palos Verdes Fault, located approximately three miles to the north. This fault has been assigned a maximum credible earthquake of Mw 7.1 (moment magnitude). Based on these parameters and data from a seismic survey performed at the site, Group Delta Consultants recommended that a horizontal acceleration of 0.52g be used as the final site acceleration for building design at the site.

Lateral Spreading. Lateral spreading is the horizontal movement of loose, unconfined sedimentary and fill deposits during seismic activity. The potential for lateral spreading is highest in areas underlain by soft, saturated materials, especially where bordered by steep banks or adjacent hard ground.

Lurching. Ground-lurching is the horizontal movement of soil, sediments, or fill located on relatively steep embankments or scarps as a result of seismic activity, forming irregular ground surface cracks. As with lateral spreading, the potential for lurching is highest in areas underlain by soft, saturated materials, especially where bordered by steep banks or adjacent hard ground. Areas underlain by thick accumulations of slopewash and alluvium are more susceptible than bedrock to ground lurching. Because deposits of loose terrace sands and slopewash were not indicated in geotechnical reports for proposed residential locations, ground lurching is not expected to occur.

i. Soil Related Hazards. Soil related hazards include expansive soils, subsidence, and settlement potential. These types of hazards, and the areas within the project site that have the potential for such failure, are discussed below.

Expansive Soils. During periods of water saturation, soils with high clay content tend to expand. Conversely, during dry periods, the soils tend to shrink. The amount of volume change depends upon the soil swell potential (amount of expansive clay in the soil), availability of water to the soil, and soil confining pressure. Swelling occurs when the soils containing clay become wet due to excessive water from poor surface drainage, over irrigation of lawns and planters, and sprinkler or plumbing leaks. These volume changes with moisture content can cause cracking of structures built on expansive soils. In addition, swelling clay soils can cause distress to lightly loaded structures, walks, drains, and patio slabs. Soils within portions of site have the potential for expansion (Group Delta Consultants, 2003).

Subsidence. Subsidence is the lowering of ground surface. It often occurs as a result of withdrawal of fluids such as water, oil, and gas from the subsurface. When fluids are removed from the subsurface, the overburden weight, which the water had previously helped support through buoyant forces, is transferred to the soil structure. Subsidence typically occurs over a long period of time and results in a number of structural impacts. Facilities most affected by subsidence are long, surface infrastructure facilities such as canals, sewers, and pipelines.

The extraction of groundwater from an aquifer beneath an alluvial valley can result in subsidence or settlement of the alluvial soils. The factors that influence the potential occurrence and severity of alluvial soil settlement due to groundwater withdrawal include: degrees of groundwater confinement; thickness of aquifer systems; individual and total thickness of fine-grained beds; and compressibility of the fine-grained layers. No known areas of subsidence are located on the project site.

Settlement Potential. The possible effects of liquefaction would likely include seismically-induced settlement and potentially lateral spreading. Seismically induced settlement of non-liquefied soil is the settlement that can occur in dry, sandy soils as a result of a seismic shock. No areas known to possess significant settlement potential are located on the project site.

j. Geologic Hazards.

Slope Stability and Landslides. Landslides result when the driving forces that act on a slope (i.e. the weight of the slope material, and the weight of objects placed on it) are greater than the slope's natural resisting forces (i.e. the shear strength of the slope material). Slope instability may result from natural processes, such as the erosion of the toe of a slope by a stream, or by ground shaking caused by an earthquake. Slopes can also be modified artificially by grading, or by the addition of water or structures to a slope. Development on a slope can substantially increase the frequency and extent of potential slope stability hazards. Steep, unstable slopes in weak soil/bedrock units that have a record of previous slope failure typically characterize areas susceptible to landslides. There are numerous factors that affect the stability of the slope, including: slope height and steepness, type of materials, material strength, structural geologic relationships, ground water level, and level of seismic shaking.

As described above, evidence of landslides and steep slopes are present on and near the project site.

k. Regulatory Setting. The City's Safety Element, the California Building Code (CBC), as well as the City of Rancho Palos Verdes Municipal Code attempt to safeguard life, health, property and public welfare. The City's Safety Element is intended to guide land use planning by providing pertinent data regarding geologic, soil, seismic, fire and flood hazards. The CBC is the regulatory environment for design and construction of building codes and standards covering state, federal, land use and environmental regulations which are developed specifically for the purpose of regulating the life safety, health and welfare of the public. The City of Rancho Palos Verdes, along with all of Southern California, is within Seismic Zone 4, the area of greatest risk and subject to the strictest building standards.

