IV. ENVIRONMENTAL IMPACT ANALYSIS
E. GEOLOGY AND SOILS

INTRODUCTION

This Draft SEIR chapter describes the environmental setting for the proposed project, including the project site's geologic environment based on recent site reconnaissance conducted on July 2, 2012 by Herzog Geotechnical Consulting Engineers and on January 16, 2013 by Gilpin Geosciences Inc. This section is also based on published and unpublished geologic reports and maps from the United States Geological Survey (USGS), California Geological Survey (CGS), Natural Resources Conservation Service (NRCS), County of Marin, and the Town of Ross. The environmental setting also describes the project regulatory framework. Following the setting, impacts that could result from implementation of the proposed project are evaluated, and mitigation measures to reduce impacts to a less-than-significant level are recommended, where appropriate.

In addition, the information and analysis in this section refers to the following site-specific reports, which are included in Appendix G-1 – G-4 of this Draft SEIR:

- Geotechnical Investigation for the Upper Road Land Division Project, Ross, California, Herzog Geotechnical Consulting Engineers, July 20, 2012.
- Third Party, Geotechnical/Geologic Review, Berg Subdivision EIR Project, Upper Road, Ross, California, Gilpin Geosciences Inc., March 29, 2013.
- Response to Geotechnical Peer Review, Upper Road Land Division, Vesting Tentative Map, Assessor's Parcel 073-011-26, Ross, California, Herzog Geotechnical Consulting Engineers, May 28, 2013.
- Review of Herzog Geotechnical 28 May 2013 Letter, Third Party Geotechnical/Geological Review, Berg Subdivision EIR Project, Upper Road, Ross, California, Gilpin Geosciences Inc., June 18, 2013.

ENVIRONMENTAL SETTING

Geology

The project site, like all properties in the San Francisco Bay area, is situated in a seismically active area (Donaldson Associates 2006). The regional seismic setting is dominated by stress associated with the oblique collision of the Pacific tectonic plate with the North American tectonic plate. The boundary between the two tectonic plates is the San Andreas Fault system, which extends nearly 700 miles along a northwest trend from Mexico to offshore northern California.

Soils

The project site is located in the Coast Ranges geomorphic province that is characterized by northwest-southeast trending valleys and ridges. These are controlled by folds and faults that resulted from the collision of the Farallon and North American plates and subsequent shearing along the San Andreas Fault. Bedrock in the region is primarily comprised of Upper Jurassic to Lower Cretaceous (~160-100 million years ago) Franciscan Complex rocks consisting of greenstone, sandstone, shale, chert, and localized limestone overlain by Quaternary alluvium, and colluvium. The site vicinity has been mapped (Figure IV.E-1) as Franciscan Complex interbedded shale and sandstone with areas of mélange. Landslide deposits are mapped blanketing most of the bedrock beneath the site (Gilpin Geosciences, March 29, 2013).

Subsurface exploration indicates that bedrock conditions (lithology and depth to rock) vary markedly throughout the site. The areas of proposed development are underlain primarily by sandstone and shale. The sandstone and shale are typically moderately strong, closely to intensely fractured, deeply to moderately weathered and nonexpansive. Mélange matrix encountered was weak, pervasively sheared, deeply weathered and weathers to expansive clay locally. Greenstone occurs locally, predominately in the form of large blocks up to 50 feet across within the mélange. Occasional hard and strong greenstone and graywacke blocks and inclusions were encountered along spur ridges and within drainages. In particular, there is a band of greenstone blocks (up to 40 feet high) that lines the head of Frog Swale at an elevation of 350-400 feet that is interpreted by the Draft SEIR Geologist as either a dike or more likely blocks within the mélange (a metamorphic rock formation) that have been exposed by weathering. Sandstone and shale bedrock was mapped and encountered upslope and downslope of this band of greenstone outcrops. In addition, smaller (car size) greenstone blocks lie downslope from this outcrop within the Frog Swale drainage but appear to have been detached from this outcrop and have slid downslope. Due to subsequent erosion, these blocks now lie on shallow dipping slopes and do not appear to be a rockfall or landslide hazard (Gilpin Geosciences, March 29, 2013).

The depth to competent bedrock varies throughout the site from 1 to over 13 feet below the existing ground surface (Herzog, 1982, 1989). Benched areas on the site slopes commonly correspond to changes in bedrock composition.

Deep colluvial soils of stiff sandy silts, sandy clays, and clayey sands are common throughout the site. Generally, these soils appeared well consolidated, only slightly compressible, and non-expansive. There was no testing to back up the soil plasticity index; only visual identification, the sandstone and shale frequently weather to expansive soil (Herzog, 1982).

Areas of extensive landslide debris were mapped in combination with colluvium as unit “Qsc,” predominately along slopes lining the eastern Swan Swale. These soils varied from dry and stiff clayey gravels, to wet and soft expansive sandy clays (Herzog, 1982).

Other landslide deposits appeared to be relatively old dormant features (Herzog, 1982). There is an area of active sliding downslope and to the south and west of the abandoned "cabin" about

65 feet downslope of the proposed road alignment. A fresh scarp and debris slide of approximately 4- 6 feet deep extends downslope with the toe encroaching Swan Swale.

There does not appear to be any significant active slope failures within the areas of proposed development or in the areas upslope from the property that could be attributed to the intense winter storms of 1981-1982 (Herzog, 1982).

Topography

The property is characterized by a steep to precipitous (typically 40 to 80 percent gradients), east-facing hillslope and intervening ravines and gullies. Elevations on the property generally are between 100 and 550 feet; however, the westernmost corner of the property rises to an elevation of approximately 675 feet. The area to the west of the property continues to rise in elevation to the crest of Bald Hill at an approximate elevation of 1,000 feet. The eastern property boundary is located immediately upslope of Ross Creek, a northeast-trending stream canyon. The southern property boundary roughly follows the crest of an east-trending spur ridge, which has a moderate slope gradient on the order of 15 to 25 percent. A second, moderately sloping (15 to 25 percent gradient) spur ridge crosses the northern portion of the property.

Overland drainage is characterized as uncontrolled sheetflow and channeled flow in two ravines (Swan Swale and Frog Swale) that are directed to the east where they are intercepted at the base of the hillslope by Ross Creek. Ross Creek flows northeastward from Phoenix Lake, located approximately 1,300 feet southeast of the property.

Groundwater

Groundwater was not encountered in any of the test pits. However, shallow subsurface groundwater seepage was encountered during Gilpin Geosciences site reconnaissance in the central-northern part of the site approximately 200 feet (horizontal) west of, and 100 feet upslope of Swan Swale in a small tributary.

