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GEOTECHNICAL STUDIES TO SUPPORT RANCH PLAN EIR

Prepared for Rancho Mission Viejo

May 28, 2004

GMU Project No. 01-80-00

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INTRODUCTION

PURPOSE

This report presents the results of our geotechnical studies for the proposed development within Rancho Mission Viejo in Orange County, California. This geotechnical report is intended to support the program-level EIR for the proposed developments. Supplemental geotechnical reports including additional subsurface exploration, analyses and recommendations related to more precise plans will be provided during review and processing of the grading plans when such more precise plans is made available.

SCOPE

The scope of our studies, as coordinated with Mr. Tom Staley and Ms. Laura Coley Eisenberg of Rancho Mission Viejo, was as follows:

1. Reviewed the results of available research, surface mapping, and subsurface exploration performed within or adjacent to the sites for proposed development.
2. Reviewed geotechnical studies, including subsurface exploration, prepared to support the EIR prepared by the Transportation Corridor Agencies for continuation of the Foothill Toll Road.
3. Performed surface geologic mapping for the planning areas at a scale of 1”=400’.

4. Performed limited subsurface exploration at and adjacent to some of the planning areas consisting of 6 drill holes excavated to depths of up to approximately 30 feet, 2 fault trenches excavated to depths of approximately 5 feet. The purpose of the subsurface investigation was to evaluate activity of faulting associated with the Mission Viejo Fault.
5. Performed office analysis of the data collected during our field investigation to arrive at conclusions and recommendations pertaining to the proposed development.
6. Prepared this report summarizing the results of our research, exploration, and analysis, and presenting our conclusions and recommendations relative to the ultimate use of the property.

RELATIONSHIP TO OTHER PLANNING PROGRAMS

As proposed by Rancho Mission Viejo, the project includes 22,815 acres general planned and zoned for development of up to 14,000 dwelling units in nine planning areas and other uses, and open space within four planning areas. Other uses include 251 acres of urban activity center uses, 80 acres of business park uses, 50 acres of neighborhood center uses, up to five golf courses, and approximately 15,121 acres of open space area which includes a proposed 1,034 acre regional park. Within the nine planning areas proposed for development, approximately 7,694 acres would be developed. Ranching and other agricultural activities would also be retained within a portion of the proposed open space area. Infrastructure would be constructed to support all of these uses, including road improvements, utility improvements and schools.

PROJECT DESCRIPTION

LOCATION

The area for proposed development, the "study area," is located within Rancho Mission Viejo in Orange County, and is generally bounded by Oso Parkway, Coto de Caza, and Ronald W. Caspers Wilderness Park on the north, by undeveloped land and San Juan Creek on the east, by Camp Pendleton Marine Base, the City of San Clemente, and the City of San Juan Capistrano to the south, and by the Ladera Ranch development and the City of San Juan Capistrano to the west. The site is bisected by Ortega Highway (Highway 74), which crosses in a generally east-west direction. The proposed project includes nine planning areas for residential and non-residential (i.e., commercial) development. These individual planning areas are shown on the Planning Area Location Map, included in this report as Plate 1. The geotechnical characteristics of the planning areas are described in detail in subsequent sections of this report. Planning Areas designated as open space are not evaluated in this report. These areas include Planning Areas 10 through 13.

PHYSIOGRAPHIC SETTING

Physiographic features of the study area range from rugged topography to a wide, meandering creek channel. North-south trending ridges and valleys dominate the topography north of San Juan Creek, and east-west ridges and valleys dominate to the south of San Juan Creek. San Juan Creek, trending west, bisects these ridges across the middle of the development area. Major named valleys addressed in this report include Cañada Chiquita, Cañada Gobernadora, Trampas Canyon, Cristianitos Canyon, Gabino Canyon, Verdugo Canyon, Talega Canyon, and Blind Canyon. Gentle to moderate topography bounds Cañada Chiquita, Cañada Gobernadora, and Trampas Canyon. East of Cañada Gobernadora and Cristianitos Canyon, terrain is moderately steep to rugged.

Fluvial terrace deposits, creating wide, nearly flat mesas stepping down to the creek channel overlay the flanks of the ridges north of San Juan Creek, east of Cristianitos Creek, south of Gabino Canyon, and north of Talega Canyon.

MANMADE FEATURES

Rancho Mission Viejo has been used as a working cattle ranch for over a century. Unimproved roads cross the site, generally trending along ridges and canyon bottoms. Structures, pastures, and corrals used for ranching have been built across the area. Residences and ranch buildings are predominately located just north of San Juan Creek, along with paved roads, fenced pastures, corrals, and stables. Portions of the property to the east of Antonio Parkway have been leased for industrial purposes. These areas include rock crushers, concrete plants, office buildings, and storage facilities. Additional property has been leased for industrial purposes south of Ortega Highway, within Trampas Canyon. Structures associated with a sand mining operation, as well as a large man-made lake, are present in the canyon. Land has been leased for plant nurseries on some of the mesas north of San Juan Creek. This area includes several office and storage buildings, as well as greenhouses and other non-habitable structures associated with the nurseries.

A waste water treatment plant is located in Cañada Chiquita, on the east side of the valley floor. This area is not considered part of the development area, and is designated on the Planning Area Location Map – Plate 1 as Not A Part.

Citrus orchards have been planted on flat-lying or gently sloping areas across the study area. These orchards are predominately located just north of San Juan Creek, east of Cañada Gobernadora. Lesser citrus acreage is planted in Cristianitos Canyon.

Several areas on the eastern flanks of Cristianitos Canyon have been used historically for clay mining operations. No structures are located here; however, several ponds were excavated for mining use. The ridge south of Blind Canyon and above Talega Canyon, located in the southernmost portion of the planning area, has been leased to TRW for their Capistrano Test Site. Structures and testing facilities are located on the ridgetop, with scattered structures located on the ridges east of the main test site.

PROPOSED PROJECT

The project proposes the development of approximately 7,694 acres of the 22,815 acres in nine planning areas. This would allow residential and associated urban development. The proposed residential uses would allow for a broad range of housing types and densities for a diversity of income levels and lifestyles. A mix of housing types would be provided, including single-family, multi-family, senior (age-restricted) housing, and apartments. The uses in each of these nine planning areas are described below.

Planning Area 1 -- This planning area is located east of the City of San Juan Capistrano boundary in the vicinity of Antonio Parkway and Ortega Highway. This planning area would encompass approximately 810 acres and provide a mix of residential, urban activity center, business park, and open space uses. Approximately 451 acres of residential development are proposed, with construction of 1,020 dwelling units. Approximately 89 gross acres of urban activity center are also proposed as use categories within this area. These uses would support approximately 1,190,000 square feet of urban activity uses. Within this planning area there would be 148 acres of open space together with a 122-acre portion of the proposed Rancho Mission Viejo Regional Park. Existing authorized land uses would continue until the commencement of any new proposed land use for the affected areas.

Planning Area 2 -- Located north of Ortega Highway, east of Antonio Parkway, south of Oso Parkway and Tesoro High School, and west of Canada Gobernadora, this planning area encompasses approximately 1,680 acres. A total of 1,550 units are proposed on approximately 985 acres within this planning area, and approximately 40 gross acres of urban activity uses, with an expected 610,000 square feet of business park uses and 50,000 square feet of neighborhood retail. 650 acres of open space is proposed in this planning area. The proposed Rancho Mission Viejo Regional Park (Planning Area 13) would extend along the southern boundary of this planning area.

Planning Area 3 -- This planning area encompasses approximately 2,353 gross acres and is located north of San Juan Creek, west of Caspers Regional Park, south of Coto de Caza, and east of Cañada Gobernadora. Approximately 5,630 dwelling units would be constructed on 1,957 acres. The remainder of the planning area (264 acres) would remain as open space. This planning area would also support uses that propose 122 gross acres of urban activity center with an expected 1,680,000 square feet of business use and 10 gross acres of commercial use with an estimated 100,000 square feet of neighborhood retail space. Existing authorized land uses would continue until the commencement of any new proposed land use for the affected areas.

Planning Area 4 -- This planning area is located south of Ortega Highway and is proposed for 211 acres of residential development. Proposed development would total 150 dwelling units and uses for a five-acre commercial site with approximately 50,000 square feet of neighborhood center. Existing authorized land uses would continue until the commencement of any new proposed land use for the affected areas.

Planning Area 5 -- This planning area is located south of Ortega Highway and east of the City of San Juan Capistrano. The project proposes the designation of a total of 1,350 acres. Approximately 2,440 dwelling units are proposed on 1,181 acres for this planning area. Open space (159 acres) is also proposed within this planning area. This planning area would also have uses of approximately ten acres for commercial development with a total of 100,000 square feet of neighborhood center. Existing authorized land uses would continue until the commencement of any new proposed land use for the affected areas.

Planning Area 6 -- This planning area is located north of the Donna O'Neill Land Conservancy at Rancho Mission Viejo (previously known as the Rancho Mission Viejo Land Conservancy). This planning area consists of a total of 308 acres. A total of 110 dwelling units are proposed on 263 acres. 45 acres of open space are also proposed in this planning area.

Planning Area 7 -- Located north of the existing TRW site, this planning area consists of 1,442 acres. Approximately 1,480 dwelling units are proposed on 843 acres of this planning area. 589 acres of open space are also proposed within this planning area. This planning area would also support uses with a ten-acre commercial site providing approximately 100,000 square feet of neighborhood center. Existing authorized land uses would continue until the commencement of any new proposed land use for the affected areas.

Planning Area 8 -- This planning area is located south of Planning Area 7, and north of the southern RMV property boundary. The planning area consists of 1,264 gross acres, supporting

1,400 dwelling units on 982 acres. Open space (172 acres) is also proposed within this planning area. An additional ten acres of commercial development would provide a total of 100,000 square feet of neighborhood center. This area would also support uses of approximately 80 acres of proposed business park with 1,220,000 square feet of business park uses, and 20 acres for a golf-oriented resort. Existing authorized land uses would continue until the commencement of any new proposed land use for the affected areas.

Planning Area 9 -- This planning area would cover approximately 9,272 acres in the southeastern portion of the project site with 8,852 acres of open space. Also, within a 420-acre use, known as the O'Neill Ranch, the Project would provide for a total of 100 estate homes on approximately 200 acres, along with 120 casitas on 20 acres, and a 200-acre golf course. The very low-density housing to be developed in this land use would be incorporated within the surrounding open space. Existing authorized land uses would continue until the commencement of any new proposed land use for the affected areas.

Planning Areas 10-13 – The remaining planning areas are proposed as open space. Planning Area 10 consists of 845 acres, Planning Area 11 consists of 1,015 acres, Planning Area 12 consists of 1,348 acres, and Planning Area 13 is proposed as Rancho Mission Viejo Regional Park (1,034 acres).

INVESTIGATIONS BY OTHERS

Geotechnical investigations performed by Leighton and Associates and Saddleback Constructors for the Transportation Corridor Agencies (TCA) included studies within Planning Areas 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, and 13. These studies are listed in the Existing Data/Prior Studies section of this report as references (A) through (H). Data included in these reports were reviewed for this study, including surface and subsurface information obtained during these investigations. The field investigations for these reports included excavation of multiple large and small-diameter drill holes, as well as trenches and test pits. A total of 290 borings and 25 trenches are included in the reports completed for TCA. Some of these excavations were observed in the field by geologists from this office. The logs of these excavations have been reviewed, and the data considered in our preparation of this study.