The City's Zoning Map identifies an Open Space Hazard line running in an east-west orientation on the northern side of the ridge near the northern boundary of the property. Thus the northern portion of the site is subject to the Open Space Hazard (OH) District regulations as set forth in Municipal Code Section 17.32 - Open Space Hazard (OH) District. (It should be noted that grading would encroach into the OH zoned area, but no structures or active use locations are proposed within the OH line.) This line is shown on the proposed site plan (Figure 2-4 in Section 2.0 *Project Description*).

4.4.2 Impact Analysis

a. Methodology and Thresholds of Significance. The analysis of potential geology-related impacts is based on a review of available site specific geologic studies. Impacts relating to geology are considered significant if the project would:

- *Expose people or structures to substantial risk of loss, injury or death involving rupture of a known earthquake fault, seismic ground shaking, seismically related ground failure (including liquefaction), or landslides;*
- *Result in substantial soil erosion or the loss of topsoil;*
- *Be located on a geologic unit that is unstable or would become unstable as a result of the project, potentially resulting in landslide, lateral spreading, subsidence, liquefaction, or collapse; or*
- *Be located on expansive soil, creating substantial risks to life or property.*

All areas of Southern California are subject to certain risks associated with seismic and geologic activity. Therefore, impacts are considered significant if the project would be exposed to an unusually high potential for hazards associated with ground shaking, landslides, subsidence, liquefaction, or expansive soils without incorporation of appropriate design techniques to minimize their potential to cause substantial risk of loss, injury, or death.

As discussed in the Initial Study for the proposed project, the potential for surface rupture in the project area is considered low as is the potential for liquefaction to occur. Also, the site is not located in an area that is subject to settlement due to seismic shaking, liquefaction, or lateral spreading. Therefore, these issues will not be discussed in the following section. For further detail see Appendix A.

b. Project Impacts and Mitigation Measures.

Construction of the proposed project involves excavation of the existing slope to accommodate flat building pads stepping gradually upward. Much of the ridge itself would be removed and graded generally flat. The maximum depth of excavation would be approximately 40 feet. Site preparation would involve excavation of approximately 145,000 cubic yards of material (soil and rock) and placement of approximately 2,000 cubic yards of fill material. In addition, the northern portion of the site adjacent to Vista del Norte preserve would be landscaped and developed with a system of paved pedestrian paths. Impacts related to grading activities are addressed in Sections 4.2 (*Air Quality*), 4.5 (*Greenhouse Gases*), 4.6 (*Hydrology*), 4.7 (*Noise*) and 4.8 (*Traffic*).

Impact GEO-1 **Seismically induced ground shaking could destroy or damage structures and infrastructure, resulting in loss of property or risk to human safety. However, mandatory compliance with applicable City of Rancho Palos Verdes and California Building Code requirements would reduce impacts to a Class III, *less than significant*, level.**

Given the highly seismic character of the Southern California region and the project site's proximity to known active and potentially active faults, severe ground shaking is anticipated during the life of the new residences that could be built under the proposed ordinance revisions. As discussed in *Setting* above, several active and potentially active faults are located in the region. These include the Palos Verdes Fault, Elysian Park Blind Thrust system, the Compton-Los Alamitos Blind Thrust Fault system and the Newport-Inglewood fault and among others.

Two faults are present on the Peninsula: the Palos Verdes and Cabrillo Faults. The active Palos Verdes fault trends northwest-southeast and marks the eastern termination of the Palos Verdes Hills. The Palos Verdes Fault is located approximately three miles north of the project area and is considered to have the most substantial effect on the site from a probabilistic design standpoint. No known active or potentially active faults underlie the project area. However, earthquakes along any of the faults in the region could potentially damage buildings and pose risks to human health and safety. Construction of the new senior housing units would be required to comply with the California Building Code (CBC) standards. CBC standards require that structures are built to resist forces generated by ground shaking during an earthquake. With mandatory compliance with CBC standards, impacts from ground shaking would be less than significant.

Mitigation Measures. As impacts would be less than significant with required adherence to existing regulations, no mitigation is required.

Significance after Mitigation. Impacts would be less than significant without mitigation.

Impact GEO-2 The slope stability analysis prepared for the project site concluded that the on-site existing and proposed slopes could be subject to landslides. This is considered a Class II, *significant but mitigable impact.*

Hazards resulting from landslides encompass several categories. In general, landslides are downslope motions of earth material. They occur because the earth materials lose their ability to maintain their integrity at a specific gradient and settle into a lesser gradient or position of greater equilibrium.