Seismic Conditions

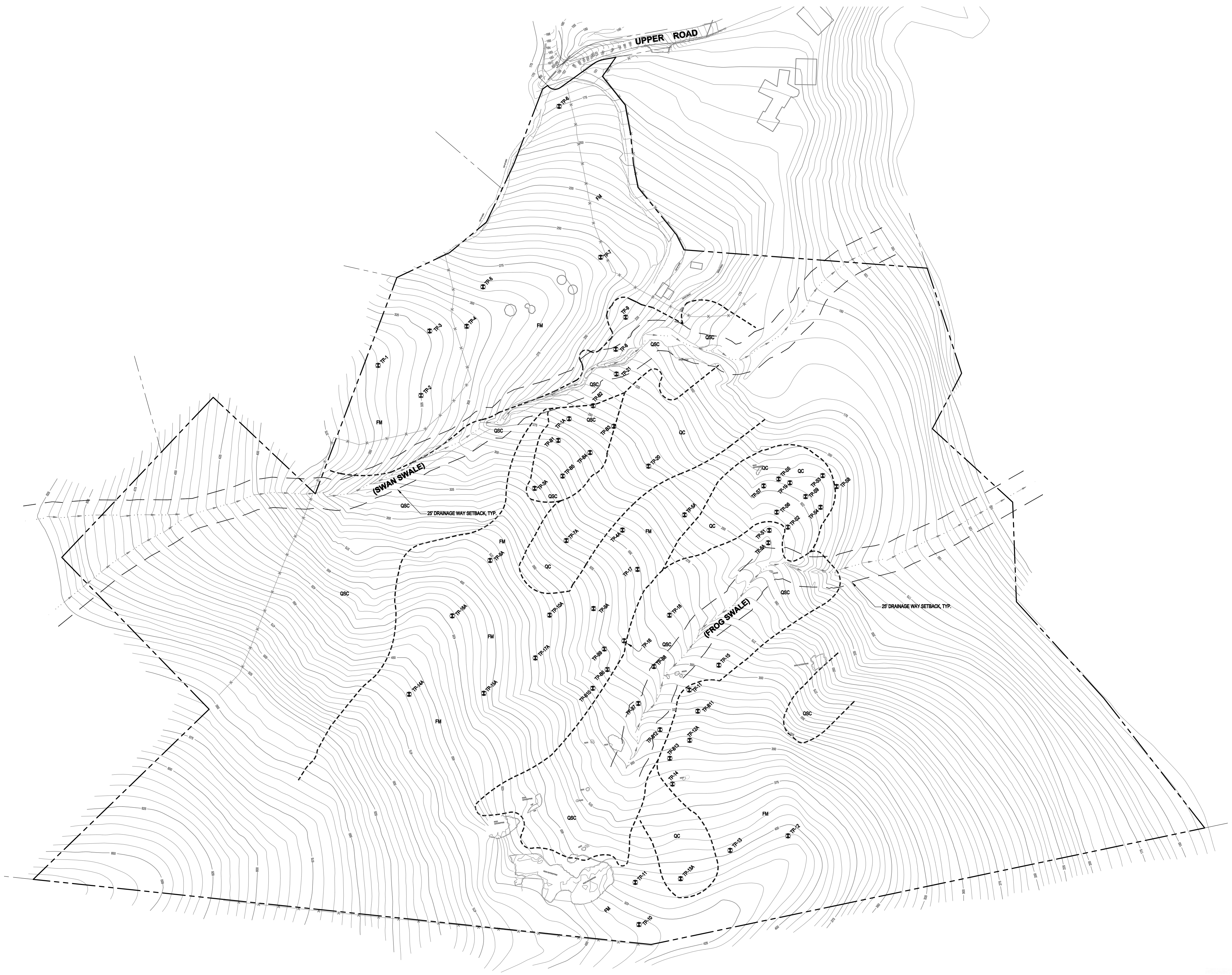
The severity of an earthquake is measured by magnitudes and intensities. Magnitude is a measure of the energy released by an earthquake. Intensity is a subjective measure of the perceptible effects of an earthquake at a given point and varies with distance from the epicenter and local geologic conditions. The Modified Mercalli Intensity Scale (MMI) is the most commonly used scale for measurement of the subjective effects of earthquake intensity and is shown in Table IV.E-1. Intensity can also be quantitatively measured using accelerometers (strong motion seismographs) that record ground acceleration at a specific location. Acceleration is measured as a fraction or percentage of the acceleration of gravity (g).

The entire San Francisco Bay Area is located in a larger area of active seismicity. The seismicity of the region is primarily related to the San Andreas Fault Zone (SAFZ), a complex of active faults forming the boundary between the North American and the Pacific plates.

Historically, numerous moderate to strong earthquakes have been generated in northern California on several major faults and fault zones in the SAFZ system. During a major earthquake on one of the active or potentially active nearby faults, very strong to violent (MMI VIII-IX) ground shaking is expected to occur at the project site. Strong shaking can result in ground failures, such as those associated with liquefaction, settlement, lateral spreading, and cyclic soil densification.

The U.S. Geological Survey's Working Group on California Earthquake Probabilities estimated that there is a 63 percent probability that a 6.7 or greater magnitude earthquake will occur in the San Francisco Bay Area between 2008 and 2038. The probability of a 6.7-magnitude or greater earthquake occurring along individual faults was estimated to be 21 percent along the San Andreas Fault, 31 percent along the Hayward-Rodgers Creek Fault, and 7 percent along the Calaveras Fault. When predictions are expanded to 100 years, it is estimated that about three Moment Magnitude (Mw) 6.7 or greater events could occur during that time. Thus, the probability of at least one Mw 6.7 or greater earthquake rises to the near certainty of about 96 percent when calculated for a 100-year span.[1]

[1] *Working Group on California Earthquake Probabilities 2007 (WGCEP), 2008. The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2): USGS OFR 2007-1437 and CGS Special Report 203 http://pubs.usgs.gov/of/2007/1437.*



LEGEND

TP-12A	TEST PIT
	LITHOLOGIC CONTACT
FM	FRANCISCAN MELANGE. A MIXTURE OF ROCK TYPES INCLUDING SANDSTONE, SILTSTONE, GREENSTONE, CHERT AND SHEARED SHALE
QC	COLLUIAL SOILS, WHERE RELATIVLEY DEEP DEPOSITS EXIST, GENERALLY GREATER THAN SIX FEET DEEP.
QSC	COMINATION OF COLLUIAL SOILS AND SLIDE DEBRIS, PLANAR CONTACTS IN SOME PITS, OTHERS CONTAING WEAK, SOFT AND POTENTIALLY UNSTABLE MATERIALS

0 200

Figure IV.E-1. Geotechnical Constraints - Existing Conditions

Upper Road Land Division Project
Town of Ross, California

ENVIRONMENTAL CONSULTANTS

Date: OCTOBER 2012
Source: CSW | Stuber-Stroeh Engineering Group, Inc.