FIELD INVESTIGATION

Our field investigation for this report included surface mapping and limited subsurface exploration. The purpose of this investigation was to determine the general conditions at the site and to evaluate any geotechnical impacts associated with the proposed development.

Surface mapping was completed for all planning areas, and included mapping exposures of surficial soils, bedrock materials, and geologic structure, such as faulting and folding. The results of our surface mapping are presented on the Geological Map – Plates 3.1 through 3.3.

Our subsurface investigation included fault trenches and large-diameter bucket auger drill holes in areas without sensitive biological resources. Subsurface investigations adjacent to sensitive biological areas were monitored by biologists from Dudek & Associates. Two fault trenches and six large-diameter bucket auger drill holes were excavated to evaluate the activity of the Mission Viejo Fault. Logs of the drill holes and test pits are presented in Appendix A. No offset was observed within the surficial soils overlying the fault within these excavations. The results of our subsurface investigation and review of the available literature indicate this fault is not active pursuant to the Alquist-Priolo Earthquake Fault Zone Act. Faulting is discussed in more detail in a subsequent section of this report.

STUDY AREA GEOLOGY

REGIONAL GEOLOGIC SETTING

The study area lies on the southwestern flank of the Santa Ana mountains, within the Peninsular Ranges geomorphic province of California. The geologic units within the area are laterally transitional between the units of the Los Angeles basin and San Diego County (Morton, 1974). These units form a generally homoclinal sequence of marine and non-marine sedimentary rocks ranging in age from late

Cretaceous to early Miocene, offset by regional faulting. Regional structure shows these units dipping gently westward, with local folding observed predominately near faults. The sequence is overlain in some areas by Quaternary sediments. The geology of the proposed project is illustrated on Plate 3.1 through 3.3 – Geologic Map.

GEOLOGIC UNITS

Surficial and bedrock units that were encountered within the study area are shown on the Geologic Map – Plates 3.1 through 3.3. The Geologic Map is intended to present a general picture of the geology within the study area, and is based on reference (9). Surficial units are found overlying bedrock formations across much of the development area. These Quaternary-age units consist of sediments placed by wind, water, or mass movements.

Principal Bedrock Units. Bedrock units within the study area, in general, increase in age towards the east. These units comprise the ridges and slopes, and underlie surficial units on flanks and canyon bottoms. The bedrock units encountered within the study area are described from youngest to oldest as follows:

Capistrano Formation (Tc). Bedrock of the Capistrano Formation is exposed in the westernmost portions of Planning Area 1 and 11. In general, the bedrock is composed of clayey siltstone, siltstone, and sandy siltstone. The Capistrano Formation is generally massive, and overlies the Monterey Formation in gradational contact. Bedding within the Capistrano Formation is infrequent at best, and tends to be localized and discontinuous. Bedding mapped west of the project indicates that the formation is dipping gently to the west approximately 5 to 15 degrees. Due to its fine-grained nature and the presence of thin clay beds, the Capistrano Formation is prone to landsliding. Examples of this include the large landslides mapped across the western boundaries of the study area.

Monterey Formation (Tm). The Monterey Formation is exposed in Planning Areas 1, 5 and 11. The Monterey Formation has been mapped in the western portion of Planning Area 1, in the far western portion of Planning Area 5, and across most of Planning Area 11. Where encountered, the Monterey Formation consists of light gray, well- and thinly-bedded tuffaceous and diatomaceous siltstone and clayey siltstone, with local beds of bentonitic clay. Bedding within the Monterey in Planning Area 1 dips gently north-northwest. Within Planning Area 5, bedding is highly variable and folded, due to the proximity of the Cristianitos fault zone. The Monterey Formation unconformably overlies the Topanga Formation, but across most of the site, the two units have been faulted against one another. The Monterey Formation is also prone to slope failure, generally due to thinly bedded clays. Examples include the deep-seated landslides mapped within Planning Area 1 and 11.

Topanga Formation (Tt). The Topanga Formation is exposed in Planning Areas 1, 5, and 11 adjacent to and east of the Monterey Formation. The Topanga Formation is exposed on both sides of the Cristianitos fault zone. Where exposed, the Topanga Formation consists of light gray to light brown, moderately well bedded, well-cemented sandstone interbedded with lenticular, poorly bedded siltstone.

Sandstone beds dominate the unit. Within the sandstone are rare conglomerate beds and pebble units. Bedding within the Topanga Formation in Planning Area 1 generally dips east-northeast, and is locally folded due to the proximity of the Cristianitos fault zone. Within Planning Area 5, the bedding within the Topanga Formation is locally folded and fractured due to faulting. The Topanga Formation is interfingered with the San Onofre Breccia member of the Topanga Formation. The Topanga Formation also is in faulted contact with the Monterey Formation. Large, deep-seated landslides overlie the Topanga Formation within Planning Areas 1, 5, and 11.

Topanga Formation, San Onofre Breccia (Ttso). The San Onofre Breccia is exposed in Planning Areas 1, 5, and 11, on the eastern side of the Cristianitos fault zone. Bedrock of this member of the Topanga Formation consists of light gray to reddish brown, poorly bedded to massive, poorly to well-cemented, poorly sorted angular breccia. The matrix consists of sands and silts, while the clasts are of variable composition and size. Interbedded with these massive units of breccia are poorly bedded siltstones and sandstones. Bedding is difficult to determine, due to the massive nature of the unit. Where observed, bedding is randomly oriented and steeply dipping due to the proximity of the Cristianitos fault zone. The San Onofre Breccia lies in faulted contact with the Santiago Formation, and locally is overlain by the Monterey Formation. Multiple large, deep-seated landslides overlie the San Onofre Breccia within Planning Areas 5 and 11, in proximity to the Cristianitos fault zone. These large landslides are the largest failures mapped within the project (see Plates 3.2 and 3.3).

Sespe Formation (Ts). The Sespe Formation is exposed in the northern portion of Planning Area 2 and 10 east of the Cristianitos fault zone. Where observed in mapped outcrops, the Sespe Formation consists of very light gray to pale yellowish gray, massive sandstone. The sandstone is coarse and conglomeratic and forms resistant ridges and outcrops near the base of the formation. Minor thin lenses of siltstone are interbedded with the sandstone throughout the formation. Where observed, bedding within the formation is inclined to the northwest, with dips generally ranging from 0 to 10 degrees. Locally steeper beds were observed near faults. The Sespe Formation has a gradational contact with the underlying Santiago Formation and is in faulted contact with the Topanga Formation and San Onofre Breccia.

Santiago Formation (Tsa). The Santiago Formation covers a majority of the western and central portions of the study area, between the Cristianitos and Mission Viejo fault zones as illustrated on Plates 3.2 through 3.3. This formation is exposed in Planning Areas 2, 3, 5, 6, 7, 8, 9, 10, 12, and 13. The Santiago Formation, where observed in surface outcrops and in drill holes, consists of fine- to medium-grained sandstone interbedded with siltstone and sandy siltstone, with local interbeds of coarse sandstone and claystone. The lower portion of the formation generally consists of massive, friable, light gray sandstone. The bedrock is light gray to olive gray when oxidized, and gray to dark gray when unoxidized. Generally, the Santiago Formation is poorly bedded to massive. Where bedding was observed during surface mapping, inclinations ranged from 0 to 15 degrees to the northwest.

Local folding has been mapped within the Santiago Formation in Planning Areas 2, 3, and 6. The

Santiago Formation has a gradational contact with the overlying Sespe Formation and has a pronounced unconformity with the underlying Silverado Formation. The Santiago Formation also appears in faulted contact with the San Onofre Breccia, the Pleasants Sandstone Member of the Williams Formation, and the Silverado Formation. Scattered small landslides have been mapped within the Santiago Formation, primarily within Planning Area 2.

Silverado Formation (Tsi). The Silverado Formation is exposed in Planning Areas 3, 6, 7, and 8, adjacent to and west of the Mission Viejo fault. The Silverado Formation, where encountered in surface outcrops or drill holes, consists of varicolored sandstone, silty sandstone, sandy siltstone, siltstone, and claystone. The sandstone beds within the Silverado Formation are typically biotite rich. Bedding dips west between 5 and 15 degrees, except in proximity to faulting, where bedding appears severely folded. The Silverado Formation unconformably underlies the Santiago Formation and is in faulted contact with the Pleasants Sandstone Member of the Williams Formation. Locally, the Silverado Formation also unconformably overlies the Pleasants Sandstone Member of the Williams Formation.

The Williams Formation has been divided into two members, Pleasants Sandstone and Schulz Ranch. These are described below:

Williams Formation, Pleasants Sandstone Member (Kwp). The Pleasants Sandstone Member of the Williams Formation was encountered in Planning Areas 3, 4, 7, 8, and 9. The member generally consists of light brown to brown, fine- to medium-grained sandstone, with siltstone interbeds. The unit is massive to locally well-bedded, biotite-rich, and well indurated. Where observed, bedding dips gently to the west, between 5 and 10 degrees. The Pleasants Sandstone Member gradationally overlies the Shulz Ranch Member of the Williams Formation. Several landslides have been mapped within the Pleasants Sandstone member within Planning Areas 7 and 8.

Williams Formation, Shulz Ranch Member (Kws). The Shulz Ranch Member of the Williams Formation is exposed in Planning Areas 4, 8, and 9. The Schulz Ranch member generally consists of light gray to light olive gray, moderately well bedded to thickly bedded, siltstone and fine- to coarse-grained sandstone with conglomeratic sandstone interbeds. Bedding has been mapped dipping westerly between 5 and 10 degrees. The basal member of the Williams Formation rests unconformably on the Ladd Formation. Within the finer grained units of the Shulz Ranch member, scattered small landslides have been mapped in Planning Area 9.

The Ladd Formation, exposed in Planning Area 9, has been divided into two members. Undifferentiated Ladd Formation bedrock has also been mapped within this planning area. The two members of the Ladd Formation, the Holz Shale member and the Baker Canyon member, are described below:

Holz Shale Member, Ladd Formation (Klh). The Holz Shale member is exposed in the central and eastern portions of the site. The unit generally consists of light olive gray to gray green, poorly bedded shale, interbedded with conglomeratic limestone, sandstone, and coquina. Bedding within the unit dips westerly between 5 and 10 degrees. The Holz Shale member grades downward into the Baker Canyon member of the Ladd Formation in the eastern portion of Planning Area 9. No landslides have been mapped within this unit in the project area.

Baker Canyon Member, Ladd Formation (Klbc). The Baker Canyon member generally consists of interbedded light gray to yellow gray, well bedded sandstone and conglomeratic sandstone. The conglomeratic sandstone contains well-rounded pebble to cobble sized clasts. The member is medium to coarse-grained, and well indurated. The unit grades into a basal conglomerate that is well-indurated, yellow brown to light gray, massive to well bedded, with well-rounded clasts in a sandstone matrix. This basal conglomerate unit overlies the Trabuco Formation, exposed in the eastern portion of Planning Area 9. Bedding within this unit dips westerly between 5 and 15 degrees. No landslides have been mapped within this unit in the project area.

Trabuco Formation (Kt). The Trabuco Formation, exposed in Planning Area 9, generally consists of reddish brown to brown gray conglomerate. The conglomerate is massive, poorly indurated, deeply weathered, with well-rounded pebble to boulder sized clasts. The matrix of the conglomerate consists of sand and silt with abundant lithic fragments. Bedding within this unit is difficult to determine, based on the massive nature of the material. Where observed, local bedding indicates westerly dips between 5 and 20 degrees. The Trabuco Formation underlies the Ladd Formation in both gradational and unconformable contact. The Trabuco Formation is prone to slope failure, including landslides, due to the highly weathered nature of the material. One landslide within the Trabuco Formation has been mapped within Planning Area 9.

