4.3 GEOLOGY AND SOILS

This section describes and evaluates the existing geologic, soils, seismic conditions of the Project site, and discusses the impacts that would result from the Project. The information and analysis provided in this section is based upon the Project applicant's geotechnical studies of the site prepared by TERRASEARCH, Inc. (2003, 2005a-d) and a peer review of those studies conducted by Earth Investigations Consultants (July 1, 2004, and October 5 and December 11, 2005).

4.3.1. Existing Setting

Geologic Setting

The site is located within the central Coast Range at the northern end of the East Bay Hills. It lies within a nearly 50-mile wide zone formed by interaction between the Pacific and North American Plates. This deformation, occurring over at least the past five million years, is reflected in a complex system of fractures, and northwest-trending faults and folds, the distribution of which has been obscured by complex regional landsliding.

The East Bay Hills are bordered on the southwest by the Hayward fault and on the northeast by the Calaveras fault. Right-lateral, strike slip movement across these and related faults, including the San Andreas fault, has formed the steep and dissected slopes of San Pablo Ridge.

Soils

According to the Soil Conservation Service, soils that underlie the site include loam of the Tierra Series in the southern and western portions of the site, and clay loam of the Los Osos Series in the eastern and northern portions of the site

The Tierra loam forms on gentle slopes (9-15 percent) underlain by sedimentary rocks. Tierra loam has a high shrink-swell potential, low shear strength, and very slow permeability. Runoff is medium to rapid and erosion hazard is moderate to high on barren slopes. It is a poor source for fill, but is considered to have fair to good compaction characteristics. Soil derived from this deposit may be corrosive to uncoated steel. Because of the potential for high shrink-swell, it is described as posing a severe limitation to shallow house foundations.

The Los Osos clay loam forms on moderate to steeply sloping (30-50 percent) sedimentary terrane such as soft shale and fine-grained sandstone. Soil slips, also known as shallow landslides are common in this soil type. It has high shrink-swell potential, low shear strength, and slow permeability. Runoff is medium to rapid, and erosion hazard is low to high on barren slopes. Subsurface erosion is also a potential hazard. It is considered a poor source for fill because of the high plasticity and low strength, and, for the same reasons, presents severe limitations for support of shallow house foundations. It may present a corrosion hazard to uncoated steel.

Soils on site identified during an early summer site visit were fissured and perforated by rodent burrows. Slope gradients as shallow as 5H:1V (20 percent) commonly contain irregular surfaces caused by soil creep within the expansive soils. Soil creep, generally in the upper three to five feet of the soil profile is mobilized by seasonal variation in soil moisture. An example of accelerated soil creep was observed on the drainage divide below the graded equestrian facility in the middle of the site.

Seismic Setting

The site lies between the northern segment of the Hayward and Concord faults, in an area of high seismic activity. Figure 4.3-1 depicts the main faults in the project vicinity. Major earthquakes are likely produce strong ground shaking at the site. The potential for fault rupture across the site is considered low because it contains no mapped active faults; however, close proximity and similar orientation to the Hayward fault are potential cause of sympathetic, coseismic movement in the event of a major earthquake on a nearby segment of the Hayward fault.

According to U.S. Geological Survey records, the southern segment of the Hayward fault produced a magnitude 6.5 earthquake in 1868. The most recent earthquake on the northern segment of the Hayward fault occurred 200-350 years ago with at least 4 to 7 large earthquakes over the past 2000 years. This fault segment is predicted to have a 25 percent chance of producing one or more major earthquakes by the year 2020. As shown in Table 4.3-1, the maximum probable earthquake on the Hayward fault is 7.1, while the maximum probable earthquake on the Pinole fault is 6.6.