P:\Projects\22000\22141\Figures\EIR Figures\22141-figures

Table IV.E-1
Modified Mercalli Intensity (MMI) Scale

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

Geologic Hazards

Active Faults

The major active faults in the area are the San Andreas, Rodgers Creek, Hayward Faults, and Concord/Green Valley, and West Napa. For each of the active faults, the distance from the site and estimated maximum Moment magnitude (USGS, 2008) and Cao et al. (2003) are summarized in Table IV.E-2. The Town of Ross is not located within an Alquist-Priolo zone, so the risk of seismically induced ground rupture is low (Town of Ross 2007a). No active faults are known to exist in the Ross planning area (Town of Ross 2007a). The subject property is located approximately seven miles northeast of the active San Andreas fault zone, which is responsible for several large historic earthquakes in northern California, including those reported in 1800 (San Juan Bautista area), 1838 (San Francisco to Santa Clara), and 1865 (Santa Cruz Mountains).

Table IV.E-2
Regional Faults and Seismicity

Fault Segment	Approximate Distance from Site (km)	Direction from Site	Mean Characteristic Moment Magnitude*
San Andreas -North Coast	11	West	7.5
Total Hayward	18	East	6.9
Total Hayward – Rodgers Creek	18	East	7.3
North Hayward	18	East	6.5
Rodgers Creek	19	Northeast	7.0
West Napa	37	Northeast	6.5
Concord - Green Valley	44	East	6.7
Mount Diablo	48	East	6.7

Source: Gilpin Geosciences, March 29, 2013.
**Moment magnitude is an energy-based scale and provides a physically meaningful measure of the size of a faulting event. Moment magnitude is directly related to average slip and fault rupture area.*

The largest northern California earthquake was the 1906 San Francisco earthquake (M=7.9), in which an estimated 270-rnile-long segment of the San Andreas fault ruptured from near Fort Bragg to Hollister. That earthquake was felt from the Oregon border south to Los Angeles, and as far east as Nevada. The 1906 San Francisco earthquake had an estimated Moment Magnitude (Mw) of 7.8 and created a surface rupture along the San Andreas Fault approximately 290 miles long, with a maximum horizontal surface displacement of about 21 feet. (Gilpin Geosciences, March 29, 2013). The epicenter of the 1906 event is estimated to be offshore of the San Francisco coastline near the Golden Gate, southwest of the site. Strong shaking also occurred at many sites in the East Bay and extensive damage was documented.

The recent Loma Prieta Earthquake (Mw 6.9) was centered on or near the San Andreas fault more than 70 miles from the site. It produced moderate ground shaking and minor damage in the San Rafael area.

The Rodgers Creek and Hayward faults form the main subsidiary faults making up the San Andreas Fault System in the East Bay and Northern San Francisco Bay Region. These faults lie approximately 18 km from the site and are capable of generating magnitude 7.0 to 7.3 earthquakes.

Two moderate earthquakes (Richter Magnitude 5.6 and 5.7) occurred on the Rodgers Creek fault near Santa Rosa in 1969. These earthquakes resulted in widespread minor damage and localized structural damage in Sonoma County but no significant damage in the San Rafael area.

Ground Shaking

Ground shaking is a general term referring to the motion of the earth's surface resulting from an earthquake. Ground shaking is normally the major cause of damage in seismic events. The extent of ground shaking is controlled by the magnitude and intensity of an earthquake, distance from the epicenter, and local geologic conditions. The recent Loma Prieta Earthquake (Mw 6.9) was centered on or near the San Andreas fault more than 70 miles from the site. It produced moderate ground shaking and minor damage in the Ross area.

The San Andreas Fault is the controlling fault in terms of future ground shaking estimates. Probabilistic seismic hazard analysis from the State of California Geological Survey estimates peak horizontal ground acceleration at the site having a 10 percent probability of exceedance in 50 years to be 0.483g (CGS, 2005).

Liquefaction

Liquefaction is the temporary transformation of loose, saturated granular sediments from a solid state to a liquefied state as a result of seismic ground shaking. In the process, the soil undergoes a temporary loss of strength, which commonly causes ground displacement or ground failure to occur. The project site is in an area mapped by the USGS and Association of Bay Area Governments (ABAG) as having a very low susceptibility to liquefaction within a majority of the site. Furthermore, in order for liquefaction to occur, two criteria must be met: 1) potentially liquefiable soils must be present, and 2) those soils must be saturated or nearly saturated (i.e., high ground water levels). The majority of liquefaction hazards are associated with sandy soils, certain gravelly soils, and silty soils of low plasticity. Cohesive soils, similar to the majority of non-bedrock materials encountered on the property, are generally not considered to be susceptible to liquefaction. Liquefaction is not a significant hazard at the project site, because the geologic materials that are normally susceptible to liquefaction are not present (Gilpin Geosciences, March 29, 2013; Donaldson Associates 2006). Soil liquefaction could result in limited localized ground failures, such as lateral spreading where proximity to steep-sided stream banks could result in localized failures. To mitigate the potential for adverse impacts associated with lateral spreading, the project's Geotechnical consultant has set back the building envelope areas from the edges of the steep-sided stream banks. (Gilpin Geosciences, March 29, 2013).

Landslides

Slope stability issues can result in either slow slumping earth movements or rapid landslide events. Mudflows are a particular type of landslide, and can occur where colluvial soils and detritus become saturated and flow downslope, usually following existing or historic stream channels. Mudflows can also occur as a result of denuded slopes and channels, for instance after a wildfire event, which can result in weakened soil conditions and soil saturation during rain events resulting in increased slope instability. The potential impacts of landsliding and hillslope instability are the most significant geologic hazards at the project site, and mitigation of potential slope instability is the most serious geologic problem to overcome. Elevations on the property generally are between 100 and 550 feet; however, the westernmost comer of the property rises to an elevation of approximately 675 feet. The presence of extensive landslide deposits and thick colluvium deposits on the property indicate a moderate to high potential for future slope instability and proposed construction activities could potentially decrease existing slope stability in localized areas. As detailed in Section IV.F (Hazards and Hazardous Materials) of this Draft SEIR the proposed project is According to CAL FIRE, the project site is not located within a Very High Fire Hazard Severity Zone (VHFHSZ) but the site is located directly adjacent to a VHFHSZ.[2]

Expansive Soils

Expansive soils swell and shrink as they gain and lose moisture and lightly loaded foundations, slabs and pavements can heave and crack. Clay mineralogy, clay content, and porosity of the soil influence the change in volume. The shrinking and swelling caused by expansive clay-rich soil can result in damage to overlying structures. As part of the geotechnical investigation, soil samples were collected and analyzed. The testing indicated that portions of the on-site soils are moderately expansive. Expansive soils swell and shrink as they gain and lose moisture and lightly loaded foundations, slabs and pavements can heave and crack.

[2] *CAL FIRE, 2008. Marin County Very High Fire Hazard Severity Zones in LRA. http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones_maps.php, accessed June 26, 2013.*

REGULATORY SETTING

The following discussion describes the regulatory context (including regulatory agencies and policy documents) for geologic and seismic issues as they relate to development on the project site.