Principal Surficial Units. Surficial units are found overlying bedrock formations across much of the development area. These Quaternary-age units consist of sediments placed by wind, water, or mass movements. The surficial units encountered are described as follows:

Native Soil. Native soil covers much of each planning area as a thin veneer of insitu developed soil. The constituents of the native soil unit vary depending on the underlying material, but are generally composed of dark brown, clayey sand to clayey silt with a moderate to high organic content. The native soil generally contains roots and rootlets, and may contain gravels, cobbles, and/or boulders. Native soil is ubiquitous throughout the planning area, and is not shown on the Geologic Map – Plates 3.2 and 3.3.

Artificial Fill. Artificial fill is found across the study in localized areas. These deposits can range from engineered fill placed for structures or roads, to loose, dry, non-engineered fill placed for ranching purposes. The composition of these soils varies across the project, and can consist of clayey sand to silty sand, depending on the location.

Alluvium (Qal, Qac). Deposits of alluvium are located in and adjacent to San Juan Creek and other major drainages within all planning areas. The alluvium generally consists of sand with some silt, and scattered to abundant gravels, cobbles, and boulders. It tends to be laminated, with no developed soil structure.

Landslide Debris (Qls). Landslides have been mapped within all planning areas except Planning Areas 4 and 6. These deposits are composed of blocks and bedrock fragments that have moved downslope. The landslide debris composition varies widely, depending on the source material. The deposits tend to consist of siltstone or sandstone blocks, surrounded by a silty or sandy clay matrix. The material tends to be fractured and weathered. Landslide debris is usually found on the lower flanks of slopes, where the material has come to rest after failure. Landslides range in size from small, local failures to large, deep-seated failures. Planning Areas 2, 3, and 7 contain several small landslides, while Planning Areas 1, 5, and 11 contain large, deep-seated landslides. The remaining planning areas contain scattered mapped landslides that are small to moderate in size.

Lake Deposits (Ql). Lake deposits have been mapped in Planning Areas 2 and 3, within Cañada Chiquita and Cañada Gobernadora. Lake deposits generally consist of silts, sands, and clays. The material generally is grayish brown to dark brown, locally organic, slightly porous, firm, and thinly bedded, with a well-developed soil structure.

Perched Soil (Qps). Local deposits of perched soil were encountered across the study area, predominately on the slopes and ridges of Cañada Chiquita and Cañada Gobernadora. Perched soil deposits are thought to occur as remnant soils from colluvium or slopewash deposited prior to uplift or erosion of the canyons (reference (7)). Perched soil deposits vary in composition, depending on the underlying material but, in general, are dark brown and clayey with some silts and sands. Perched soil deposits have a low permeability where high in clay content.

Terrace Deposits (Qt). Terrace deposits have been mapped within Planning Areas 1, 2, 3, 4, 7, 8, 9, 11, and 13. These deposits are located predominately adjacent to San Juan Creek. Terrace deposits are deposited by ancient streams and subsequently undercut by stream erosion. The units generally form tabular surfaces, either flat-lying or very gently dipping. These materials consist predominately of sands and gravels, with local zones of clayey or silty material. Cobbles and boulders are common. The terrace deposits are generally reddish brown, locally varicolored, and are generally more consolidated than alluvium. The terraces can form "steps" on slope flanks where multiple deposits of differing ages accumulate. The age of the deposits increases with the elevation of the terrace. These multiple terraces are distinct topographic features, and relative ages can be determined between the steps.

GEOLOGIC STRUCTURE

The geologic structure within the study area consists of a sequence of westerly dipping bedrock units, offset by two major fault zones, and overlain by Quaternary sediments. These two fault zones are the Cristianitos and Mission Viejo fault zones. The bedrock units exposed within the project include, from youngest to oldest, the Capistrano, Monterey, Topanga, Sespe, Santiago, Silverado, Williams, Ladd, and Trabuco Formations. The youngest formation is exposed at the western edge of the project, while the oldest formation is exposed at the eastern edge of the project. The bedrock formations are generally homoclinal sequences of Cretaceous and Cenozoic sedimentary rocks, with contacts that range from gradational to abrupt angular unconformities.

The Cristianitos fault zone crosses Planning Areas 1, 5, 10 and 13 and offsets the Monterey Formation, San Onofre Breccia, and Topanga Formation against the Santiago Formation. Within the Cristianitos fault zone, multiple sub-parallel faults offset these bedrock formations. The fault zone lies in the eastern portion of Planning Area 1. The Forster fault, within the western portion of the fault zone, crosses the site trending predominately north to south. This branch of the fault offsets the Monterey Formation against the Topanga Formation to the east.

Within Planning Area 5, the Cristianitos fault zone lies in the western portion of the site. The Forster fault, which is approximately the western limit of the fault zone, lies offsite to the west. The main branch of the Cristianitos fault zone, which is approximately the eastern limit of the fault zone, lies in the west-central portion of the planning area. The Cristianitos fault zone offsets Monterey and Topanga Formations on the west against the Santiago Formation to the east. Within the fault zone, multiple faults offset these formations against each other. Bedding within and adjacent to the fault zone is highly irregular, and ranges from flat-lying to steeply dipping. Large landslides overlie or are adjacent to this fault zone.

The Mission Viejo fault zone crosses Planning Areas 3, 7, 8, 9, and 13. This fault offsets the Santiago and Silverado Formations against the Silverado and Williams Formations. The Mission Viejo fault trends generally north to south through the eastern portion of Planning Area 3. The fault offsets the lower beds of the Santiago Formation against the Pleasants Sandstone member of the Williams Formation. The Mission Viejo fault bifurcates in the southeastern portion of Planning Area 3. The western branch of the fault offsets the lower beds of the Santiago Formation against the Silverado Formation. The eastern branch offsets the Silverado Formation against the Pleasants Sandstone member of the Williams Formation. General bedding inclinations are gently dipping westerly on both sides of the Mission Viejo fault, with localized folding in proximity to the fault zones. The western branch of the Mission Viejo fault was not observed during mapping south of San Juan Creek. The eastern branch of the fault continues south across San Juan Creek through Planning Areas 7, 8, and 9.

In the northwestern portion of Planning Area 9, the Mission Viejo fault offsets the Williams Formation against itself. Within Planning Areas 7 and 9, the Santiago and Silverado Formations are offset against the Pleasants Sandstone member of the Williams Formation. In the central portion of Planning Area 7, the Mission Viejo fault bifurcates into two branches. The Williams Formation remains east of the eastern branch, while the basal beds of the Santiago Formation and the upper beds of the Silverado Formation are exposed in between the two branches, and west of the western branch. Bedding orientations in the vicinity of the Mission Viejo fault in this planning area are gently to steeply dipping.

In the central portion of Planning Area 8, the Santiago and Silverado Formations are offset by the eastern branch against the Pleasants Sandstone member of the Williams Formation. In the far western portion of the planning area, the western branch of the fault offsets Santiago Formation against itself. Bedding orientations in the vicinity of the Mission Viejo fault in this area are gently to steeply dipping, with local folding.

Sub-parallel, discontinuous faulting has also been mapped within Planning Areas 2, 5, and 9. These faults show offset within the Monterey, Topanga, Sespe, Santiago, and Silverado Formations, or may offset two formations. The offset on these faults, however, does not appear to be continuous.

Bedding within the project is generally consistent, dipping gently westward approximately 5 to 15 degrees. Gently dipping anticlines and synclines have been mapped within the project, and locally steep bedding has been mapped near faults. Bedding inclinations increase at the eastern edge of the project, within Planning Area 9. In the northeastern portion of this planning area, bedding dips range from 10 to 20 degrees.

GROUNDWATER

Shallow groundwater generally occurs within alluvium placed in drainages with perennial or seasonal flow. Perched zones of groundwater may occur within surficial deposits or within bedrock formations.

Groundwater in alluvial deposits has been encountered at shallow depths within Planning Areas 1, 2, and 3. Groundwater within alluvial deposits has been encountered at moderate to deep depths within Planning Areas 5, 6, and 7. Based on data collected within these planning areas, inferences can be made for the majority of the project.

Within Planning Areas 1, 2, and 3, groundwater has been encountered at shallow depths within the major drainages, San Juan Creek, Cañada Chiquita, and Cañada Gobernadora. These shallow depths are found within the alluvium placed in the canyon bottoms.

Within Planning Areas 5, 6, and 7, groundwater has been encountered within alluvial deposits in Trampas and Cristianitos Canyons. These depths are generally moderate to deep.

Planning Areas 4, 8, 9, and 11 may contain groundwater at shallow depths within the major drainages where alluvium has been mapped. Planning Areas 10, 12, and 13 will likely contain groundwater at very shallow depths, since these planning areas contain active drainages of Cañada Chiquita, Cañada Gobernadora, and San Juan Creek. Alluvial deposits within these planning areas are extensive.

Zones of perched water have been encountered during our limited study and during previous investigations (references (A) through (H)). These zones are localized pockets, and tend to occur within terrace deposits, landslide debris, or bedrock formations.

FAULTING AND SEISMICITY

Seismicity. Most of southern California is subject to some level of ground shaking (ground motion) as a result of movement along active and potentially active fault zones in the region. Several sizeable, historic earthquakes have occurred in southern California (Table 1). The commercial software program *EQSEARCH* ver. 3.0 was used to perform a search of historical earthquakes with M = 5.0 for the site and surrounding area. Review of the earthquake search indicates that 147 earthquakes with M 5.0 or greater have occurred between 1800 and 2003 within a 100-mile radius of the site. Notable historic earthquakes for the site and surrounding area are presented in Table 1.

Table 1 - Historic Earthquakes

Date	Name	Magnitude [1,2]	Epicentral Distance (km)	Fault(s)	Reference(s)
12/8/1812	Wrightwood	M_W~7.5	95	probably San Andreas fault near Wrightwood	Townley (1939), Jacoby et al. (1988), Sieh et al. (1989)
1/9/1857	Fort Tejon	M_W~8	283	San Andreas fault	Townley (1939), Agnew and Sieh (1978), Sieh (1978)
2/24/1892	Laguna Salada	M_W~7	150	Laguna Salada fault Zone	Townley (1939)
7/22/1899	Cajon Pass	M_L~5.7	87	uncertain	Townley (1939)
12/25/1899	San Jacinto	M_L~6.5	62	San Jacinto fault	Townley (1939)
5/15/1910	Elsinore	M_L 6	26	probably Elsinore fault near Glen Ivy	Townley (1927)
6/23/1915	Imperial Valley	M_L 6.1	210	Imperial fault	Townley (1939)
6/23/1915	Imperial Valley	M_L 6.3	210	Imperial fault	Townley (1939)
4/21/1918	San Jacinto	M_L 6.8	60	San Jacinto fault	Townley (1918)
7/23/1923	North San Jacinto	M_L 6.3	62	San Jacinto fault	Laughlin (1923)
3/11/1933	Long Beach	M_W 6.4	36	Newport-Inglewood fault	Wood (1933)
3/25/1937	Terwilliger Valley	M_W 6.0	123	San Jacinto fault	Wood (1937)
5/19/1940	Imperial Valley	M_W 6.9	213	Imperial fault	Ulrich (1941)
7/21/1952	Kern County	M_W 7.5	210	White Wolf fault	Steinbrugge and Moran (1954)
3/19/1954	San Jacinto Fault	M_W 6.4	132	San Jacinto fault	Magistrale et al. (1989)
4/9/1968	Borrego Mountain	M_W 6.5	140	Coyote Creek fault	Lander (1968)
2/9/1971	San Fernando	M_W 6.4	124	San Fernando Fault Zone	Bolt (1971), Petersen and Wesnousky (1994), Wesnousky (1986)