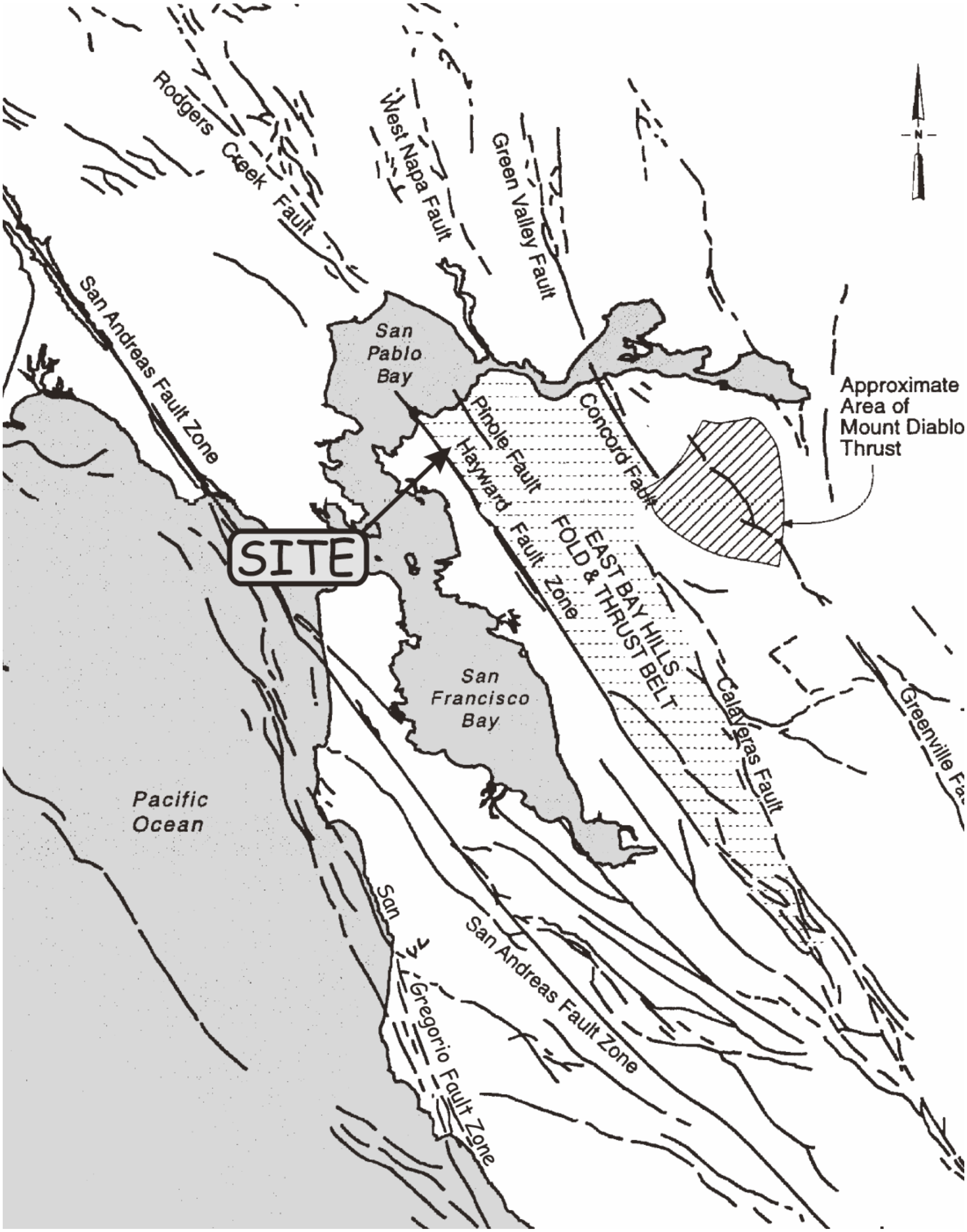

Figure 4.3-1

Faults in Project Vicinity

Table 4.3.1 Seismic Information for Nearby Faults

Seismic Source (fault)	Magnitude	Distance to Site (km)	Mean Peak Horizon Ground Acceleration (g) (PGA for soft rock & stiff soil)
Hayward	7.1	1.5	0.62
Rogers Creek	7.0	25.5	0.2
San Andreas	7.9	29	0.25
Pinole	6.6	4	0.5
Calaveras	6.8	29	0.17
Concord	6.5	22	0.16

Source: Idriss (1991); Mulchin and Jones, 1992; California Division of Mines and Geology (1998); Sadigh and others (1997); Fenton and Williams (2000).

Potential secondary seismic hazards that can affect local and large expanses of the ground surface include liquefaction, lateral spreading, landsliding and ground lurching. Liquefaction occurs when poorly consolidated, granular sediments beneath the ground water table are temporarily transformed during strong ground shaking into a liquid state. Lateral spreading is a form of landslide movement, but commonly occurs during ground shaking and liquefaction on a sub-horizontal rupture surface oriented toward an unsupported bank. The risk of occurrence for liquefaction and lateral spreading is considered low because of the consolidated and clayey nature of the site's earth materials. Landsliding can occur in a dry or saturated soil state on steep slopes during strong ground shaking. Ground lurching is a slow lateral movement similar to lateral soil creep during a major earthquake. The potential for this is low on graded and gentle native slopes, and moderate on steep channel banks.

Landslides

The property lies within the midsection of an approximate 212-acre complex of landslides in bedrock and soil, disturbed ground, and soil and rock creep occurring within Contra Costa Group terrane. From photogeology and previous geologic mapping, landsliding is interpreted to exist between the 800-foot peak on San Pablo Ridge and San Pablo Creek to the north of the site. The lateral margins of the landslide complex tend to coincide with the regional, predominant northwest-trending geologic structural grain and therefore extend beyond the site boundaries.

Geologic mapping and subsurface exploration for the proposed Project revealed that more than 50 percent of the property is affected by disturbed ground (dg), probable deep active (Qal), and dormant (Qld) landslides nested on a very deep, ancient or old (Qlo) bedrock landslide that extends beyond the limits of the property. Figure 4.3-2 depicts the geologic features of the site.