Alquist-Priolo Earthquake Fault Zoning Act (A-PEFZA)

The A-PEFZA's main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active earthquake faults. Surface rupture is the most easily avoided seismic hazard. The A-PEFZA was passed in December 1972 to mitigate the hazard of surface faulting in structures used for human occupancy. The A-PEFZA only addresses the hazard of surface fault rupture and is not directed toward other earthquake hazards. As discussed below, the Seismic Hazards Mapping Act, passed in 1990, addresses non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides.

Seismic Hazards Mapping Act (SHMA)

In 1990, following the 1989 Loma Prieta earthquake, the California Legislature enacted the SHMA to protect the public from the effects of strong ground shaking, liquefaction, landslides, and other seismic hazards. The SHMA established a state-wide mapping program to identify areas subject to violent shaking and ground failure; the program is intended to assist cities and counties in protecting public health and safety.

California Building Code

The 2006 Uniform Building Code (UBC) is published by the International Conference of Building Officials (ICBO) and is the widely adopted model building code in the United States. The 2010 California Building Code (CBC) is another name for the body of regulations known as the California Code of Regulations (CCR), Title 24, Part 2, which is a portion of the California Building Standards Code (CBSC). The CBC incorporates, by reference, the UBC requirements with necessary California amendments. Title 24 is assigned to the California Building Standards Commission, which, by law, is responsible for coordinating all building standards. Under State law, all building standards must be centralized in Title 24 or they are not enforceable.

Compliance with the 2010 CBC requires that (with very limited exceptions) structures for human occupancy be designed and constructed to resist the effects of earthquake motions. Every structure is assigned a Seismic Design Category ranging from A to D (with D representing the most severe conditions) based on each structure's occupancy category and the severity of the design earthquake ground motion at the site in accordance with either CBC Section 1613 – Earthquake Loads or American Society of Civil Engineers (ASCE) Standard No. 7-05, Minimum Design Loads for Buildings and Other Structures. The classification of a specific site and related calculations must be determined by a qualified person and are site-specific.

ENVIRONMENTAL IMPACTS

Thresholds of Significance

In accordance with Appendix G of the CEQA Guidelines, the proposed project could have a significant environmental impact if it would:

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

   i. 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.

   ii. Strong seismic ground shaking.

   iii. Seismic-related ground failure, including liquefaction.

   iv. Landslides.

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

c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.

d) Be located on expansive soil, as defined in the Town Building Code, creating substantial risks to life or property.

e) 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.

Geology and Soils Issues not Further Analyzed

The following issues were addressed in the Initial Study (see Appendix A) and Section IV.A of the Draft SEIR and were determined to result in no impact or a less-than-significant impact and not warrant further analysis:

- Rupture of a Known Earthquake Fault
- Seismic-Related Ground Failure, Including Liquefaction
- Septic Systems

Based on the 2006 SEIR and associated geotechnical reports, no active or potentially active faults have been identified on the project site. Consequently, the hazard associated with potential surface fault rupture is considered to be ***less than significant***.

The project site is in an area mapped by the USGS and ABAG as having a very low susceptibility to liquefaction within a majority of the site. Furthermore, in order for liquefaction to occur, two criteria must be met: 1) potentially liquefiable soils must be present, and 2) those soils must be saturated or nearly saturated (i.e., high ground water levels). The majority of liquefaction hazards are associated with sandy soils, certain gravelly soils, and silty soils of low plasticity. Cohesive soils, similar to the majority of non-bedrock materials encountered on the property, are generally not considered to be susceptible to liquefaction. Liquefaction is not a significant hazard at the project site, because the geologic materials that are normally susceptible to liquefaction are not present (Donaldson 2006). However, portions of the site adjacent to Ross Creek are illustrated as having very high susceptibility.[3] These areas will not be developed as part of the proposed project. Therefore, the proposed project would not expose people or property to seismic-related ground failure, including liquefaction and impacts would be ***less than significant.***

No impact is anticipated related to the use of septic tanks or other wastewater disposal systems as the proposed project would connect sewer lines to the existing sewer mains located adjacent to the project site running underneath Upper Road. Therefore, ***no impacts*** are anticipated.

Impacts and Mitigation Measures

The proposed project will consist of subdividing an approximately 36-acre property into three residential lots. From the new project entrance at Upper Road, a 20-foot wide access way would extend about 992 feet connecting Upper Road to 12-foot wide driveways for Parcels 1, 2 and 3. The common road is shown climbing the ridge on Parcel 3 in a series of switchbacks that are graded in cuts. However, the profile requires stacked (up to 3) 6-foot high concrete retaining walls above the road and in some sections up to 26-foot high retaining walls on the downslope side of the alignment. The curving entranceway would have a maximum slope of 18 percent compared to the 27 percent average slope of the existing topography at this location.

The project objectives of balancing cut and fill on-site and reducing road grades is proposed to be accomplished by taking the cut material from the road system and incorporating it into a single surplus fill pad on Parcel 1 supported by up to six stacked 6-foot high concrete retaining walls. The fill is graded with irregular contours which is intended to preserve the adjacent Redwood grove and swales. The result is that no material would be off-hauled by truck. Total cut and fill has been reduced 62.5 percent from 61,500 cubic yards (CY) in the prior design to

---

[3] *ABAG, 2006. Bay Area Liquefaction Susceptibility Mapping based on USGS OFR 00-444. Accessed June 26, 2013 at http://gis.abag.ca.gov/website/LiquefactionSusceptibility/index.html.*

23,100 CY in the proposed project. Figure IV.E-2 illustrates the proposed grading over the existing on-site geotechnical constraints and Figure IV.E-3 illustrates geotechnical constraints cross sections.

Impact GEO-1: Strong Seismic Ground Shaking

All structures and improvements in the Bay Area could potentially be affected by ground shaking in the event of an earthquake on regional active faults. Ground shaking potential is estimated on a worst-case basis by assessing the maximum expected earthquakes and calculating the peak accelerations that may be generated. Due to the proximity of the project site to regional faults (including the San Andreas Fault), the project may be subjected to very strong to violent ground shaking during a major earthquake. During the service life of the proposed project, the site is likely to experience at least one moderate to severe earthquake that could produce potentially damaging ground shaking.

Violent ground shaking corresponds to an MMI-IX, and typically some masonry and frame structures would be damaged, unbolted structures shifted off their foundations, and people would have difficulty standing or walking. This level of seismic shaking could cause injuries and/or fatalities and extensive structural and non-structural damage to buildings at the site. This is a ***potentially significant*** impact.