Table 1 - Historic Earthquakes (continued)

Date	Name	Magnitude [1,2]	Epicentral Distance (km)	Fault(s)	Reference(s)
10/15/1979	Imperial Valley	M_W 6.4	234	Imperial, Brawley and Rico faults	SCEC web page
7/8/1986	North Palm Springs	M_L 5.6	104	Banning or Garnet fault	Person (1986)
7/13/1986	Oceanside	M_L 5.4	66	San Diego Trough or Palos Verdes-Coronado Bank fault zones	Person (1986); Hauksson and Jones (1988)
10/1/1987	Whittier Narrows	M_W 6.0	75	Puente Hills fault	Shaw and Shearer (1999)
12/3/1988	Pasadena	M_L 5.0	86	Raymond fault	Jones et al. (1990)
1/18/1989	Malibu	M_L 5.0	105	uncertain	SCEC web page
2/28/1990	Upland	M_L 5.4	68	San Jose fault	Person (1990)
6/28/1991	Sierra Madre	M_W 5.8	90	Clamshell-Sawpit fault	Hauksson (1994)
4/23/1992	Joshua Tree	M_W 6.1	126	Eureka Peak fault (?)	SCEC web page
6/28/1992	Landers	M_W 7.3	130	Johnson Valley, Landers, Homestead Valley, Emerson & Camp Rock faults	Rymer (1992)
6/28/1992	Big Bear	M_W 6.4	103	uncertain	Jones et al, (1995)
1/17/1994	Northridge	M_W 6.7	116	Northridge Thrust fault	Teng and Aki (1996)
10/16/1999	Hector Mine	M_W 7.1	169	Lavic Lake & Bullion faults	SCEC web page

[1]Magnitudes from SCEC web page http://www.scecdc.scec.org/clickmap.html
[2]M_W = moment magnitude; M_L = local magnitude

Given the proximity of the study area to several active and potentially active faults (see discussion below), the study area will likely be subject to earthquake ground motions in the future. The level of ground motion at a given site resulting from an earthquake is a function of several factors including earthquake magnitude, type of faulting, rupture propagation path, distance from the epicenter, earthquake depth, duration of shaking, site topography, and site geology.

Fault Rupture. No known active or potentially active faults are shown on current available geologic maps as crossing the study area. The site is not within a designated Alquist-Priolo Earthquake Fault Zone (Jennings, 1994; Hart and Bryant, 1997). However, the study area is located within close proximity of several surface faults (Plates 2.1 and 2.2) that are presently zoned as active or potentially active pursuant to the guidelines of the Alquist-Priolo Earthquake Fault Zoning Act (Jennings, 1994; Hart and Bryant, 1997). The nearest of these faults, the strike-slip Newport-Inglewood fault zone, trends northwest-southeast and is located approximately 15 kilometers southwest of the study area.

Preliminary research by Grant et al. (1999) suggests the site may also be located near or underlain by segments of a low-angle fault system (e.g., blind thrusts), the fault surfaces of which do not necessarily break the ground surface during sizeable earthquakes. Although Grant et al. (1999) speculate that the site may be located near or underlain by a blind thrust fault named the San Joaquin Hills Blind Thrust, review of this journal article indicates that no detailed, quantitative data on the surface or subsurface geometry of this fault is available. In other words, the San Joaquin Hills Blind Thrust has not yet been studied in sufficient detail to determine the existence, location, or subsurface geometry of the fault let alone classify it as "Active" pursuant to the guidelines of the Alquist-Priolo Earthquake Fault Zoning Act (Hart and Bryant, 1997).

Two prominent Cenozoic faults cross the study area, the Cristianitos and Mission Viejo faults. The main branch of the Cristianitos fault zone is a northwest-trending, high-angle normal fault (Morton, 1974) that crosses the western portion of the study area, trending along the ridge west of Trampas Canyon.

Several faults associated with this fault zone are also mapped in the study area. The fault zone offsets the sedimentary rock sequence, displacing Eocene-age bedrock against Middle Miocene-age rocks within the development area (Plates 3.2 and 3.3 – Geologic Map). The Mission Viejo fault crosses the eastern portion of the study area, generally trending north to northwest. This fault is a vertical to steeply dipping normal fault, which offsets Late Cretaceous rocks against Paleocene-age units within the development area, as shown on Plate 3 – Geologic Map. Review of available literature indicates that the Cristianitos Fault Zone and Mission Viejo fault are not considered active or potentially active pursuant to the Alquist-Priolo Earthquake Fault Zoning Act.

Ground Shaking. A probabilistic seismic hazard analysis (PSHA) of horizontal ground shaking was performed to evaluate the likelihood of future earthquake ground motions occurring at the study area. A PSHA is a mathematical process based on probability and statistics that is used to estimate the mean number of events per year (Annual Frequency of Exceedance) in which the level of some ground motion parameter exceeds a specified risk level. The mathematical computations of probability and statistics are based on work by Cornell (1968). The commercial computer program *FRISKSP* ver. 4.0 was used to make the mathematical computations for this analysis. The software program *FRISKSP* is based on earlier work of McGuire (1976) but has been updated and modified to analyze earthquake sources as 3-D planes using modern attenuation relationships.

The seismic source model used for the PSHA computation was the CDMG Statewide Database of faults (CDMG OFR 96-08; Petersen et al., 1996). A search radius of 80 kilometers was selected as this is the maximum site-to-source distance applicable to the attenuation relationship used in the PSHA computations (Boore et al., 1997). Review of the CDMG database indicates that 21 seismogenic faults are located within a radius of 80 kilometers of the site coordinates (USGS Cañada Gobernadora 7-1/2 minute quadrangle, Latitude 33.5214°N, Longitude 117.5862°W). The "Maximum Moment Magnitude" presented in Appendix A of CDMG OFR 96-08 and the CDMG California Fault Parameters web page (http://www.consrv.ca.gov/cgs/rghm/psha/index.htm) are taken to represent the maximum earthquake each of the 21 faults presented in Table 2 are capable of generating under the current tectonic regime.

Table 2 - Seismic Source Model[1]

Fault Name	Distance (km)	Seismology Parameters			
		Maximum M_W	Fault Type[2]	Fault Length (km)	Slip Rate (mm/yr)
San Joaquin Hills Blind Thrust	11	6.6	bt	28	0.5
Newport-Inglewood (Offshore)	15	6.9	rl-ss	66	1.5
Elsinore - Glen Ivy	24	6.8	rl-ss	38	5.0
Elsinore – Temecula	25	6.8	rl-ss	42	5.0
Chino-Central Avenue	30	6.7	rl-r-o	28	1.0
Newport-Inglewood (L.A. Basin)	32	6.9	rl-ss	64	1.0
Whittier	37	6.8	rl-ss	37	2.5
Palos Verdes	41	7.1	rl-ss	96	3.0
Coronado Bank	42	7.4	rl-ss	185	3.0
Rose Canyon	46	6.9	rl-ss	55	1.5
Puente Hills Blind Thrust	46	7.1	bt	44	0.7
Upper Elysian Park Thrust	47	6.4	bt	34	1.3

Elsinore - Julian	55	7.1	rl-ss	75	5.0
San Jacinto - San Jacinto Valley	61	6.9	rl-ss	42	12.0
San Jacinto - San Bernardino	63	6.7	rl-ss	35	12.0
San Jose	63	6.5	ll-r-o	22	0.5
San Jacinto - Anza	66	7.2	rl-ss	90	12.0
Cucamonga	68	7.0	r	28	5.0
Sierra Madre	68	7.0	r	57	3.0
San Andreas – Southern	79	7.4	rl-ss	203	24.0
San Andreas - San Bernardino	79	7.3	rl-ss	107	24.0

[1] - CDMG Statewide Fault Database (CDMG OFR 96-08)
[2] - rl = right-lateral; ll = left-lateral; ss = strike-slip; r = reverse; o = oblique; bt = blind thrust

The PSHA computations were performed for peak horizontal ground acceleration (PHGA) using the attenuation relationship of Boore et al. (1997). This attenuation relationship requires that the study area be categorized according to material type in the upper 30 meters of the study area. For the purposes of this analysis, it was assumed that the study area is underlain predominantly by alluvium. Therefore, the study area is categorized with a S_D Soil Profile Type with an average shear wave velocity of 250 meters/second. Given that the majority of the planned development areas are underlain by bedrock formations, this is considered a conservative assumption. The specified risk level for this analysis was a ~475 ARP hazard level (i.e., 10% probability of exceedance in 50 years). The site coordinates used in the PSHA were 33.5214^o North Latitude and 117.5862^{o}West Longitude. The PSHA included contributions of earthquake events with magnitude of 5.0 or greater. The PHGA at the specified risk level of ~475 ARP is 0.35g.

SECONDARY SEISMIC EFFECTS

Surface Displacement. Surface displacement generally occurs from surface expression of active faulting, or within proximity to active faulting. Given that no active or potentially active faults have been mapped within or adjacent to any of the planning areas, potential for surface displacement is considered to be negligible.

Seismically Induced Landslide. Seismically-induced landslides are generally triggered within weak, poorly consolidated soils such as native soil, slopewash, landslide debris or, in some cases, within bedrock formations susceptible to mass movements.

Review of the Seismic Hazard Zones Maps covering the project (reference (3), (4), and (5)) suggests that portions of all the planning areas may be susceptible to seismically induced landslides (Plate 4). The Seismic Hazards Mapping Act, reference (2), requires site-specific geotechnical investigations for all areas delineated as a hazard on the Seismic Hazard Zones Maps. Future investigation will be required to evaluate the areas delineated as seismic hazards, and to determine specific mitigation measures for each of these hazards. As noted above, these investigations will be undertaken and submitted for County review at the grading plan stage.

Based on our knowledge of the geology of the site and on the Seismic Hazard Zones Maps discussed above, the potential for these seismically induced mass movements is low to moderate in localized areas within the development area. The potential for seismic-induced landslides can be mitigated using conventional grading techniques. These grading techniques include buttressing of slopes, filling of canyons, and/or partial or complete removal of existing landslides. Supplemental geotechnical reports including additional subsurface exploration, analyses and recommendations will be provided during review and processing of the grading plans.

Liquefaction. Liquefaction is an earthquake-induced effect that may cause damage to structures if not properly mitigated. Liquefaction usually occurs in a cohesionless soil with a high groundwater table, where ground shaking causes the soil to liquefy. Cohesionless soils are generally sandy, coarse-grained, unconsolidated soils with little or no clay content. For the purposes of this document, the term "liquefaction" includes phenomena such as ground failure, lateral spreading and settlement resulting from earthquake ground motions.

Review of the Seismic Hazard Zones Maps (references (3), (4), and (5)) for the project suggests that portions of Planning Areas 1 through 13 may be susceptible to liquefaction (Plate 4). It is our understanding that no development is planned in Planning Areas 10, 11, 12, and 13. A small portion of the southern portion of Planning Area 6 adjacent to Cristianitos Creek is mapped as being susceptible to liquefaction (reference (4)). A small portion of a tributary canyon within Planning Area 7 north of Gabino Canyon is mapped as being susceptible to liquefaction (reference (4)). Planning Area 8 contains a very small portion, including the mouth of Blind Canyon, that is considered a potential hazard zone (reference (4)).