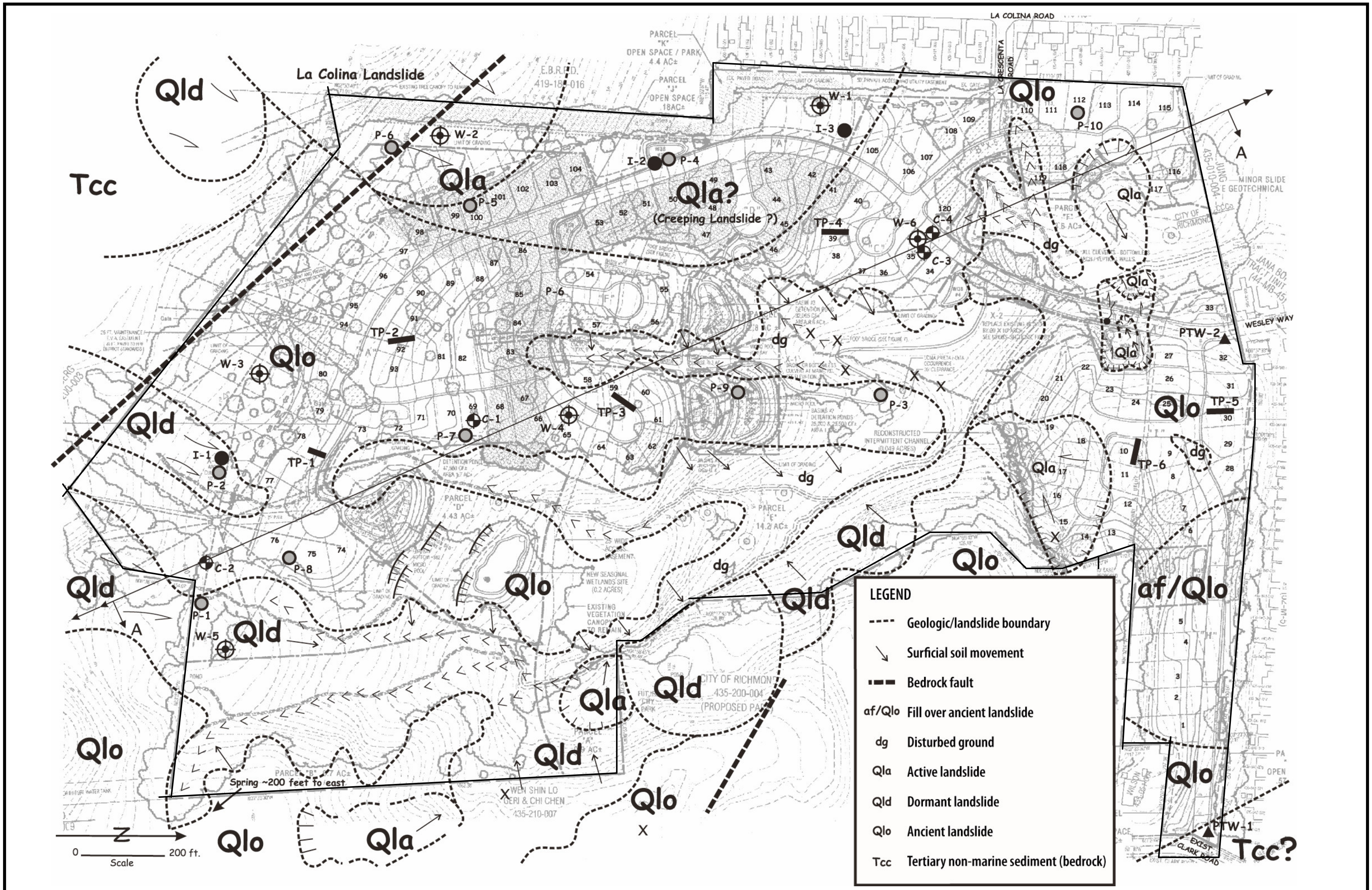

Figure 4.3-2

Geologic Features

The classification of relative landslide activity is provided below.

Active Landslides-Als (including Disturbed Ground dg): "…recognized by angular to slightly smoothed, bare to slightly weathered scarps; open cracks; loose, low density soil materials (in and across ground fissures); undrained depressions; highly irregular broken rubble, actively or recently moving downslope, with bare scarps, undrained depressions, and recently disturbed vegetation. Many of the landslides so classified are known to have moved in recent years. All are judged by the criteria used to have been actively moving downslope within the past 50 years or less;

Dormant Landslide-Qld: "…are distinguished by clearly defined but weathered and overgrown scarps, a lack of open cracks, moderately firm soil materials (in and across ground fissures), subdued depressions and hummocky surface features, well rotted, fallen trees, older growing trees, bowed or distorted, and undisturbed younger vegetation. Landslides in this category are judged to have been actively moving downslope 50 to 100 years ago but have relative stability over the past several decades;

Old Landslide-Qlo (including ancient): "…are recognized by their overall morphology, lobate in plan, concave-convex in profile, with well rounded and overgrown scarps; very subdued irregular surfaces; firm soils (in and across the surface), and generally undisturbed vegetation. It is presumed that these landslides were actively moving downslope sometime in the past several hundred years but have been relatively stabilized for the past century or so.

In order to characterize landsliding on the property, the applicant conducted extensive soil and groundwater testing across the site, and the data collected was peer reviewed by an independent geotechnical consultant. Data was collected through the following tests:

- six backhoe test pits ranging in depth from 16 to 18.5 feet;
- three, 8-inch diameter continuous core borings, ranging in depth from 55 feet to 224.5 feet;
- down-hole geologic logging of six, 24-inch diameter borings, ranging in depth from 75 to 100 feet;
- two, small diameter percolation test borings to a depth of 40 feet;
- two borings drilled in the toe region of the La Colina slide and underlying a creeping landslide encroaching from the East Bay Regional Park District land;

- Nested piezometers[1] and an inclinometer[2] casing were installed at each of these boring locations;
- In addition, 10 borings were drilled (not logged) for construction of nested piezometers to evaluate ground water, and three borings were drilled for installation of inclinometer casing.

The subsurface test pit and boring data indicates that an ancient landslide exists beneath the site to a depth locally greater than 300 feet. All of the explorations reportedly encountered landslide shears throughout the depth explored, but primarily in the more clay-rich zones.

The ancient landslide underlying the site is interpreted by TERRASEARCH, Inc. (2003) to be a continuous mass across the site, occurring in Contra Costa Group rocks. Debris slides and slumps from the steep banks of the main drainage channel have historically produced relatively high sedimentation near the northeast portion of the site. The northeastern tributary channel bank has retreated into the adjoining land occupied by The East Bay Waldorf School to the northeast of the site, and the residential land near the south end of Clark Road. Photogeologic interpretation indicates that 1 or 2 homes at the south end of Wesley Way were removed prior to 1958 due to slide related retreat near the northwest corner of the site.

A large expanse of land in the western part of the Project area is constrained by deep, active landsliding and creep, estimated to be at least 50 feet thick extending several hundred feet west of the site. TERRASEARCH, Inc. (1998, 2003) extrapolated the active slope movements in that area of the site from previous work by Alan Kropp & Associates (AKA) (2000), who reported damage to private and public property from the La Cima and La Colina Landslides. The slope movements are characterized as deep, re-activation on the western margin of the old landslide underlying the entire Project site (see Figure 4.3-3, Geological Constraints). The La Colina Landslide and a creeping deep landslide are believed by AKA (2000) and TERRASEARCH, Inc. (2003) to encroach approximately 300 feet into the western part of Forest Green Estates site.

AKA (2000) concludes, on the basis of piezometer ground water monitoring (average depth of 29.5 feet to ground water in the La Colina Landslide), that the mechanism for movement in the upper 80 feet of an apparently static 150-foot thick, ancient landslide, is