Mitigation Measure GEO-1: Strong Seismic Ground Shaking

Project design and construction shall be in conformance with current best standards for earthquake resistant construction in accordance with the California Building Code. In addition, project design shall follow the recommendations of a final site-specific geotechnical investigation report and the October 12, 1989 and May 28, 2013 reports prepared by Herzog (Appendix G). All recommendations for seismic and geohazard impact mitigation provided in the October 12, 1989 and May 28, 2013 reports and the final site-specific geotechnical investigation reports shall be adopted by the project design and engineering team and implemented during development and construction of the project. The following mitigation measures are from the October 12, 1989 and May 28, 2013 reports prepared by Herzog:

Mitigation Measure GEO-1a: Strong Seismic Ground Shaking

Upon completion of the final wall layout, the modular retaining wall design should be finalized based on at least the following minimum factors of safety:

Failure Mode	Static	Seismic[4]
A)Base sliding	1.5	1.1
B) Overturning	1.5	1.1
C) Bearing Capacity	2.0	1.2
D) Tensile Overstress	1.0	1.0
E) Pullout	1.5	1.1
F) internal Sliding	1.5	1.1
G) Shear (bulging)	1.5	1.1
H) Connection	1.5	1.1
I) Global Instability	1.5	1.1

Wall facing shall be provided with backdrains. The backdrains will consist of a four-inch diameter, rigid perforated pipe which is located at the base of the wall and which is surrounded by a drainage blanket. The pipe shall be PVC Schedule 40 or ABS with an SDR of 35 or better, and the pipe shall be sloped to drain at least one percent by gravity to an approved outlet. Accessible sub-drain cleanouts shall be provided, and shall be maintained on a routine basis. The drainage blanket shall consist of Caltrans Class 2 "Permeable Material." The drainage blanket shall be at least one foot in width and will extend to within one foot of the surface. The uppermost one foot shall be backfilled with compacted soil to exclude surface water.

Compacted fill behind the modular walls shall be founded on level benches excavated into bedrock or approved competent soils. The depth of required benches shall be as recommended by the project engineering geologist during excavation. It will be necessary to provide sub-drains on the benches at least every 15 vertical feet and where evidence of seepage is observed, as recommended by the project engineering geologist. Site excavation, fill compaction and sub-drainage installation shall be performed in accordance with the previous grading recommendations for the project.

Mitigation Measure GEO-1b: Strong Seismic Ground Shaking

Retaining walls shall be designed to resist surcharge pressures imposed by adjacent upslope retaining walls. Where an imaginary 1-1/2:1 (horizontal: vertical) plane projected downward from the base of an upslope retaining wall intersects the downslope wall, that portion of the downslope wall below the intersection shall be designed for an additional horizontal uniform pressure equivalent to the maximum calculated lateral earth pressure at the base of the upslope wall. Wall backfill shall be founded on level benches excavated into competent bedrock.

---

[4] *A seismic coefficient (kh) of at least 0.15 should be used in the design of the modular walls.*

Mitigation Measure GEO-1c: Strong Seismic Ground Shaking

All utility lines, including power, water, sewer, and gas must be moderately flexible to accommodate potential differential settlement between areas of compacted fill and native soils or rock. Where utilities are located in creeping soils, it will be necessary to provide flexible joints to accommodate creep movement. Lines that extend through engineered fills shall not be subject to significant creep, and these fills are considered as being suitable for utility line construction. If utilities extend through unrepaired slide areas, it will be necessary to extend the utilities into firm rock beneath the potential zone of movement.

Mitigation Measure GEO-1d: Strong Seismic Ground Shaking

Pavement thicknesses shall be computed using Method 301-F of the CalTrans Pavement Design Manual and will be based on a pavement life of 20 years.

After utility trenches are properly backfilled, compacted, and tested, pavement subgrade shall be prepared by scarifying to a depth of at least six inches, moisture-conditioning to wet of optimum, and compacting to at least 95 percent relative compaction. Finished subgrade shall be smooth and non-yielding. Aggregate base material shall then be spread, moisture·conditioned as necessary, and compacted to at least 95 percent relative compaction. The aggregate base material shall also be smooth and non-yielding.

In areas where concentrated storage and/or wheel loads are anticipated, the slabs and pavements shall be designed to support these loads. Support shall be provided by increasing pavement sections or by providing reinforced concrete slabs. Loading areas for self-loading garbage trucks shall be designed with reinforced concrete slabs of at least six inches thick, and reinforced with #4 bars at 12-inch centers each way.

Pavements shall be constructed during the dry season to avoid the saturation of the subgrade and base materials, which often occurs during the wet winter months. Pavements constructed during the dry season generally have a longer service life and require less maintenance than those constructed during the wet season.

If pavements are constructed during the winter, unstable areas shall be overexcavated to remove soft soils. The excavations will probably require backfilling with imported crushed rock. The soils engineer shall be consulted for recommendations at the time of construction if this condition is encountered. Where pavements will abut landscaped areas, the pavement baserock layer and subgrade soils shall be protected against saturation from irrigation and rainwater by means of a concrete curb and gutter, redwood header-board, a subdrain, or a thickened asphalt concrete section. The curb and gutter, headerboard, subdrain, or thickened asphalt shall extend to a depth of at least six inches below the bottom of the baserock layer.

Mitigation Measure GEO-1e: Strong Seismic Ground Shaking

Spread Footing Foundations

Conventional continuous and isolated spread footing foundations shall be used wherever level excavations expose strong bedrock. Spread footings shall be at least 12 inches wide and extend at least 12 inches into undisturbed rock. The footings shall be stepped as necessary to produce level tops and bottoms. Footings shall be deepened, as necessary, to provide at least seven feet of horizontal confinement between the footing bottoms and the face of the nearest slope.

Footings installed shall designed using the allowable bearing pressures of 2,000, 3,000, and 4,000 pounds per square foot (psf), for dead loads, dead plus code live loads, and total loads (including wind and seismic), respectively.

The portion of spread footing foundations extending into rock and at least seven horizontal feet from the face of the nearest slope may impose a passive equivalent fluid pressure and a friction factor of 350 pcf and 0.40 respectively, to resist sliding.