The Seismic Hazards Mapping Act (reference (2)) requires a site-specific geotechnical investigation to evaluate the areas delineated as potential liquefaction hazards, and to determine specific mitigation measures for each of these hazards. As noted above, these investigations will be undertaken and submitted for County review at the grading plan stage.

Mitigation to reduce the potential for liquefaction can be achieved utilizing conventional grading techniques. These methods may include removal and recompaction of the soils. Alternate methods to mitigate liquefaction potential may include deep dynamic compaction, dewatering, and stone columns.

Tsunamis. A tsunami is a large ocean wave, generally with a large amplitude and high velocity that is created by earthquake or submarine landsliding. The project is located approximately 5 to 7 miles northeast of the Pacific Ocean. This distance is large enough that impact from a tsunami is considered negligible.

Seiches. A seiche is a similar phenomenon to a tsunami, except that a seiche is a large wave created within an enclosed body of water, such as a lake or reservoir. No natural lakes or other enclosed bodies of water of significant size are in the vicinity of the project. Planning Area 5 currently contains a man-made lake for mining purposes. The water level within the lake is maintained at a minimum distance of approximately 20 feet below the dam crest. Given that the water level is maintained and that the man-made lake would be removed prior to grading of the planning area, the impact from a seiche in Planning Area 5 and all other planning areas is considered negligible.

LANDSLIDES AND OTHER MASS MOVEMENTS

Landslides. Landslides are a type of mass movement in which soil and rock material moves as a large mass downslope, under the force of gravity. Landslides include translational slides and block glides, as well as rockfalls. Landslides have been mapped within Planning Areas 1, 2, 3, 5, 7, 8, 9, 10, 11 12, and 13. The following table summarizes our GIS analyses of the number of landslides and the approximate minimum and maximum area within each of the planned development areas:

Ranch Plan Development Area Landslide Summary

Planning Area No.	Total No. of Landslides	Approximate Landslide Area (acres)			Development Acres	Development Area Covered by Landslide (%)
		Minimum	Maximum	Total		
1	22	<1	42	105	540	20
2	32	<1	8	39	1,030	4
3	18	<1	6	29	2,089	1
4	0	0	0	0	216	0
5	4	11	149	239	1,191	20
6	0	0	0	0	263	0
7	4	7	17	50	853	6
8	3	<1	6	7	1,092	1
9	4	<1	2	3	420	1

Review of the Seismic Hazard Maps of the project prepared by the California Geological Survey (references (3), (4), and (5)) indicates that portions of Planning Areas 1 through 9 are within a zone of required investigation for earthquake-induced landslides. It should be noted that areas within a zone of required investigation does not necessarily indicate that a landslide is present. According to the CGS

Seismic Hazard Maps, areas of required investigation for earthquake-induced landslides include "areas where previous occurrence of landslide movement or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacement…" In accordance with the requirements of CDMG SP 117, supplemental geotechnical reports including additional subsurface exploration, slope stability analyses and recommendations will be provided during review and processing of the grading plans when such more precise plans are made available.

Twenty-two landslides within the Monterey and Capistrano Formations have been mapped within the northern portion of Planning Area 1 (see Plates 3.2 and 3.3). Within the development area, these landslides vary in size from less than one acre up to 42 acres. Review of available literature (reference (J)) suggests these landslides vary in depth from 25 feet up to 157 feet. Landslide and earthquake-induced landslide potential at the site can be mitigated by removal and recompaction of on-site soils utilizing conventional grading techniques.

Thirty-two landslides have been mapped within Planning Area 2 (see Plates 3.2 and 3.3). Within the development area, these landslides vary in size from less than one acre up to 8 acres. The majority of the landslides within Planning Area 2 are less than 1 acre in size. Most of these failures are relatively shallow involving the native soil, colluvium, and weathered bedrock. For the purposes of this report, a shallow landslide is less than 25 feet in depth. Review of the available literature suggests two larger landslides (i.e., greater than 2 acres in areal extent) located in the northern portion of the proposed project vary in depth of from approximately 30 to 55 feet. Based on our review of the available reports, these landslides appear to be translational failures along or sub-parallel to bedding. Review of reference (K) suggests that a large landslide (approximately 123 acres) located across the boundary between Planning Areas 2 and 10 is approximately 35 to 70 feet in depth. This landslide is likely due to severe fracturing, and faulting of the bedrock formations adjacent to and within the Cristianitos fault zone. Landslide and earthquake-induced landslide potential within Planning Area 2 can be mitigated by removal and recompaction of on-site soils utilizing conventional grading techniques.

Eighteen landslides have been mapped within Planning Area 3 (see Plates 3.2 and 3.3). Within the development area, these landslides vary in size from less than one acre up to approximately 6 acres. The majority of the landslides within Planning Area 3 are less than 1 acre in size. Based on the size and morphology of these landslides most of these failures appear to be relatively shallow involving the native soil, colluvium, and weathered bedrock. Landslide and earthquake-induced landslide potential at the site can be mitigated by removal and recompaction of on-site soils utilizing conventional grading techniques.

Four landslides or landslide complexes have been mapped within Planning Area 5 (see Plates 3.2 and 3.3). For the purposes of this report, a landslide complex is a mappable area of landsliding that includes multiple landslides. Within the development area, these landslides or landslide complexes vary in size from 11 acres up to 149 acres. These large landslides have been mapped along the western margin of Planning Area 5 in proximity to the Cristianitos fault zone (references (7), (9), (B), (C), and (D)). These landslides are considered to be deep-seated failures with the landslide planes between approximately 50 to 120 feet in depth. Landslide and earthquake-induced landslide potential for the landslides discussed above within Planning Area 5 can be mitigated by removal and recompaction of on-site soils utilizing conventional grading techniques. A very deep and areally extensive landslide complex is located across the boundary of Planning Areas 5, 11, and 13 at the northern portion of Planning Area 5 (Plates 3.2 and 3.3). This landslide extends well outside of Planning Area 5 to the north beneath Ortega Highway and into San Juan Creek. Review of the available reports suggests this landslide has experienced multiple episodes of failure and has a landslide rupture surface deeper than 200 feet. Mitigation of this landslide utilizing conventional grading techniques is not considered feasible due to the mapped horizontal and vertical extent of this landslide. The landslides mapped within Planning Area 5 are likely due to severe folding, fracturing, and faulting of the bedrock formations adjacent to and within the Cristianitos fault zone.

Four landslides have been mapped within Planning Area 7 (see Plates 3.2 and 3.3). Within the development area, these landslides vary in size from approximately 7 acres up to approximately 17 acres. Based on the size and morphology of these landslides most of these failures appear to be relatively deep-seated landslides with failure surfaces estimated to be between 35 to 50 feet in depth. Landslide and earthquake-induced landslide potential within Planning Area 7 can be mitigated by removal and recompaction of on-site soils utilizing conventional grading techniques.

Three landslides have been mapped within Planning Area 8 (see Plates 3.2 and 3.3). Within the development area, these landslides vary in size from less than one acre up to approximately 6 acres. Based on the size and morphology of these landslides these failures appear to be relatively shallow involving the native soil, colluvium, and weathered bedrock. Landslide and earthquake-induced landslide potential within Planning Area 8 can be mitigated by removal and recompaction of on-site soils utilizing conventional grading techniques.

Four landslides have been mapped within Planning Area 9 (see Plates 3.2 and 3.3). Within the development area, these landslides vary in size from less than one acre up to approximately 2 acres. Based on the size and morphology of these landslides these failures appear to be relatively shallow involving the native soil, colluvium, and weathered bedrock. It should be noted that there are larger landslides within Planning 9 outside of the planned development area that range in size up to approximately 25 acres in size (see Plates 3.2 and 3.3). Landslide and earthquake-induced landslide potential within Planning Area 9 can be mitigated by removal and recompaction of on-site soils utilizing conventional grading techniques. Potential landslide impacts at the site could also be mitigated by avoidance (i.e., relocating estate lots within or adjacent to mapped landslide).

Review of the available literature indicates that Planning Area 11 contains multiple large, deep-seated landslides that extend offsite under La Pata (references (7), (9), (B), (C), and (D)). These landslides cover a majority of the planning area. Regional mapping of the underlying Monterey and Capistrano

Formation bedrock indicates bedding dips gently toward the west. This dip direction is generally parallel to or shallower than the slope of the natural topography. This condition is similar to a deck of cards that is lifted up at one end. When the one end is lifted, the cards slide off one another at the lower end of the deck that is not supported. Failure of these landslides within Planning Area 11 is due to the unsupported nature of the bedding planes in addition to the weak nature of the underlying bedrock and the severe folding, fracturing, and faulting of the bedrock by the Cristianitos fault zone.

Shallow Failure/Surficial Slumps. Shallow failures, surficial slumps, and slope creep are mass movements that generally occur within surficial units located on slope faces. These types of failures are localized, and tend to be less than 5 to 10 feet deep. Surficial slumps were observed during our surface mapping, predominately within Planning Areas 1, 5, 9, and 11. The potential for future shallow failures or surficial slumps is considered to be moderate to high in these planning areas. Within Planning Areas 2, 3, 4, 6, 7, 8, 10, 12, and 13, the potential for future shallow failures or surficial slumps is considered to be low.

Soil Creep. Soil creep is the almost imperceptibly slow movement of material due to gravity. Creep generally occurs on slopes mantled with clayey or expansive soils, or weathered bedrock prone to movement. Creep can be episodic, predominately occurring or increasing after periods of rainfall. This phenomenon generally occurs in the upper few feet of material, with no distinct basal failure surface.

Based on observations made during surface mapping, the potential for future creep within Planning

Areas 1, 4, 5, 9, and 11 is considered to be moderate. The potential for future creep within Planning Areas 2, 3, 6, 7, 8, 10, 12, and 13 is considered to be low.

Debris Flows. A debris flow is a mass of rock fragments, soil, and mud that moves under the influence of gravity, and generally occurs during or shortly after a period of intense rainfall.

Based on field observations and aerial photograph review, debris flows are common within the Capistrano Formation, the Santiago Formation, the Pleasants Sandstone member of the Williams Formation, the Holz Shale member of the Ladd Formation, and the Trabuco Formation. Debris flows are less common within the Monterey Formation, the Sespe Formation, the Silverado Formation, and the Schulz Ranch member of the Williams Formation. Debris flows are infrequent to rare in the San Onofre Breccia and Topanga Formation, and the Baker Canyon member of the Ladd Formation.

The potential for debris flows is moderate to high within Planning Areas 2, 3, 4, 6, 7, 8, and 9, low to moderate within Planning Areas 1, 5, and 11, and negligible to low within Planning Areas 10, 12, and 13.

GEOTECHNICAL CONSIDERATIONS AND CONCLUSIONS

PLANNING AREA 1

Slope Stability.

Cut Slopes. The northern and western portions of Planning Area 1 are underlain largely by landslide debris and bedrock of the Capistrano and Monterey Formations. The inactive Cristianitos Fault Zone trends through the project area. Given these geologic constraints, all planned cut slopes will likely require stabilization or buttressing. The large landslide complex located north of Ortega Highway and west of Antonio Parkway will require extensive corrective grading and slope stabilization. This grading can be accomplished utilizing conventional grading techniques, including, but not limited to stabilizing slopes, buttressing slopes, reducing slope angles, and/or partial or complete removal of landslides.