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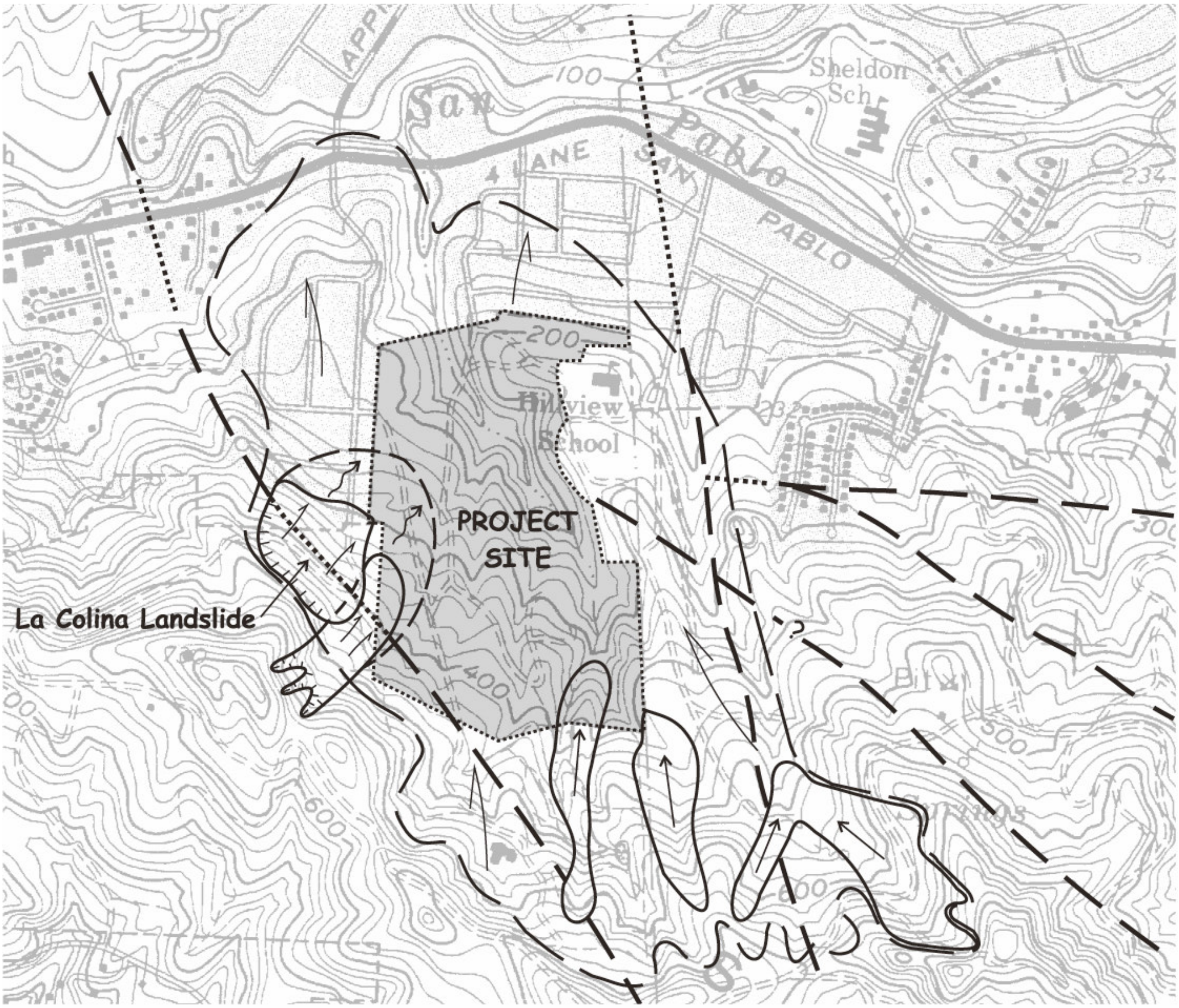
[1] Peizometer: Small diameter, usually plastic casing installed to a predetermined depth below the ground surface to monitor ground water elevations and fluctuations from seasonal rainfall
[2] Inclinometer: An instrument periodically inserted into small diameter plastic casing extending a predetermined depth below the ground surface. The inclinometer measures deflections to the casing from subsurface ground movement, such as creep or landsliding.



EXPLANATION

Approximate Location of Confirmed Landslide Area:
Chiefly active landslides confirmed by geologic or geotechnical investigations which included both a detailed surface reconnaissance and subsurface exploration

Deep actively creeping landslide

Approximate Location of Possible Landslide Area:
Includes active and dormant landslides, as well as areas of disturbed ground that contain a concentration of smaller landslides, mapped from published sources and generally confirmed by serial photo-interpretation

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Approximate Location of Inactive, Bedrock Fault (dashed where approximately located, dotted where concealed, queried where location uncertain)

N

0 ______ 1000 ft.
Scale

U.S.G.S. Topographic Map, Richmond Quadrangle, 7.5' Series (1959)
Geology from Terrasearch, Inc. (2003); Bishop & others (1973); Alan Kropp and Associates (2000)

Figure 4.3-3

Geologic Constraints

from the regional ground water table rising into the zone of movement during periods of heavy rainfall, and from discrete, perched water tables affecting individual planes within the active landslide. Borings and analysis by TERRASEARCH, Inc. (2005a) indicate the depth of these slides at the western property line is 50 feet.

To evaluate site stability characteristics, TERRASEARCH, Inc. (2003, 2005a,b,c) performed limited equilibrium, computer-generated slope stability analyses to search for critical on- and offsite landslide geometries within the upper 200 feet of the ancient landslide. The stability analyses concluded that additional landsliding could be triggered if ground water were to rise within 30 feet of the ground surface.

4.3.2. Explanation of Geotechnical Terms

The testing and feasibility analyses conducted at the project site recommend several geotechnical improvements to address potential slope instability. The following concepts are discussed in the Impacts and Mitigation section of this EIR:

Buttresses - A buttress is a compacted and drained earthen mass constructed in an excavation that extends several feet below unstable ground.

Subdrainage – Subdrainage is used to prevent water from permeating site soils and causing destabilization and possible landsliding. Subdrains are typically constructed on the upslope side of a structure (retaining wall, house or pavement) or unstable slope, and is constructed within and on the upslope side of a buttress fill to collect and remove ground water traveling from upper elevations.

Soldier Piers – Also known as shear pins or stitch piers, are closely spaced, drilled, cast-inplace, steel-reinforced piers that are designed to provide lateral support to unstable earth. They are usually interconnected at the top by a reinforced concrete grade beam or wall.

Tieback Wall – A tieback wall is a retention structure that achieves lateral support from a series of closely spaced, steel tendons extending from a structural wall connection to a predetermined distance, angled approximately 30 degrees downward from the horizontal, into stable earth.

Geologic Hazard Abatement District (GHAD) – Public Resources Code section 26500 -26654 authorizes a city or county to create an independent Geologic Hazard Abatement District (GHAD) empowered to finance the prevention, mitigation, abatement, or control of actual or potential geologic hazards through the levy and collection of special assessments. The statute broadly defines geologic hazards to include: landslides, land subsidence, soil erosion, earthquakes, or "any other natural or unnatural movement of land or earth."[3]

4.3.3. Impacts and Mitigation Measures

Thresholds of Significance

The Project would have a significant impact on Geology or Soils if any of the following criteria are met:

Geology

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault;
  - Strong seismic ground shaking;
  - Seismic-related ground failure, including liquefaction; or
  - Landslides;
- Result in substantial soil erosion or the loss of topsoil;
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in on-or off site landslide, lateral spreading, subsidence, liquefaction or collapse;
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property; or

[3] When forming a GHAD, the legislative body of the city or county can be the governing body of the district. Alternatively, the legislative body can appoint five land owners to act as the district's board of directors. Thereafter, board members will be elected every four years from within the district. Unlike most special assessment districts, the GHAD is an entity independent of the city or county.