The most significant geological/geotechnical issue concerning site development is the stability of the northerly facing natural slope. This 200+ foot high, descending slope is located outside and below the northern property line. This slope descends down to Indian Peak Road. The majority of this slope is natural and has inclinations ranging from about 3 horizontal to 1 vertical (3:1) to 2:1, and locally as steep as 1:1. Some cut and fill grading was done along the toe of the slope during the construction of Indian Peak Road. Other than fine/shallow grading for landscaping adjacent to/north of the proposed structural development, no grading of this slope is planned as part of the proposed project.

Slope stability evaluations for the site were conducted during a number of the previous geotechnical studies for the project site, with the most recent performed by Geotek in 2012. Based on the analyses conducted, a Structural Setback Line has been established for the site. That setback line, which is shown on Figure 4.4-1, represents an interpreted location where slope stability analyses would yield a calculated factor of safety of 1.5 under static conditions.

This is the minimum acceptable factor of safety for permanent slopes under static conditions.[1] The areas north of the line would generally be considered to have a calculated factor of safety less than 1.5 under static conditions, while the areas south of the line would generally be considered to have a calculated factor of safety greater than 1.5, also under static conditions.

In addition, Pacific Soils Engineering (2006b) recommended establishment of a "Special Foundation Zone" south of the structural setback line. This 40-foot zone was established to address the higher displacement values in this area of the site. Pacific Soils Engineering recommended that proposed structures within this zone be founded on mat slabs and design differential settlement of 2.5 inches in 30 feet be used in the design of the mat slabs in this area. A differential settlement value of 1 inch in 30 feet is recommended for structural elements located south of this 40-foot zone. This 40-foot wide Special Foundation Zone is shown on Plate 2 of the Pacific Soils Engineering Report dated October 19, 2006 and can be viewed at the Rancho Palos Verdes Community Development Department.

On the south, along Crestridge Road, existing 12-foot to 48-foot high cut-fill slopes descend from the ridge and the bedrock has out of slope bedding of up to about 20 degrees. The previous analysis undertaken by Group Delta Consultants (2003) assumed that any existing buttress fill on the slope would be removed and replaced with a new buttress fill. Based on the results of their analyses, a 25-foot wide buttress is required along the southern slope, to maintain a static factor of safety of at least 1.5 and a seismic factor of safety of 1.1. The key should be 25-feet wide by 2 feet deep, and should be inclined into the slope with a 1-foot deeper heel. For more details please see the Group Delta Consultants, Inc. 2003 report.

Finally, a retaining wall is planned along the eastern boundary of the site. The majority of this wall would be located at the top of an existing southeast facing cut slope. Owing to variations in the geologic structure, portions of this existing slope expose daylighted bedding. As such, the slope is considered unstable and requires remediation.

All properly constructed slopes are considered to be grossly and surficially stable. However, any slope would be subject to erosion and degradation with time, due to both natural and man-made conditions. Therefore, impacts related to slope stability and seismically induced landslides are considered a potentially significant impact.

Mitigation Measures. The following measures are required to address the potential impact resulting from seismically included landslides.

GEO-2(a) Compliance with the recommendations included in the previous geotechnical studies undertaken at the site shall be required. These recommendations include maintenance of a uniform, near optimum moisture content in the slope soils, and avoidance of over-drying or excess irrigation, which will reduce the potential for softening and strength loss. In addition, slope maintenance shall include the immediate planting of the slope with approved, deep rooted, lightweight, drought resistant vegetation, as well as proper care of

[1] Safety factor is defined as the quotient of the sum of forces tending to resist failure divided by the sum of forces tending to cause failure.

erosion and drainage control devices, and a continuous rodent control program. Brow ditches and terraces shall be cleaned each fall, before the rainy season, and shall be frequently inspected and cleaned, as necessary, after each rainstorm. Access to the slopes, including foot traffic outside of designated pedestrian footpaths, should be minimized to avoid local disturbance to surficial soils. The City of Ranch Palos Verdes Public Works Department shall review and approve all final plans for slope maintenance prior to issuance of a grading permit.

GEO-2(b) The proposed retaining wall at the top of the existing cut slope at the eastern boundary of the site shall be designed as a buried retaining wall to support the project and underlying adverse geologic structure. The system requires a design and depth of embedment that would safeguard onsite improvements in the event the offsite slope failed.