Fill Slopes. As noted above, the northern and western portions of Planning Area 1 are underlain by landslide debris and bedrock of the Capistrano and Monterey Formations. These materials within Planning Area 1 typically have lower strength characteristics than materials found within the other planning areas. As a result of these lower strength parameters, the maximum fill slope height will be lower. Based on our experience with similar materials in adjacent developments, the maximum fill slope height constructed at a 2:1 (horizontal to vertical) ratio will be approximately 80 to 100 feet. Specific recommendations for fill slope construction including maximum fill slope height should be determined based on detailed field investigation, laboratory testing, and geotechnical analyses and review of the engineered grading plans.

Settlement.

Collapsible Soils/Compressible Soils. Collapsible soils and/or compressible soils were encountered during surface mapping throughout the planning area. The surficial deposits, including portions of the terrace deposits, landslide debris, and weathered portions of the bedrock, are generally considered to be collapsible or compressible. In areas of planned development, removal and recompaction of all collapsible/compressible soils is recommended.

Existing Fills. Isolated areas of undocumented fill materials occur throughout Planning Area 1. These fills generally occur along existing ranch roads, along the southern edge of the old horse pasture located north of Ortega Highway and west of Antonio Parkway, and along the northern margin of the polo fields located north of Ortega Highway and west of La Pata. These areas of undocumented fill should be removed to competent, dense, native materials and replaced with engineered fill within areas of planned development.

Rippability. Based on our preliminary investigation, we anticipate that materials encountered in Planning Area 1 could be excavated with standard construction equipment with moderate ripping. No hard rock was encountered during our limited investigation, however, beds within both the Capistrano and Monterey Formations may contain well-cemented layers or lenses that may require moderate to heavy ripping and may produce oversize material.

Groundwater. Review of ranch wells along San Juan Creek indicates that groundwater was encountered at shallow depths (i.e., 15 to 25 feet below the ground surface) within Planning Area 1. Review of the referenced consultant reports indicates that groundwater also occurs in laterally discontinuous perched zones within landslide debris and the Capistrano and Monterey Formations.

Liquefaction. Review of the Seismic Hazard Maps prepared by the California Geological Survey (references (3) and (5)) indicates that a majority of the alluvial areas within Planning Area 1 are within a zone of required investigation for liquefaction. It should be noted that this does not indicate that a liquefaction hazard requiring mitigation is present.

As noted above, groundwater does occur at shallow depths within the alluvium of Planning Area 1. Liquefaction potential at the site can be mitigated by removal and recompaction of on-site soils and by raising grades. Other techniques including deep dynamic compaction or stone columns could be utilized in areas where removal and recompaction and raising grades is not sufficient to mitigate the potential for liquefaction. In accordance with the requirements of CDMG SP 117, supplemental geotechnical reports including additional subsurface exploration, liquefaction analyses and recommendations will be provided during review and processing of the grading plans when such more precise plans are made available.

Erosion Potential/Erodibility. All surficial units, with the exception of the terrace deposits, are highly susceptible to erosion. The terrace deposits have a low to moderate erosion potential, with sand lenses and unconsolidated beds more likely to be subject to erosion. Bedrock of the Monterey and

Capistrano Formations has high erosion potential. Erodibility can be mitigated during grading utilizing conventional grading techniques such as slope stabilization and construction of drainage devices.

Soil Creep. Soil creep within the surficial units may occur on the natural slopes, or on cut slopes where surficial materials are exposed. Due to the clayey and expansive nature of the on-site surficial soils, soil creep may impact the development. Mitigation measures to reduce the potential impact of soil creep can be implemented during grading and design. Specific measures to mitigate soil creep, such as foundation design, setbacks, and removal and recompaction of creep prone materials, should be determined during grading plan review, based on the specific slopes and the design grading.

Expansive Soils. Soils generated from excavations of the native soil, landslide debris, and bedrock of the Capistrano and Monterey Formations will likely be expansive. Mitigation measures to reduce the potential for expansive soils within the proposed development can be implemented during grading and design and construction of the foundation systems. Specific measures to mitigate expansive soils should be determined during the grading plan review period.

Compactibility of Materials. All on-site native soil, terrace deposits, landslide debris, and Capistrano and Monterey Formation bedrock are suitable for use as compacted fill.

Corrosivity. Based on our experience in adjacent developments and review of reference (B), the on-site soils and bedrock range from moderately corrosive to severely corrosive to ferrous metals and possess a negligible to severe sulfate exposure to concrete. Typical measures to mitigate sulfate exposure in

Orange County include using sulfate-resistant designed concrete and protection of underground conduit. Specific measures to mitigate corrosive soils should be determined during the grading plan review period.

PLANNING AREA 2

Slope Stability.

Cut Slopes. Planning Area 2 is underlain by bedrock of the Santiago and Sespe Formations. In general, these units dip gently toward the west. West-facing cut slopes within Planning Area 2 will require buttressing. All cut slopes may need to be stabilized to reduce erosion given the granular nature of the bedrock materials. The buttressing and slope stabilization can be accomplished utilizing conventional grading techniques. Given the underlying bedrock formations, the strength of fills materials derived from these bedrock formations and our experience with adjacent developments, the magnitude of corrective grading necessary to stabilize the planned cut slopes within Planning Area 2 will be significantly less than was required for Planning Area 1.

Fill Slopes. As noted above, Planning Area 2 is underlain by bedrock of the Santiago and Sespe Formations. In general, these materials have higher strength characteristics than those within Planning Area 1. As a result of these higher strength parameters, the maximum fill slope height will likely be higher than that for Planning Area 1. Specific recommendations for fill slope construction including maximum fill slope height should be determined based on detailed field investigation, laboratory testing, and geotechnical analyses and review of the engineered grading plans.

Settlement.

Collapsible Soils/Compressible Soils. Based on our review of the available geotechnical reports and our field investigations, collapsible soils and/or compressible soils are present throughout the planning area. The compressible soils include the native soil, colluvium, perched soil, portions of the terrace deposits, the upper portions of the landslide debris, and weathered portions of the bedrock. The compressible soils can be mitigated by removal and recompaction.

Rippability. Based on our preliminary investigation, we anticipate that materials encountered in Planning Area 2 could be excavated with standard construction equipment with moderate ripping. No hard rock was encountered during our limited investigation, however, beds within both the Sespe and Santiago Formations may contain well-cemented materials that may require moderate to heavy ripping and may produce oversize material.

Groundwater. Groundwater is present at shallow to moderate depths within Cañada Chiquita and several of the tributary canyons within the planning area. Shallow groundwater may impact the development in areas where improvements are planned within the main alluvial canyon of Cañada Chiquita and should be taken into consideration during the design of development and associated infrastructure. Review of the development plan indicates that the majority of the proposed development is located on the ridges east of Cañada Chiquita. Therefore, groundwater is not anticipated to be an impact to the proposed development.

Liquefaction. Review of the Seismic Hazard Map prepared by the California Geological Survey (reference (3)) indicates that a majority of the main stem and associated tributaries of Cañada Chiquita within Planning Area 2 are within a zone of required investigation for liquefaction. As discussed above this does not indicate that a liquefaction hazard requiring mitigation is present.

Groundwater is present at shallow to moderate depths within Cañada Chiquita and several of the tributary canyons within the planning area. Review of the development plan indicates that the majority of the proposed development is located on the ridges east of Cañada Chiquita. Therefore, liquefaction is not anticipated to be an impact to the proposed development. Nevertheless, liquefaction potential at the site can be mitigated by removal and recompaction of on-site soils and by raising grades. Other techniques including deep dynamic compaction or stone columns could be utilized in areas where removal and recompaction and raising grades is not sufficient to mitigate the potential for liquefaction. In accordance with the requirements of CDMG SP 117, supplemental geotechnical reports including additional subsurface exploration, liquefaction analyses and recommendations will be provided during review and processing of the grading plans when such more precise plans are made available.

Erosion Potential/Erodibility. All surficial units are highly susceptible to erosion with the exception of the terrace deposits and the perched soil horizon that caps some of the ridges. The terrace deposits have a low to moderate erosion potential, with sand lenses and unconsolidated beds more likely to be subject to erosion. The perched soil horizons are clay-rich and have a low erosion potential and low permeability. Bedrock of the Sespe Formation has a moderate to high erosion potential due to the friable nature of the material. The upper beds of the Santiago Formation have high erosion potential, while the lower beds of the Santiago Formation have low erosion potential. Erodibility can be mitigated during grading by construction of buttress or stabilization slopes.

Soil Creep. Soil creep is not likely to impact the development within Planning Area 2. However, the areas where the Sespe Formation or upper units of the Santiago Formation underlie the surficial units would be the most susceptible. Mitigation measures to reduce the potential impact of soil creep can be implemented during the design and grading. Specific measures, such as foundation design, setbacks, and removal and recompaction of creep prone materials, should be evaluated during the design and grading plan review process.

Expansive Soils. Expansive soils were encountered within the planning area, particularly within some of the surficial units, as described in a previous section of this report. Some of the finer- grained units within the Sespe and upper beds of the Santiago Formation are moderately expansive, while the lower beds of the Santiago Formation generally have low expansion potential. Mitigation measures to reduce the potential for expansive soils within the proposed development can be implemented during design and construction of foundations.

Compactibility of Materials. All on-site native soil, terrace deposits, landslide debris, and Santiago and Sespe Formation bedrock are considered suitable for use as compacted fill.

Corrosivity. Based on review of reference (B), the on-site soils and bedrock range from mildly corrosive to severely corrosive to ferrous metals and possess a negligible to moderate sulfate exposure to concrete. No information is available to evaluate corrosivity to copper pipes. Specific measures to mitigate corrosive soils should be determined during the grading plan review period.

PLANNING AREA 3

Slope Stability.

Cut Slopes. The following geologic constraints exist within Planning Area 3 in regards to planned cut slopes: 1) bedrock units within Planning Area 3 generally dip gently to the west, 2) most of the planning area is underlain by sandstone of the Santiago Formation, 3) the Mission Viejo fault crosses the eastern portion of the site, and 4) scattered small landslides have been mapped within the planning area. Cut slopes that are affected by these constraints will likely require stabilization or buttressing. All westerly facing cut slopes will likely require buttressing to mitigate adverse bedding orientations. Cut slopes that expose sandstone will likely require stabilization or buttressing to prevent erosion or raveling of the slope face. In areas where the Mission Viejo fault may be exposed in the cut slope, stabilization will likely be required to mitigate the fractured nature of the bedrock. Cut slopes that will expose landslide debris will require stabilization to prevent slope failure. This corrective grading and slope stabilization can be accomplished utilizing conventional grading techniques. Given the underlying bedrock formations, the strength of fills materials derived from these bedrock formations and our experience with adjacent developments, the magnitude of corrective grading necessary to stabilize the planned cut slopes within Planning Area 3 will be significantly less than was required for Planning Area 1.

Fill Slopes. Within Planning Area 3, the material generated for fills will consist of silty sands and sandy silts derived from the surficial materials and the Santiago, Silverado, and Williams Formations. These materials should have higher strength values than the material within Planning Area 1. We anticipate that the maximum fill slope height constructed at a 2:1 (horizontal:vertical) ratio will be higher than that of Planning Area 1. Future geotechnical investigation and grading plan review, including laboratory testing and geotechnical analyses, will be necessary to determine maximum fill slope height.

Settlement.

Collapsible Soils/Compressible Soils. Collapsible soils and/or compressible soils were encountered during surface mapping throughout Planning Area 3. The native soil, non-engineered fill, alluvium, slopewash, landslide debris, lake deposits, perched soils, portions of the terrace deposits and landslide debris, and weathered portions of the bedrock are generally considered to be collapsible or compressible. In the areas of planned development, removal and recompaction of all collapsible/compressible soils is recommended.

Existing Fills. Isolated areas of undocumented fill materials occur throughout Planning Area 3.