Contra Costa County has formed GHADs in its Blackhawk and Canyon Lakes developments. In both, the County Board of Supervisors serves as the governing body. A GHAD is managed by an independent, licensed engineering geologist.

A GHAD has several advantages to recommend it. One, its boundaries need not be contiguous, so it can focus on just those properties subject to hazard. Second, it is an independent district with its own board of directors drawn from the affected property owners. Third, it is not limited to a single city or county; its boundaries can cross jurisdictional lines. Fourth, its formation proceedings are not subject to review by the Local Agency Formation Commission, thereby simplifying the process. Fifth, its formation is exempt from the California Environmental Quality Act.

- 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.

Less Than Significant Impacts

The following discussion describes less-than-significant impact related to soils and geology.

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.

Project generated wastewater would be conveyed to the City's sanitary sewer system and no septic tanks are proposed for treatment of wastewater. The provision of wastewater infrastructure for the Project is further discussed in Chapter4.9, Infrastructure and Public Services.

Significant Impacts

Impact GEO-1: Areas of known or potential slope instability, including creep and existing fills, could result in significant damage to the proposed development and neighboring developments, and could expose residents to increased levels of risk to injury and loss of property if not properly mitigated.

The entire site is underlain by weak unstable earth. Numerous active and dormant landslides have been identified, and there is available on- and off-site geotechnical data to suggest that the old landslide is susceptible to deep-seated, damaging creep movements. The western margin of the old landslide, off-site, has spawned abundant active landslides that threaten or have damaged existing property west of the site. If not properly characterized by thorough geologic and geotechnical investigations, landslide mitigation measures would likely be inappropriate. If mitigations are not properly engineered, the proposed development would experience significant damage from slope movements.

Mitigation Geo-1: The applicant shall implement all recommendations from the geotechnical reports, including those prepared by Terrasearch, Inc. (March 19, 2003, August 3, 2005) ; and by Drill Tech Drilling and Shoring, Inc (August 15, 2005). As noted in these reports, subsequent excavation of the site will provide additional data through which the recommendations of these reports can be refined. This process is commonly referred to as adaptive mitigation, and is employed to achieve the highest level of effectiveness through onsite monitoring of excavation, and refinement of construction techniques to reflect actual conditions in the field. A summary of the recommendations is provided below and is shown in Figure 4.3-4, Geotechnical Mitigation Plan:

- **Deep Earth Buttresses –** The final design shall include the construction of buttresses to provide lateral support to the slope that will support the east-west streets in the southwestern part of the site. The buttresses shall be 40 to 60 feet deep and 40 to 50 feet wide. A subdrain system, will carry captured ground water to the site drainage system.

- **Deep Subdrainage –** The final design shall include at least two 20- 25-foot diameter by 120-foot deep, dewatering shafts to mitigate potential reactivation of the ancient landslide on-site. Effectiveness of the dewatering system in maintaining ground water levels shall be confirmed by the applicant's geotechnical consultant through design-level monitoring and pumping tests.

- **Soldier Piers and Tieback Wall –** A tie back wall shall be constructed to mitigate lateral movement of existing landslides along the western side of the site. The tie-back elements shall be located under the area designated for a park adjacent to the western property boundary. A concrete wall shall be constructed to integrate the soldier piers, and shall be buried after the tiebacks are completed and tested to the design load. The area between the main channel and the tieback wall shall be buttressed.

- **A 50-foot building setback** – The final design shall reflect a 50-foot setback on the east side of the soldier pier system to account for potential offsite surficial debris flow over the system.

- **Monitoring** – The Project applicant shall assume responsibility for monitoring slope maintenance and landslide hazards for the first 15 years after the Project is constructed. This responsibility is described in more detail in Mitigation Measure GEO-8.