Mitigation Measure GEO-1f: Strong Seismic Ground Shaking

Drilled Piers

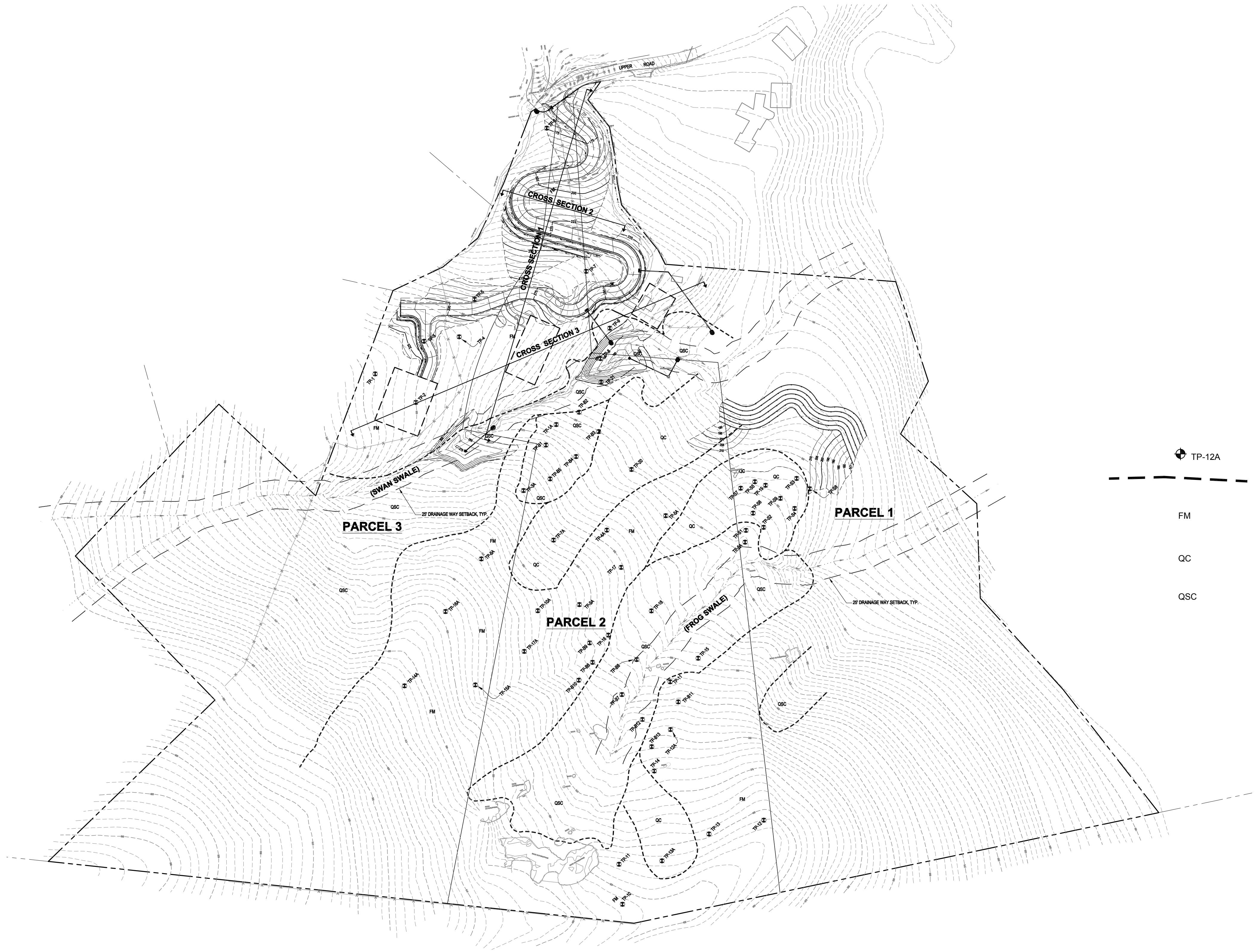
Drilled cast-in-place reinforced concrete piers shall be used to support retaining walls wherever level cuts do not extend through the soil and expose rock. The piers shall be designed by the project structural engineer. All piers shall be reinforced with at least four No.5 bars and be tied together with grade beams. The grade beams shall be designed to span between the piers in accordance with structural requirements. The portion of the piers extending into undisturbed rock may impose an allowable skin friction of 800 pounds per square foot (psf). The portion of the piers in compacted fill or dense/stiff soil beneath the colluvium may impose an allowable skin friction of 600 psf. End bearing shall be neglected because of the difficulty of cleaning out small diameter pier holes, and the uncertainty of mobilizing end bearing and skin friction simultaneously.

Lateral loads on piers shall be resisted by passive pressure in the fill and rock. An equivalent fluid pressure of 350 pcf for rock and 250 pcf for compacted fill or stiff soil, acting on two pier diameters, shall be used. The stability of the system shall be calculated using a minimum factor of safety of 1.5. Confinement for passive pressure may be assumed from two feet below the roadway surface if rock is not exposed as a result of the cutting. Where rock is exposed, the confinement for passive pressure shall begin at the roadway grade.

If groundwater is encountered, it may be necessary to dewater the holes and/or place the concrete by the tremie method. If caving soils are encountered, it may be necessary to case the holes. Hard drilling may be required to achieve the required penetration.

Because of the potential that retaining walls could be used in areas of compacted fill, the subdrain line locations shall be surveyed and staked prior to pier drilling. Drilled piers shall be located so that they do not encroach within five feet of the surveyed line. If drainrock and subdrain lines are encountered during pier drilling, the wall design and layout may need to be modified.

Implementation of these mitigation measures would reduce the potential impacts related to seismic shaking to a ***less-than-significant*** level.



LEGEND

TP-12A	TEST PIT
	LITHOLOGIC CONTACT
FM	FRANCISCAN MELANGE. A MIXTURE OF ROCK TYPES INCLUDING SANDSTONE, SILTSTONE, GREENSTONE, CHERT AND SHEARED SHALE
QC	COLLUVIAL SOILS, WHERE RELATIVELY DEEP DEPOSITS EXIST, GENERALLY GREATER THAN SIX FEET DEEP.
QSC	COMBINATION OF COLLUVIAL SOILS AND SLIDE DEBRIS, PLANAR CONTACTS IN SOME PITS, OTHERS CONTAINING WEAK, SOFT AND POTENTIALLY UNSTABLE MATERIALS