These fills generally occur along existing ranch roads, within some of the tributary canyons, and in pockets within the southern portion of the planning area, just north of the San Juan Creek drainage. Undocumented fill is likely to be within the nursery and industrial areas in the southern and southeastern portions of Planning Area 3. These areas of undocumented fill should be removed to expose competent, dense, native materials and be replaced with engineered fill within areas of planned development.

Rippability. Based on our limited preliminary investigation, we anticipate that materials encountered in Planning Area 3 could be excavated with standard construction equipment with moderate to heavy ripping. No hard rock was encountered during our limited investigation, however, beds within the Santiago and Silverado Formations may contain well-cemented layers or lenses that may require moderate to heavy ripping and may produce oversize material. Depending on the depth of cut, excavations within the Williams Formation may encounter material that requires heavy ripping or may require blasting and will likely produce oversize material.

Groundwater. Groundwater was encountered within drill holes advanced within the alluvium in portions of Cañada Gobernadora. Water may occur in laterally discontinuous perched zones within terrace deposits, landslide debris, and bedrock of the Santiago, Silverado, and Williams Formations. The groundwater within the alluvium occurs at relatively shallow depths (0 to 25 feet below ground surface). Groundwater depths should be taken into consideration during design of the planned development.

Liquefaction. Review of the Seismic Hazard Map prepared by the California Geological Survey (reference (3)) indicates that a majority of the main stem and associated tributaries of Cañada Gobernadora within Planning Area 3 are within a zone of required investigation for liquefaction. As discussed above this does not indicate that a liquefaction hazard requiring mitigation is present.

As discussed above, groundwater is present at shallow depths within Cañada Gobernadora and several of the tributary canyons within the planning area. Review of the development plan indicates that the majority of the proposed development is located on the ridges east of Cañada Gobernadora. Therefore, liquefaction is not anticipated to be an impact to the proposed development. Nevertheless, liquefaction potential at the site can be mitigated by removal and recompaction of on-site soils and by raising grades. Other techniques, including deep dynamic compaction or stone columns, could be utilized in areas where removal and recompaction and raising grades are not sufficient to mitigate the potential for liquefaction. In accordance with the requirements of CDMG SP 117, supplemental geotechnical reports including additional subsurface exploration, liquefaction analyses and recommendations will be provided during review and processing of the grading plans when such more precise plans are made available.

Soil Creep. Soil creep is not likely to impact the development within Planning Area 3. However, the surficial soils and portions of the Silverado Formation would be the most susceptible to creep, if this phenomenon was to occur. Mitigation measures to reduce the potential impact of soil creep can be implemented during design and grading of the site. Specific measures, such as foundation design, setbacks, and removal and recompaction of creep prone materials, should be determined during the design and grading plan review process.

Erosion Potential/Erodibility. All surficial units are highly susceptible to erosion with the exception of the terrace deposits and the perched soil horizon that caps the ridges. The terrace deposits have a low to moderate erosion potential, with sand lenses and unconsolidated beds more likely to be subject to erosion. The perched soil horizons are clay-rich and have a low erosion potential and low permeability. Bedrock of the Santiago Formation has a low erosion potential. The Silverado Formation has a high erosion potential, while the Pleasants Sandstone member of the Williams Formation has a moderate erosion potential. Erodibility can be mitigated during grading utilizing conventional grading techniques.

Expansive Soils. Soils generated from excavations of the native soil, slopewash, landslide debris, lake deposits, and perched soils will likely be expansive. Portions of the Silverado Formation may also be expansive. Mitigation measures to reduce the potential for expansive soils within the proposed development can be implemented during grading and design and construction of the foundation systems. Specific measures to mitigate expansive soils should be determined during the grading plan review period.

Compactibility of Materials. All on-site native soil, alluvium, slopewash, landslide debris, lake deposits, perched soils, terrace deposits, and Santiago, Silverado, and Williams Formation bedrock are suitable for use as compacted fill.

Corrosivity. Laboratory test results in reference (B) provide preliminary corrosivity data for the bedrock formations within Planning Area 3. Alluvium ranges from moderate to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The terrace deposits range from moderate to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The Santiago Formation ranges from corrosive to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The Silverado Formation ranges from moderate to severely corrosive to ferrous metals and a negligible to moderate sulfate exposure to concrete. The Pleasants Sandstone member of the Williams Formation is severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. No information (e.g., ammonia test results) is available to evaluate corrosivity to copper pipe. Testing for corrosivity to copper pipe should be evaluated in the future. Specific measures to mitigate corrosive soils should be determined during the grading plan review period.

PLANNING AREA 4

Slope Stability.

Cut Slopes. The following geologic constraints exist within Planning Area 4 in regards to planned cut slopes: 1) bedrock units within Planning Area 4 generally dip gently to the west, and 2) most of the planning area is underlain by sandstone of the Williams Formation. Cut slopes that are affected by these constraints will likely require stabilization or buttressing. All westerly facing cut slopes will likely require buttressing to mitigate adverse bedding orientations. Cut slopes that expose sandstone will likely require stabilization or buttressing to prevent erosion or raveling of the slope face. This corrective grading and slope stabilization can be accomplished utilizing conventional grading techniques. Given the underlying bedrock formations, the strength of fills materials derived from these bedrock formations and our experience with adjacent developments, the magnitude of corrective grading necessary to stabilize the planned cut slopes within Planning Area 4 will be significantly less than will be required for Planning Area 1.

Fill Slopes. Within Planning Area 4, the material generated for fills will consist of silty sands and some sandy silts derived from the surficial materials and the Pleasants Sandstone member and the Schulz Ranch member of the Williams Formation. As in Planning Area 3, these materials should have higher strength values than the material within Planning Area 1. We anticipate that the maximum fill slope height constructed at a 2:1 (horizontal:vertical) ratio will be higher than that of Planning Area 1. Future geotechnical investigation and grading plan review, including laboratory testing and geotechnical analyses, will be necessary to determine maximum fill slope height.

Settlement.

Collapsible Soils/Compressible Soils. Collapsible soils and/or compressible soils were encountered during surface mapping in portions of Planning Area 4. The native soil, alluvium, slopewash, portions of the terrace deposits, and weathered portions of the bedrock are generally considered to be collapsible or compressible. In the areas of planned development, removal and recompaction of all collapsible/compressible soils is recommended.

Existing Fills. Isolated areas of undocumented fill materials may occur within Planning Area 4. These fills generally occur along existing ranch roads or in small, isolated pockets within the site. Areas of undocumented fill should be removed to competent, dense, native materials and replaced with engineered fill within areas of planned development.

Rippability. Based on our limited preliminary investigation, we anticipate that materials encountered in Planning Area 4 may be excavated with standard construction equipment with heavy ripping. No hard rock was encountered during our limited investigation, however, subsurface investigation for this and previous investigations within the Williams Formation has encountered well-indurated materials that, depending on the depth of cut, may require blasting and will likely produce oversize material.

Groundwater. Review of available subsurface exploration indicates no groundwater was encountered in the alluvium south of Ortega Highway. No groundwater data was available for review for the portion of Planning Area 4 located north of Ortega Highway. Groundwater may occur in shallow depths within the alluvium adjacent to San Juan Creek. Water may occur in laterally discontinuous perched zones within the Williams Formation. Groundwater depths should be taken into consideration during design of the planned development.

Liquefaction. Review of the Seismic Hazard Map prepared by the California Geological Survey (reference (3)) indicates that a majority of the alluvial adjacent to San Juan Creek within Planning Area 4 is within a zone of required investigation for liquefaction. As noted above this does not indicate that a liquefaction hazard requiring mitigation is present.

Review of available subsurface exploration indicates no groundwater was encountered in the alluvium south of Ortega Highway. No groundwater data was available for review for the portion of Planning Area 4 located north of Ortega Highway. Liquefaction potential within Planning Area 4, south of Ortega Highway, is considered negligible given that no groundwater was encountered south of Ortega Highway. The liquefaction potential north of Ortega Highway, if present, can be mitigated by removal and recompaction of on-site soils and by raising grades. Other techniques, including deep dynamic compaction or stone columns, could be utilized in areas where removal and recompaction and raising grades are not sufficient to mitigate the potential for liquefaction. In accordance with the requirements of CDMG SP 117, supplemental geotechnical reports including additional subsurface exploration, liquefaction analyses and recommendations will be provided during review and processing of the grading plans when such more precise plans are made available.

Soil Creep. Soil creep may occur within the surficial units on the natural slopes, or on cut slopes where these materials are exposed. Due to the clayey and expansive nature of the surficial soils, slope creep may impact the development. Mitigation measures to reduce the potential impact of soil creep can be implemented during design and grading of the site. Specific measures, such as foundation design, setbacks, and removal and recompaction of creep prone materials, should be determined during the design and grading plan review process.

Erosion Potential/Erodibility. All surficial units, with the exception of the terrace deposits, are considered highly susceptible to erosion. The terrace deposits have a low to moderate erosion potential, with sand lenses and unconsolidated beds more likely to be subject to erosion. Bedrock of the Pleasants Sandstone member of the Williams Formation has a moderate erosion potential, while the Schulz Ranch member has a high erosion potential. Erodibility can be mitigated during grading utilizing conventional grading techniques.

Expansive Soils. Soils generated from excavations of the native soil and slopewash will likely be expansive. The bedrock is not likely to be expansive. Mitigation measures to reduce the potential for expansive soils within the proposed development can be implemented during grading and design and construction of the foundation systems. Specific measures to mitigate expansive soils should be determined during the grading plan review period.

Compactibility of Materials. All on-site native soil, alluvium, slopewash, landslide debris, terrace deposits, and Williams Formation bedrock are suitable for use as compacted fill.

Corrosivity. Laboratory test results in reference (B) provide preliminary corrosivity data for the bedrock formations within Planning Area 4. Alluvium ranges from moderate to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The terrace deposits range from moderate to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The Pleasants Sandstone member of the Williams Formation is severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. Data is not available for the Schulz Ranch member of the Williams Formation. No information (e.g., ammonia test results) is available to evaluate corrosivity to copper pipe. Testing for corrosivity to copper pipe should be evaluated in the future. Specific measures to mitigate corrosive soils should be determined during the grading plan review period.

PLANNING AREA 5

Slope Stability.

<u>Cut Slopes</u>. Planning Area 5 is underlain by bedrock of the Santiago Formation with small areas of Monterey Formation, Topanga Formation, and San Onofre Breccia located along the western boundary of the planning area. In general, these units dip gently toward the west. The Cristianitos Fault Zone is located

along the western boundary of Planning Area 5. Review of the available geotechnical reports and our field investigations indicate the bedrock units along the western boundary of Planning Area 5 are moderately well-fractured in close proximity to the Cristianitos Fault Zone. This fracturing of the bedrock has weakened the bedrock units in this area and resulted in the multiple landslides adjacent to the Cristianitos Fault Zone. West-facing cut slopes and cut slopes within landslide debris within Planning Area 5 will require buttressing. Design cut slopes at other orientations may need to be stabilized to reduce erosion given the granular nature of the Santiago Formation and the San Onofre Breccia bedrock materials. The buttressing and slope stabilization can be accomplished utilizing conventional grading techniques. Given the underlying bedrock formations, the strength of fills materials derived from these bedrock formations and our experience with adjacent developments, the magnitude of corrective grading necessary to stabilize the planned cut slopes within Planning Area 5 will be significantly less than was required for the Planning Area 1.