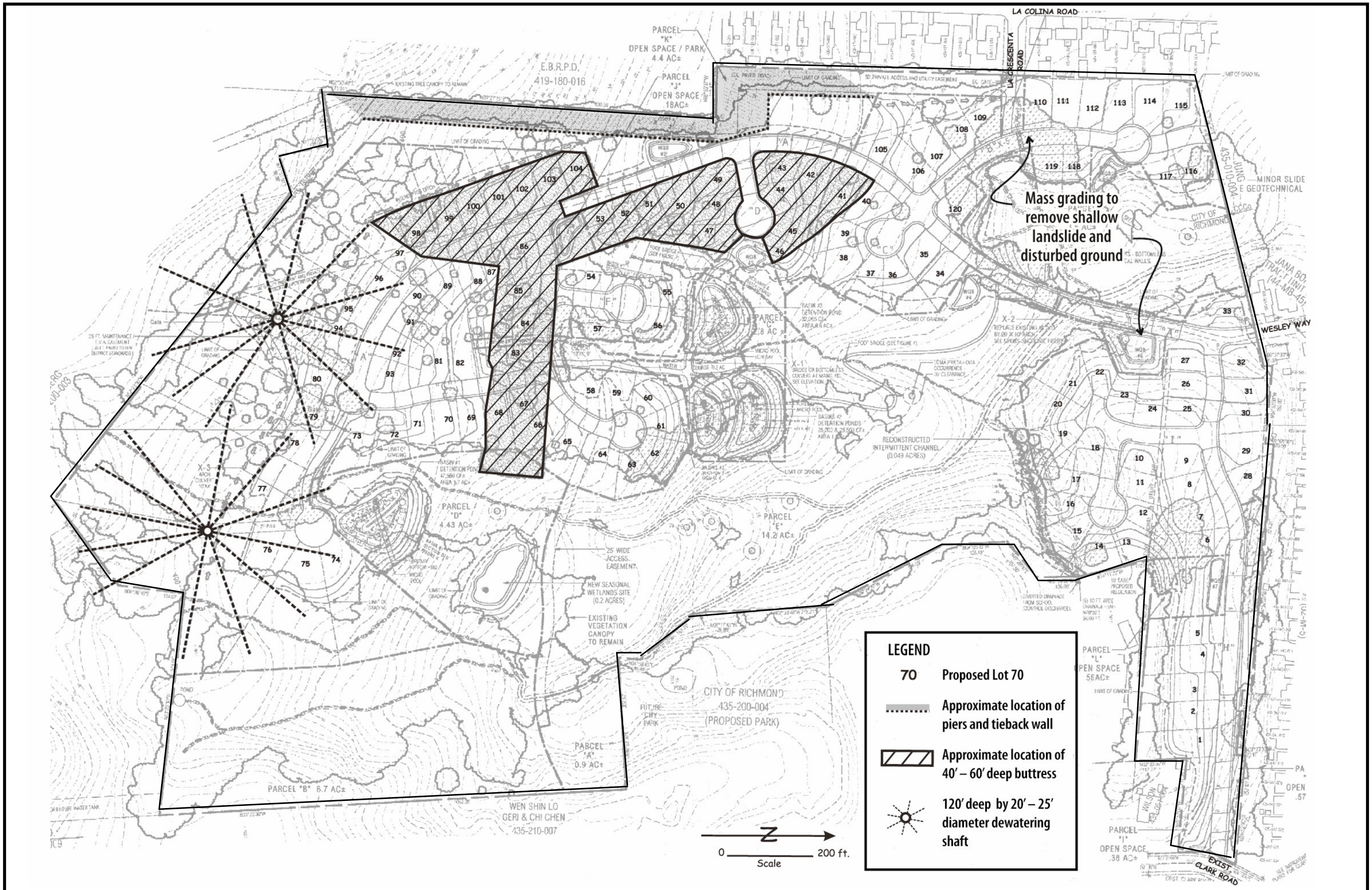

Figure 4.3-4

Geotechnical Mitigation Plan

Significance after Mitigation: Implementation of the proposed mitigation scheme should reduce potential slope hazards to less-than-significant level. However the proposed slope hazard mitigations are potentially constrained by the following uncertainties:

(1) Limited ground water and no slope monitoring data to confirm proposed mitigation design; and

(2) The possible requirement for adjacent property owner permission to complete the dewatering system on the south side of the Project, and the pier and tieback wall on the west side.

Consequently, the potential impact would remain potentially significant and unavoidable until Project mitigations have been completed, and verified by the City's Geotechnical Peer Reviewer.

Impact GEO-2: High potential for erosion and siltation exists in the main channel that extends along the eastern boundary of the site to the northwest corner. Proposed arch culverts, runoff velocity control structures and the proposed siltation basin will be adversely affected by this process.

The drainage system has actively eroding segments, and erosion of the ephemeral channel bank along the east margin of the site has historically produced high sedimentation to the northern property line that will be crossed by proposed roadways supported by arch culverts. Erosion and downstream siltation will be mitigated in part by the proposed channel relocation, but will continue until the new channel is stabilized with vegetation or commercially-available artificial erosion-control materials. The new seasonal wetlands, and proposed detention and water quality basins will tend to reduce silt movement from the site drainage divides, but not within the seasonal channel network. The process of erosion and siltation presents a significant adverse impact to the proposed channel structures by siltation, and would therefore require high maintenance considerations.

Undermining of the bank of the main channel by runoff has produced landslides into the channel, which produces downstream sedimentation, and secondary erosion of the opposing bank by re-directing channel flow. Diversion of runoff could potentially undermine the proposed arch culvert road crossings.

Mitigation Measure GEO-2a: Areas of actively eroding channel banks shall be stabilized either mechanically or with appropriate riparian vegetation (e.g., willow or other appropriate woody vegetation) as described in the Revised Hydrology Report, Balance Hydraulics, dated September 2005.

Mitigation Measure GEO-2b: The final grading plans shall mitigate gulling in the ephemeral drainages adjoining proposed lots through prudent grading and surface and subsurface drainage control practices. The City's Geotechnical Peer Reviewer shall confirm that the final grading plans demonstrate appropriate grading techniques.

Significance after Mitigation: Less than Significant.

Impact GEO-3: Potentially expansive and loose fills in the northern part of the site are unengineered and subject to settlement and erosion.

Fill placed in the late 1940's to early 1950's appear to be old landslide material side cast during grading for the existing Waldorf School adjacent to the project site. Undocumented fill also exists along existing unimproved roadways, and the north margin of the equestrian facility in the middle of the site. Unengineered fill material is unsuitable for roadway and building foundation support, and poses a potential adverse impact from settlement, creep and shallow landsliding.

Mitigation Measure GEO-3: Unengineered fills shall be removed, or stabilized with stitch piers or retaining walls. If existing fill is highly expansive, it would be unsuitable for replacement as engineered fill unless mixed with non-expansive material, or chemically treated. The applicant's geotechnical consultant shall delineate the distribution of unengineered fill throughout the site, particularly in the northeastern portion of the site where removal by mass grading may be limited.

Significance after Mitigation: Less than Significant.

Impact GEO-4: Seismically induced strong ground motion will likely affect the site over the project lifetime and could result in damage to life and/or property.

Strong ground motion from earthquakes along known, local active faults could cause damage to people and exacerbate landslide movements within the proposed development. The site is located approximately one mile from the active trace of the Hayward fault, and it is expected that this feature will produce a major earthquake within the Project lifetime (estimated to be 100 years). Severe ground shaking, although not unique to the site, will likely occur in such an event. The intensity of ground shaking is a function of the magnitude of the earthquake, distance from the site, the quality (relative density) of the earth materials that underlie the site, and the design quality of the buildings, roadways, and lifelines of the Project.

The applicant's geotechnical consultant utilized guidelines in the California Division of Mines and Geology Special Report 117 (Special Report 117) for seismic slope stability (pseudo-static) analyses. The Special Report identifies factors of safety (FS) for earthquake conditions ranging from FS 1.0 as the most liberal to FS 1.15 as the most conservative. The applicant evaluated seismically-induced sliding potential on the basis of an FS of 1.0, and the design recommendations for the project are based on that level of safety. To ensure maximum safety pursuant to the Special report 117, the applicant should re-evaluate the seismically-induced sliding potential on the basis of an FS of 1.15.[4]

Mitigation Measure GEO-4: Prior to issuance of grading or building permits, the applicant shall submit to the City an evaluation of pseudo-static stability with respect to a FS of 1.15. If shown to be necessary, the applicant shall implement any additional mitigations required to facilitate a pseudo-static of FS 1.15.