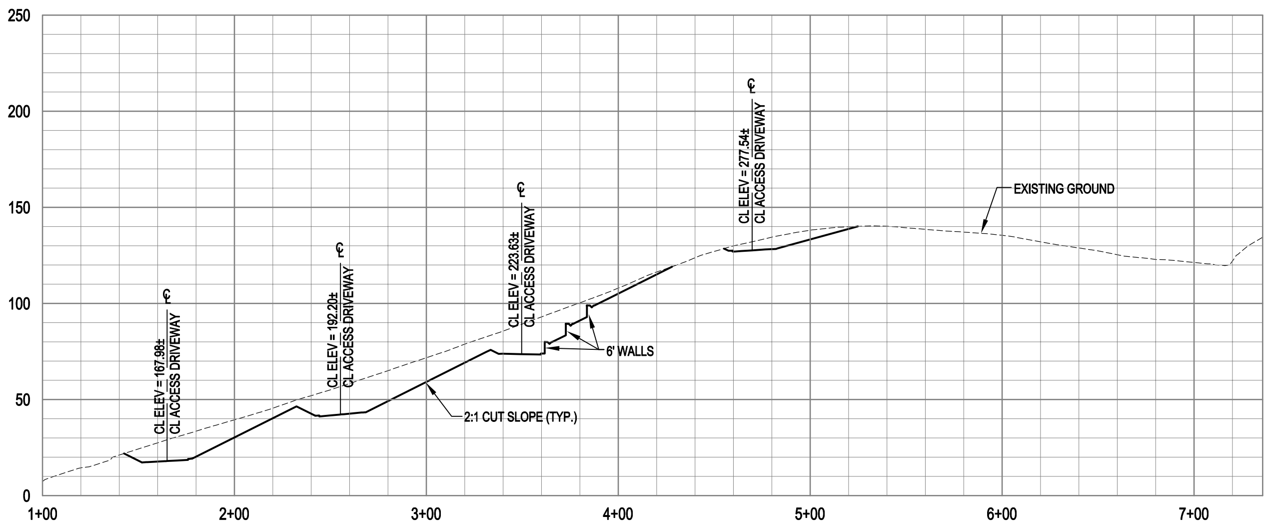
0 200

Figure IV.E-2. Geotechnical Constraints - Grading Overlay

Upper Road Land Division Project
Town of Ross, California

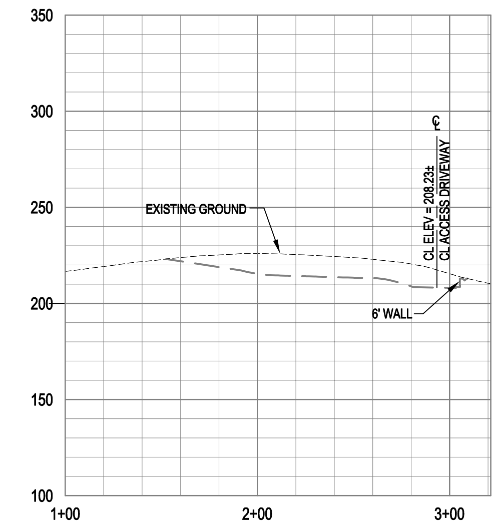
wra
ENVIRONMENTAL CONSULTANTS

Date: OCTOBER 2012
Source: CSW | Stuber-Stroeh Engineering Group, Inc.



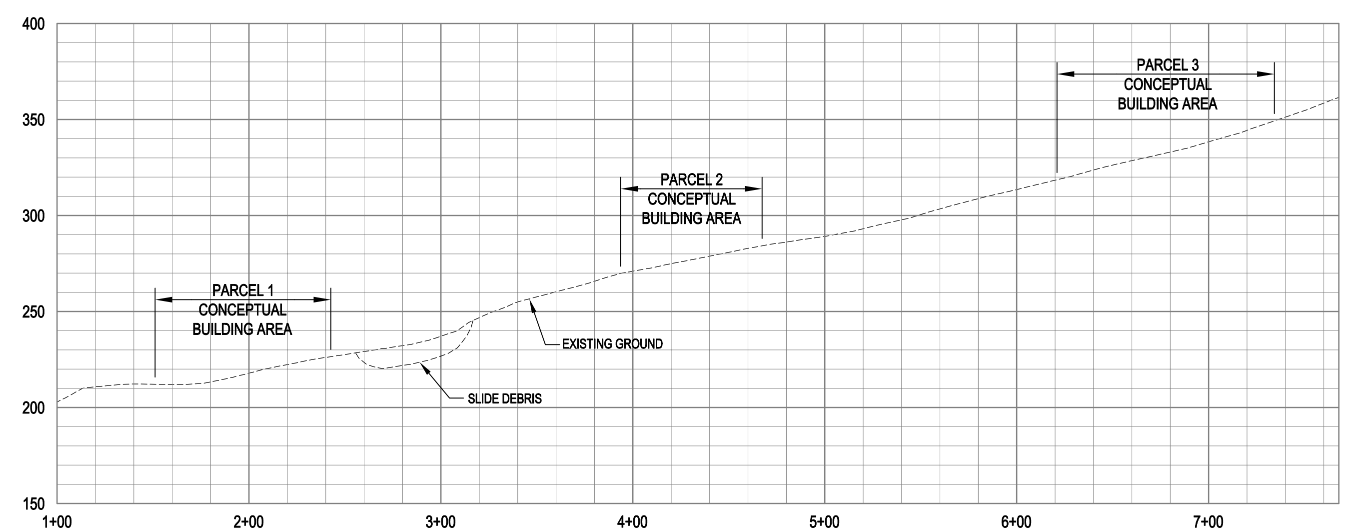
CROSS SECTION 1

H: 1"=50'; V: 1"=50'



CROSS SECTION 2

H: 1"=50'; V: 1"=50'



CROSS SECTION 3

H: 1"=50'; V: 1"=50'

Figure IV.E-3. Geotechnical Constraints - Cross Sections

Upper Road Land Division Project
Town of Ross, California

wra
ENVIRONMENTAL CONSULTANTS

Date: OCTOBER 2012
Source: CSW | Stuber-Stroeh Engineering Group, Inc.

Impact GEO-2: Expansive Soils

Expansive soils swell and shrink as they gain and lose moisture and lightly loaded foundations, slabs and pavements can heave and crack. Deep colluvial soils of stiff sandy silts, sandy clays, and clayey sands are common throughout the site. Generally, these soils appeared well consolidated, only slightly compressible, and non-expansive. However, as part of the geotechnical investigation, soil samples were collected and analyzed. The testing indicated that portions of the on-site soils are moderately expansive. Over time, these soils could undergo shrink/swell cycles that could damage or deform proposed subsurface improvements. This is a ***potentially significant*** impact.

Mitigation Measure GEO-2a: Unstable and Expansive Soils

- In areas where fills will exceed 5 feet in total thickness, compaction of the fill shall be increased to 95 percent relative compaction.[5]
- Exaggerate finished grades to ensure that proper surface drainage is maintained after settlement occurs.
- Settlement sensitive driveways in areas of deep fills may consist of structural slabs, which span between pier supported retaining walls.

Mitigation Measure GEO-2b: Unstable and Expansive Soils

- Expansive soils beneath and within three horizontal feet of pavements or slabs-on-grade shall be removed to a depth of at least 24 inches below planned subgrade, or 24 inches below existing grade, whichever is deeper. The exposed soils shall be scarified at least eight inches deep, thoroughly moisture condition to cause expansion to occur, and re-compacted. The excavated material shall be replaced with non-expansive fill. The non-expansive fill shall consist of approved clean well-graded material with little or no potential for expansion. The non-expansive material shall have a plasticity index of 15 percent or less, and a maximum liquid limit of 40 percent. Expansive on-site soils shall be segregated during excavation and not used in non-expansive fill zones. The project engineering geologist shall approve all imported fill prior to it being brought to the site, and all segregated non-expansive fill.
- The outer two feet of fill slopes shall consist of non-expansive fill to reduce sloughing due to strength loss associated with the seasonal wetting and drying of expansive soils. Cut slopes in expansive soil shall be inclined no steeper than 3:1 or be fully retained.