GEO-2(c) An as-graded geotechnical report shall be prepared by the project geotechnical consultant following completion of grading. The report shall include the results of in-grading density tests, and a map clearly depicting buttress fill keyway locations and depths, removal area locations and depths, sub-drainage system locations and depths and geological conditions exposed during grading.

GEO-2(d) The applicant shall install permanent inclinometer stations at the site to allow the northern slope to be monitored for possible movement following implementation of the project. The number and location of the inclinometer stations shall be determined by the City Geologist. The applicant shall submit a record of inclinometer readings along with any recommendations from a geotechnical engineer to the City every six months during the lifetime of the project or until the City Geologist agrees that semi-annual readings are no longer necessary. In addition, readings and geotechnical recommendations shall be submitted to the City following a heavy rainfall event (>2 times average monthly rainfall) or following a magnitude 5.0 or greater seismic event within 20 miles of the project site.

If the geotechnical engineer determines that sufficient movement has taken place that warrants further corrective or preventative action, the project applicant shall be responsible for all expenses associated with the costs of implementing any remediation recommended by the geotechnical engineer to ensure that the slope remains stable. Further monitoring by inclinometers may be required, if recommended by the geotechnical engineer or required by the City.

Significance After Mitigation. Implementation of the above measure would reduce impacts related to seismically induced landslides to acceptable engineering standards. Thus, impacts to the development project area would be reduced to a less than significant level.

Impact GEO-3 The proposed project is located in an area underlain by expansive soils. Impacts relating to expansive soils are considered Class II, *significant but mitigable*.

As discussed in *Setting*, expansive soils swell or heave with increases in moisture content and shrink with decreases in moisture content. Based on laboratory testing, the site soils and bedrock have an Expansion Index of about 68 to 104[2]. On this basis, these materials are classified to have a medium to high expansion potential (Group Delta Consultants, 2003). The shrinking and swelling of soil beneath structures can potentially result in cracking of foundations and other structural damage. The potential for property damage relating to the on-site shrink-swell of soils is considered a potentially significant impact.

Mitigation Measures. The following measures are required to reduce soil expansion/ contraction impacts.

GEO-3(a) **Geotechnical Recommendations.** Prior to issuance of any Grading Permit or Building Permit, the project applicant shall comply with all recommendations contained within the Geology and Geotechnical Investigation prepared by Group Delta Consultants (2003) including:

- Following grading, the expansion potential of the exposed subgrade shall be tested. The design of foundations and slabs shall consider the high expansion potential. Following completion of grading and until slabs and footings are poured, the exposed soil and bedrock materials shall be periodically wetted to prevent them from drying out. Pre-saturation is also recommended.

GEO-3(b) **Expansive Soil Removal and/or Treatment.** Suitable measures to reduce impacts from expansive soils could include one or more of the following techniques, as determined by a qualified geotechnical engineer and approved by the City of Rancho Palos Verdes Public Works Department:

- Excavation of existing soils and importation of non-expansive soils. All imported fill shall be tested and certified by a registered Geotechnical Engineer and certified for use as a suitable fill material; and
- On-site foundations shall be designed to accommodate certain amounts of differential expansion in accordance with Chapter 18, Division III of the UBC.

[2] By adding water to a soil sample while measuring its deformation or expansion potential, a soils engineer can compare the result to a scale or Expansion Index. The American Society of Testing Materials (ASTM D 4829) has published a test method and an Expansion Index to quantify the results. The Expansion Index range and potential expansion is as follows: 0-20: Very Low; 21-50: Low; 51-90: Medium; 91-130: High; >130: Very High.

Significance After Mitigation. If the mitigation measures above are implemented, the impacts related to soil expansion would be reduced to a less than significant level.

c. Cumulative Impacts. Proposed, pending and future development projects would increase structural development within the City of Rancho Palos Verdes. Such development would expose new residents and property to potential risks from seismic hazards in the area. The proposed project would incrementally contribute to these cumulative impacts. However, development projects would be subject to City review on a case-by-case basis, and subject to applicable CEQA review. The City of Rancho Palos Verdes shall require that all new structures comply with the latest Uniform Building Code seismic design standards, as well as supplemental design criteria necessary to ensure that buildings are designed so as to avoid structural collapse, along with application of standard engineering practices and conformity to the City Municipal Code. Potential impacts from future development would be addressed on a case-by-case basis and appropriate mitigation would be designed to mitigate impacts resulting from individual projects. Therefore, cumulative impacts would be less than significant.