Current seismic design criteria in the 1997 Uniform Building Code (UBC) and City and County guidelines, and as recommended by the applicant's geotechnical consultant, shall be implemented. The applicant's geotechnical consultant has recommended reasonable earthquake design parameters from the UBC criteria. Design and engineering plans shall be approved by the Project geotechnical consultant and City of Richmond prior to issuance of construction permits.

Significance after Mitigation: Less than Significant.

Impact GEO-5: The site is bordered and/or crossed by a bedrock fault(s) that may have potential for coseismic movement in the event of a major earthquake on a nearby segment of the Hayward fault, or may influence occurrence and distribution of ground water.

Active faults are not known to cross the site, hence risk of earthquakes from the unnamed bedrock fault mapped across the northern part of the site is less than significant. However, there is potential for sympathetic (coseismic) offset of this fault or other bedrock faults mapped in the site vicinity (Alan Kropp & Associates, 1991). This condition poses a potential significant impact to home sites and the roadway network in the northern part of the site.

Mitigation Measure GEO-5: During excavation for site grading and landslide abatement as described in mitigation measure GEO-1**,** the Project engineering geologist shall assess the potential for coseismic activity along the unnamed

[4] A factor of safety is derived by dividing the sum of the resisting forces by the sum of the driving forces that characterize a given slope.

bedrock fault below the northern portion of the site. The applicant's geotechnical consultant shall determine appropriate building setbacks from any zones of potential coseismic fault offset. Appropriate setbacks would reduce the potential impact to a less than significant level.

Similarly, construction excavations may encounter elevated ground water caused by impermeable fault zones. This information will enable the applicant's geotechnical consultant to further evaluate the distribution of elevated ground water across the site and provide appropriate dewatering recommendations to reduce this condition to less than significant level.

Significance after Mitigation: Less than Significant.

Impact GEO-6: The proposed development plan will require deep artificial cuts and fills, particularly in landslide repair areas. Additional fill will be produced in construction of the dewatering system and pier and tieback wall. Deep cuts proposed for slope hazard mitigation in the southern and western parts of the site, and anticipated mass grading in the central part pose a risk of collapse of the weak landslide deposits. Deep fill may be subject to swelling and differential settlements unless properly constructed.

Extensive grading will be required to prepare the level building pads, roadway alignments and utility trenches. Extensive grading will also be required to install subdrainage, and to repair unstable slopes and erosion gullies. Potential cuts and fills to depths up to 100 feet may be required to implement necessary subdrainage and landslide repairs, and for the recommended deep and long excavation to further evaluate landslide shear geometry and rupture surface strength. These conditions will present potential collapse and landslide movements, endangering people and adjoining property by opening a wide expanse of the ancient, dormant and active landslides.

While there are no unique geologic features that would be impacted, grading will alter the existing watercourses and permanently alter the natural landscape. All fills for the proposed project have the potential for settlement if not properly controlled by the applicant's geotechnical consultant, who should apply current standards of care for keying, benching, and soil compaction (ASTM D1557 or equivalent soil compaction test procedure). Settlements of 5 to 10 inches could occur in thicker fills that would be placed across the drainage network in the northwestern part of the site, and across the main channel to extend the Emergency Access Road (EVA) into the site and for construction of the entrance road in the northeast part of the site. This condition could result in significant impacts to building and retaining wall foundations, roadway and utility performance and stability.

Cut slopes of 2H:1V (50 %) are proposed. This inclination for cut slopes may be too steep for inherent instability of the native earth materials, which would result in significant potential impacts to life and property by inducing slope instability that could extend off-site, particularly along the western margin of the site where active landslides and old landslide creep has been reported (Alan Kropp & Associates, 1991 and 2000). Moreover, potentially significant impacts for fill slopes of 2H:1V from deep desiccation cracking, rodent burrowing, accelerated creep, and shallow landsliding could develop if they are constructed with weak and expansive, clayey soils.

Mitigation Measure GEO-6: To reduce grading impacts to acceptable levels, the following measures shall be implemented:

a) Prior to issuance of grading permits, the applicant's geotechnical consultant shall prepare a design-level geotechnical report that contains detailed earthwork recommendations. The recommendations shall include measures to protect deep excavations from collapse, and may also require sectional excavation techniques. The recommendations shall include measures to mitigate highly expansive soils to be used for engineered fill, maximum cut and fill slope inclinations, and comprehensive surface and subsurface drainage measures. The City's Geotechnical Peer Reviewer shall independently verify that the project conforms to the geotechnical recommendations.

b) Structures and improvements developed on fills deeper than 20 feet, and especially on the buttress fills shall be designed to resist damage related to anticipated differential fill settlements. Specially designed, heavily reinforced foundations, and strengthened roadbeds and utility lines shall be required. Deep fill lots shall be identified by the project applicant and a list of the same shall be prepared and submitted to the City Building Department and to the project Geologic Hazard Abatement (GHAD)/Homeowner Association (HOA; described below) prior to issuance of any building permits for individual home development.

c) Grading operations shall be appropriately sequenced to balance the cuts and fills, and incorporate the additional fill that will come from site mitigation excavations. It will be necessary to temporarily stockpile excavated soil on site, and only in an area that is away from slopes and outside designated preservation land. If expansive soils are unusable, then considerable soil off-haul and non-expansive import will be required. A detailed plan shall be prepared by the applicant's geotechnical consultant, illustrating the location and safety measures to be employed for this procedure, to be approved by the City Peer Reviewer. Clearly illustrated and detailed grading plans containing the proposed approach to balance grading shall be submitted and approved by the City's Geotechnical Peer Reviewer prior to issuance of a grading permit.

d) Prior to commencement of grading, the applicant shall submit to the City for approval, specific plans and specifications pertaining to temporary soil stockpiles, including location(s) outside sensitive areas of the site, relative compaction, drainage and measures for erosion/sediment control.

e) After the completion of site grading, the project soil engineer shall provide specific foundation requirements for each lot. Said report shall include specifications and design standards (such as the inclusion of wire mesh) for all concrete slabs on grade to minimize cracking due to soil settlement.