[5] *Relative compaction refers to the in-place dry density of a soil expressed as a percentage of the maximum dry density of the same material, as determined by the ASTM DI557 test procedure.*

- Grade beams in expansive soil areas shall be designed to resist expansive soil uplift pressures of 2,000 pounds per square foot. Alternatively, a compressible void form product (Econo-Void or equivalent) shall be provided beneath the grade beams. Expansive soils exert uplift forces on concrete overpours. Grade beams shall be formed above the trench to prevent overpours, and care will be taken to prevent overpours (mushrooming) at the tops of piers.
- Structural slabs shall be underlain by an approved void-forming product for protection from expansive soil heave. The void forms should consist of at least a two-inch thick degradable and compressible paper product (SureVoid®, or equivalent).
- In order to reduce expansive soil heave against retaining walls, the zone located above a 1:1 plane projected up from the base of the wall shall consist of approved non-expansive backfill.

Implementation of these mitigation measures, as well as Mitigation Measure GEO-1, would reduce the potential impacts related to unstable and expansive soils to a ***less-than-significant*** level.

Impact GEO-3: Landslides and Slope Stability

The presence of extensive landslide deposits and thick colluvium deposits on the property indicate a moderate to high potential for future slope instability. Persons occupying proposed residences, and personnel involved in site construction activities, would be exposed to the risk of landslides and mudslides that may occur during construction and/or during the expected life of the development due to the potential instability of existing slopes. During construction, site-grading activities would remove vegetative cover from, disturb and expose soil that could become mobilized by storm waters during construction activities. The runoff from unprotected soil areas could include significant sediment loading that could cause increased turbidity and sedimentation in downstream receiving channels. This is a ***potentially significant*** impact.

Mitigation Measure GEO-3a: Landslides and Slope Stability

Construction and grading will expose areas of weak soil/rock which may be sensitive to erosion and/or sloughing. Erosion protection measures shall be utilized during and after construction to reduce the risk of induced instability. Erosion protection measures shall include the use of seeding or hydromulch and the installation of hay bales and/or silt fences to hinder sedimentation. Detailed erosion protection recommendations shall be developed when grading plans are finalized and shall be implemented immediately after construction has been performed.

Mitigation Measure GEO-3b: Landslides and Slope Stability

All site drainage shall be designed by the project civil engineer. Surface runoff shall be directed away from the tops and toes of slopes using swales or berms. Surface drainage benches and ditches shall be provided as required by the Town's Building Code. Outlet pipes for surface drains shall extend down to approved erosion resistant outlets well away from unstable slopes. Drainpipes shall consist of rigid PVC or ABS pipe, which is Schedule 40, SDR 35 or equivalent.

Positive drainage shall be provided within five feet of buildings to direct surface runoff towards suitable discharge facilities and away from foundations and slabs. Ponding of surface water shall not be allowed. All roofs shall be provided with gutters and downspouts. All downspouts and drains shall connect into closed conduits, which discharge at approved erosion resistant outlets reviewed by the project's engineering geologist. All conduits shall consist of rigid PVC or ABS pipe, which is Schedule 40, SDR 35 or equivalent. Downspouts, surface drains and subsurface drains shall be checked for blockage and cleared and maintained on a regular basis. Surface drains and downspouts shall be maintained entirely separate from foundation drains and slab underdrains. Provisions shall be made for conducting water out of crawl spaces.

Foundation drains shall be installed adjacent to all perimeter foundations. Perimeter retaining wall backdrains may be substituted for foundation drains. The foundation drains shall consist of trenches which extend 18 inches deep, or 12 inches below lowest adjacent interior or crawl space grade, whichever is deeper, and which are sloped to drain at least one percent by gravity. The trenches shall be lined completely with a filter fabric, such as Mirafi 140N, or equivalent. A four-inch diameter rigid perforated PVC or ABS pipe (Schedule 40, SDR 35 or equivalent) shall be placed on an I-inch thick layer of drain rock at the bottom of the trenches with perforations down. Accessible subdrain cleanouts shall be provided, and be maintained on a routine basis. The pipes shall be sloped to drain at least one percent by gravity to a non-perforated pipe (Schedule 40, SDR 35 or equivalent) which discharges at an approved outlet. The trench for the perforated pipe shall be backfilled to within six inches of the ground surface with drain rock. The filter fabric shall be wrapped over the top of the drain rock. The upper six inches of the trenches shall be backfilled with compacted clayey soil to exclude surface water. The trench for the non-perforated outlet pipe shall be completely backfilled with compacted soil.

Crawl spaces shall be graded to create a smooth surface, and covered with an approved pre-fabricated drainage material such as Mirafi Miradrain 6000. A four-inch diameter, perforated Schedule 40 or SDR 35 pipe shall be provided in a trench excavated extending across the lowest portion of the crawl space. The trench shall extend 12 inches deep, and be sloped to drain at least one percent by gravity. The trench shall be completely lined with Mirafi 140N filter fabric, or equivalent. The perforated pipe slope shall drain at least one percent to a non-perforated Schedule 40 or SDR 35 pipe, which discharges at an approved outlet. The surface and trench shall be covered with reinforced gunite.

Mitigation Measure GEO-3c: Landslides and Slope Stability

Routine maintenance of drains and slopes shall be performed. Erosion that occurs must be repaired promptly before it can enlarge. Surface drains, wall backdrains, and subdrains shall be periodically checked for blockage and cleared as necessary. A homeowner's association maintenance and monitoring program shall be established to ensure maintenance of the drains and to perform maintenance and repairs of slopes, as necessary.

Mitigation Measure GEO-3d: Landslides and Slope Stability

Minimum building setbacks shall be established adjacent to the top or toe of new slopes in accordance with the current CBC to reduce the potential for seismic slope deformation, lateral fill extension, and/or slope creep from impacting the structures.

Implementation of these mitigation measures as well as Mitigation Measures GEO-1, HYDRO-1 and HYDRO-2A would reduce the potential impacts related to landslides and slope stability to a ***less-than-significant*** level.

CUMULATIVE IMPACTS

The potential cumulative impacts for geology, soils, and seismicity do not extend far beyond a project's boundaries; since geological impacts are confined to discrete spatial locations and do not generally combine to create a cumulative impact condition. The exception to this would occur where a large geologic feature (e.g., fault zone, massive landslide) might affect an extensive area, or where the development effects from the project could affect the geology of an off-site location. These circumstances are not presented as a result of implementation of the proposed project, and so do not apply. Conformance with the CBC and the mitigation measures described above would reduce project-related geohazard impacts to a less-than-significant level. Therefore, cumulative geotechnical impacts would be ***less than significant***.

LEVEL OF SIGNIFICANCE AFTER MITIGATION

Implementation of the mitigation measures listed above would reduce project impacts related to geology and soils to a ***less-than-significant*** level.