Significance after Mitigation: Less than Significant.

Impact GEO-7: Increased erosion and sedimentation during and following the construction would result from earthwork operations, drainage pattern alterations and general disruption to terrain by general construction operations.

Significant erosion to cut and fill slopes, road-crossing channel areas, and house pads could result if these areas are left unprotected from rainfall over the course of and following construction. Removal of vegetation will expose highly expansive soil to extreme temperature variations, thereby exacerbating pervasive soil cracking, creep and surficial landsliding.

Potential impacts from erosion and sedimentation can be reduced to a less-than-significant level by implementing standard erosion control measures and best management practices as delineated by the Association of Bay Area Governments (ABAG), as described below.

Mitigation GEO-7:

(a) The applicant shall prepare and implement an erosion and sediment control plan pursuant to the guidelines established in the Association of Bay Area Government's (ABAG's) Manual for Standards for Erosion and Sedimentation Control. Typical measures include installation of temporary drainage control measures such as water bars, basins to trap sediment and re-direct runoff in properly-sized pipes to positively sloped surfaces protected with hay bales, jute netting, hydro-mulching, or application of one or more of the commercially available erosion-control geotextiles materials. The final erosion and sediment control plan shall be reviewed and approved by the Project geotechnical consultant and the City prior to issuance of a grading permit.

(b) Topsoil removed during rough grading shall be stockpiled to re-use in landscape areas. Landscape areas and other common areas made barren during grading shall be planted with an appropriate vegetation material as soon as practical after the earthwork and drainage provisions are installed. All temporary soil storage shall be within grading limit line.

(c) Careful grading and soil handling shall be required at the arch culvert crossing to avoid placement of loose soil in the drainages. Following construction, the disturbed soil surfaces shall be covered with erosion-protection matting and planted with hearty ground cover to mitigate downstream siltation.

(d) Exposure of expansive soils to undue direct sunlight (extreme temperature variations) shall be mitigated by comprehensive planting of hearty vegetation.

Significance after Mitigation: Less than Significant.

Impact GEO-8: Drainage improvements and graded and native slopes will require on-going maintenance over the project lifetime to ensure site stability and performance.

The proposed project will involve an integrated system of engineered improvements that must coexist with the natural geologic setting. There will be a need to improve or repair drainage provisions, including diversion ditches, arch culverts, detention and water quality basins, new seasonal wetlands, and storm drainage outlets to maintain original design capacity and performance for the design 100-year storm event. Given the geologic setting and the earth materials available to establish the proposed grading plan, it is likely that shallow erosion and landslides will develop on sloping land, particularly at storm drain discharge points underlain by weak old landslide deposits, along the eastern property boundary where limited control of off-site drainage exists, where adverse drainage may develop because of individual homeowner activity, and common area "wear and tear". Moreover, much of the earth materials available for roadway and embankment construction are expansive and susceptible to desiccation cracking and pervasive rodent burrowing.

It will be necessary to create a mechanism that includes a financially stable organizational structure able to provide the necessary resources in perpetuity to reduce potential short- and long-term maintenance and future geologic hazard impacts within the proposed project area to less than significant.

Mitigation Measure GEO-8:

a) The applicant shall establish and implement a Geologic Hazard Abatement District (GHAD) or Homeowners Association (HOA) organized to monitor potential for on-site geologic hazards and provide for mitigation of the same should they develop over the project lifetime.

b) The project applicant shall develop a Slope Management Program (SMP) under the direction of a certified engineering geologist. The program shall be prepared by the applicant prior to occupancy and submitted to the City for review by the City City's Geotechnical Peer Reviewer. The SMP should allow for at least annual inspections of slopes and drainage systems, and shall also include provisions for timely hazard mitigations reported by the applicant's geotechnical consultant. The GHAD or HOA shall have the authority to require property owners within the development to maintain appropriate landscaping and drainage controls. Upon completion of the project, and creation of the GHAD/HOA, the financial responsibility of maintaining the SMP shall be shifted from the project applicant to the GHAD/HOA.

c) To limit the financial responsibility of the GHAD/HOA, the project developer shall provide appropriate security, in an amount and form acceptable to the City, to guarantee continual and timely maintenance of any and all future geologic hazards that may develop over a 15-year period following project completion. A separate security may be required if the project is phased. The details of posting of the security and provisions allowing the GHAD/HOA to draw upon security in the event a geologic hazard repair shall be detailed in the SMP.

Significance after Mitigation: Less than Significant.

Impact GEO-9: Springs on the site can induce ground failure and surface erosion and interfere with performance of structures.

Springs have been mapped in the southeast part of the site by the applicant's consultant, and there is also evidence of seepage observed on aerial photographs in the headward part of the tributary drainages in the southeast part of the site. Additional seepage can also be encountered during mass grading. Excess water from these sources can result in landslides and erosion, and can also affect performance of building pads, foundations, and roadway and slab pavement subgrades.

Mitigation Measure GEO-9: The grading and site development plans shall include shallow subdrains, including individual foundation subdrainage to intercept near-surface seepage. Depending upon the occurrence of the encountered seepage, and location of the mitigation, the upper part of the subdrain trench shall be backfilled with compacted soil and covered with erosion control material. The subdrain shall be connected to a similar solid pipe that drains to an erosion-protected outfall location. Regular spacing of cleanouts is mandatory.

Significance after Mitigation: Less than Significant.

Impact GEO-10: Landscape irrigation would provide additional loads on the stability of created slopes.

The geotechnical feasibility analysis concluded that the elevation of groundwater to a depth of 30 feet could trigger additional landslides. Excessive irrigation to support plant species not naturally suited to the local environment could place unnecessary pressure upon the geotechnical mitigations used to stabilize the active landslides.

Mitigation Measure GEO-10: The landscaping plan for the subdivision shall incorporate predominantly drought tolerant landscaping to alleviate the need for excessive irrigation. The CC&Rs shall also clearly indicate the need to maintain a predominantly drought tolerant and native plant palette to reduce infiltration of water by landscape irrigation.

Significance after Mitigation: Less than Significant.