Fill Slopes. As noted above, Planning Area 5 is predominantly underlain by bedrock of the Santiago Formation. In general, these materials have higher strength characteristics than those within Planning Area 1. As a result of these higher strength parameters, the maximum fill slope height will likely be higher than that for Planning Area 1. Specific recommendations for fill slope construction including maximum fill slope height should be determined based on detailed field investigation, laboratory testing, and geotechnical analyses and review of the engineered grading plans.

Settlement.

Collapsible Soils/Compressible Soils. Based on our review of the available geotechnical reports and our field investigations, collapsible soils and/or compressible soils are present throughout Planning Area 5. The compressible soils include the native soil, alluvium, colluvium, the upper portions of the landslide debris, and weathered portions of the bedrock. The compressible soils can be mitigated by removal and recompaction.

Existing Fills. Isolated areas of undocumented fill materials occur throughout Planning Area 5. These fills generally occur along existing ranch roads or roads within the Oglebay-Norton sand plant. Additional undocumented fills are associated with the sand plant. These fills include the overburden materials located along the western margin of the sand plant and the mine tailings deposited behind the Trampas Canyon Dam. All areas of undocumented fill within the limits of the planned development should be removed to competent, dense, native materials and replaced with engineered fill.

Rippability. Based on our preliminary mapping and review of the available geotechnical reports, we anticipate that materials encountered in Planning Area 5 could be excavated utilizing standard construction equipment with moderate to heavy ripping, with two exceptions. Deep excavations planned within the Topanga Formation and San Onofre Breccia, and the landslide debris generated from these units will likely encounter extensive zones of hard, cemented material. These areas will likely require blasting in order to excavate these bedrock materials. The bedrock of the Topanga Formation and San Onofre

Breccia and landslide debris generated from these units may produce oversize material. Surficial soils and bedrock of the Monterey and Santiago Formations generally contain material that could be excavated with moderate ripping. The Monterey and Santiago Formations may contain some discontinuous, well-cemented materials that may require moderate to heavy ripping and may produce oversize material.

Groundwater. Groundwater monitoring of water levels within Trampas Canyon indicate the water surface within the alluvium is approximately 40 feet below existing ground surface. The presence of shallow groundwater within the alluvium is not considered to be an impact to the proposed project.

Liquefaction. Review of the Seismic Hazard Maps prepared by the California Geological Survey (reference (3) and (4)) indicates that a majority of the main stem and associated tributaries of Trampas Canyon within Planning Area 5 are within a zone of required investigation for liquefaction. As previously discussed this does not indicate that a liquefaction hazard requiring mitigation is present. As noted above, groundwater occurs at a depth of approximately 40 feet below existing ground surface. Therefore, liquefaction potential within Planning Area 5 is considered low.

Soil Creep. Soil creep may occur within the surficial units on the natural slopes, or on cut slopes where these materials are exposed. Some of the beds within the Monterey Formation may also be susceptible to creep. Due to the clayey and expansive nature of these soils, slope creep may impact the development. Mitigation measures to reduce the potential impact of soil creep can be implemented during design and grading of the site. Specific measures, such as foundation design, setbacks, and removal and recompaction of creep prone materials, should be determined during the design and grading plan review process.

Erosion Potential/Erodibility. All surficial units are highly susceptible to erosion. Bedrock of the Monterey Formation has moderately low erosion potential, while the San Onofre Breccia and the Topanga Formation have low erosion potential. The lower beds of the Santiago Formation also have low erosion potential. Erodibility can be mitigated, if necessary, by using conventional grading and construction techniques.

Expansive Soils. Expansive soils were encountered within the planning area, particularly within some of the surficial units, as described in a previous section of this report. Some of the beds of the Monterey Formation are expansive, particularly those with bentonite content. The San Onofre Breccia, the Topanga Formation, and the lower beds of the Santiago Formation generally have low expansion potential. Specific measures to mitigate expansive soils should be determined during the grading plan review period.

Compactibility of Materials. All on-site native soil, terrace deposits, landslide debris, and Santiago and Sespe Formation bedrock are considered suitable for use as compacted fill.

Corrosivity. Based on review of reference (B), the on-site soils and bedrock range from mildly corrosive to severely corrosive to ferrous metals and possess a negligible to severe sulfate exposure to concrete. No information is available to evaluate corrosivity to copper pipes. Specific measures to mitigate corrosive soils should be determined during the grading plan review period.

PLANNING AREA 6

Slope Stability.

Cut Slopes. The following geologic constraints exist within Planning Area 6 in regards to planned cut slopes: 1) bedrock units within Planning Area 6 generally dip gently to the west and 2) a majority of the planning area is underlain by sandstone of the Santiago Formation. Cut slopes that are affected by these constraints will likely require stabilization or buttressing. All westerly facing cut slopes will likely require buttressing to mitigate adverse bedding orientations. Cut slopes that expose sandstone will likely require stabilization or buttressing to prevent erosion or raveling of the slope face. Given the underlying bedrock formations, the strength of fills materials derived from these bedrock formations and our experience with adjacent developments, the magnitude of corrective grading necessary to stabilize the planned cut slopes within Planning Area 6 will be significantly less than was required for Planning Area 1.

Fill Slopes. Within Planning Area 6, the material generated for fills will consist of silty sands and sandy silts derived from the surficial materials and the Santiago and Silverado Formations. These materials should have higher strength values than the material within Planning Area 1. We anticipate that the maximum fill slope height constructed at a 2:1 (horizontal:vertical) ratio will be higher than that of Planning Area 1. Future geotechnical investigation and grading plan review, including laboratory testing and geotechnical analyses will be necessary to determine maximum fill slope height.

Settlement.

Collapsible Soils/Compressible Soils. Collapsible soils and/or compressible soils were encountered during surface mapping in portions of Planning Area 6. The native soil, slopewash, perched soils, and weathered portions of the bedrock are generally considered to be collapsible or compressible. In the areas of planned development, removal and recompaction of all collapsible/compressible soils is recommended.

Existing Fills. Isolated areas of undocumented fill materials may occur within Planning Area 6. These fills generally occur along existing ranch roads or in small, isolated pockets within the site. Areas of undocumented fill should be removed to competent, dense, native materials and replaced with engineered fill within areas of planned development.

Rippability. Based on our limited preliminary investigation, we anticipate that materials encountered in Planning Area 6 may be excavated with standard construction equipment with moderate ripping. No hard rock was encountered during our limited investigation, however, beds within the Santiago and Silverado Formations may contain well-cemented zones that may require heavy ripping and may produce oversize material.

Groundwater. Groundwater has been observed at depths of 40 to 50 feet within wells located in the canyon at the southwestern edge of the planning area. Water may also occur in laterally discontinuous perched zones within the Santiago and Silverado Formations. Groundwater depths should be taken into consideration during design of the planned development.

Liquefaction. Review of the Seismic Hazard Maps prepared by the California Geological Survey (reference (3) and (4)) indicates that a portion of the canyon area along the southwestern margin of Planning Area 6 is located within a zone of required investigation for liquefaction. This does not indicate that a liquefaction hazard requiring mitigation is present. As noted above, groundwater occurs at a depth of approximately 40 feet below existing ground surface. Therefore, liquefaction potential within Planning Area 6 is considered low.

Soil Creep. Soil creep is not likely to occur within Planning Area 6. Surficial materials, as well as some of the beds within the Silverado Formation would be the most susceptible to creep, if it was to occur. Mitigation measures to reduce the potential impact of soil creep can be implemented during design and grading of the site. Specific measures, such as foundation design, setbacks, and removal and recompaction of creep prone materials, should be determined during the design and grading plan review process.

Erosion Potential/Erodibility. All surficial units are considered highly susceptible to erosion. Bedrock of the Santiago Formation has a low erosion potential, while the Silverado Formation has a high erosion potential. Erodibility can be mitigated during grading utilizing conventional grading techniques.

Expansive Soils. Soils generated from excavations of the native soil, slopewash, and perched soils will likely be expansive. Some beds within the Silverado may be expansive, especially those with high clay content. Mitigation measures to reduce the potential for expansive soils within the proposed development can be implemented during grading and design and construction of the foundation systems. Specific measures to mitigate expansive soils should be determined during the grading plan review period.

Compactibility of Materials. All on-site native soil, slopewash, perched soil, Santiago Formation, and Silverado Formation bedrock are suitable for use as compacted fill.

Corrosivity. Laboratory test results in reference (B) provide preliminary corrosivity data for the bedrock formations within Planning Area 6. The Santiago Formation ranges from corrosive to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The Silverado Formation ranges from moderate to severely corrosive to ferrous metals and a negligible to moderate sulfate exposure to concrete. No information (e.g., ammonia test results) is available to evaluate corrosivity to copper pipe. Testing for corrosivity to copper pipe should be evaluated in the future. Specific measures to mitigate corrosive soils should be determined during the grading plan review period.

PLANNING AREA 7

Slope Stability.

<u>Cut Slopes</u>. The following geologic constraints exist within Planning Area 7 in regards to planned cut slopes: 1) bedrock units within Planning Area 7 generally dip gently to the west, 2) most of the planning area is underlain by friable sandstone and siltstone of the Santiago and Silverado Formations, 3) the Mission Viejo fault crosses the central portion of the planning area, and 4) scattered small to moderate-sized landslides have been mapped within the planning area. Cut slopes that are affected by these constraints will likely require stabilization or buttressing. All westerly facing cut slopes will likely require buttressing to

mitigate unsupported bedding orientations. Cut slopes that expose sandstone and siltstone will likely require stabilization or buttressing to prevent erosion or raveling of the slope face. In areas where the Mission Viejo fault may be exposed in the cut slope, stabilization will likely be required to mitigate the fractured nature of the bedrock. Cut slopes that will expose landslide debris will require stabilization or buttressing to prevent slope failure. This corrective grading and slope stabilization can be accomplished utilizing conventional grading techniques. The strength of the underlying bedrock formations and the fills materials derived from these bedrock formations are expected to be higher than those encountered in Planning Area 1. With the exception of two large landslide complexes within the planning area, the magnitude of corrective grading necessary to stabilize the planned slopes within Planning Area 7 is anticipated to be significantly less than will be required for Planning Area 1.

Fill Slopes. Within Planning Area 7, the material generated for fills will consist primarily of silty sands and sandy silts derived from the surficial materials and the Santiago, Silverado, and Williams Formations. These materials should have higher strength values than the material within Planning Area 1. We anticipate that the maximum fill slope height constructed at a 2:1 (horizontal:vertical) ratio will be higher than that of Planning Area 1. Future geotechnical investigation and grading plan review, including laboratory testing and geotechnical analyses, will be necessary to determine maximum fill slope height.

Settlement.

Collapsible Soils/Compressible Soils. Collapsible soils and/or compressible soils were encountered during surface mapping throughout Planning Area 7. The native soil, non-engineered fill, alluvium, slopewash, landslide debris, perched soils, portions of the terrace deposits and landslide debris, and weathered portions of the bedrock are generally considered to be collapsible or compressible. In the areas of planned development, removal and recompaction of all collapsible/compressible soils is recommended.

Existing Fills. Isolated areas of undocumented fill materials occur throughout Planning Area 7. These fills generally occur along existing ranch roads, within some of the tributary canyons, and at the small reservoir in the north central portion of the planning area. Undocumented fills are also likely to be associated with the various clay pits located throughout Planning Area 7. These areas of undocumented fill should be removed to competent, dense native materials and replaced with engineered fill within areas of planned development.

Rippability. Based on our limited field studies and review of the available geotechnical reports, we anticipate that materials encountered in Planning Area 7 could be excavated with standard construction equipment with moderate to heavy ripping. No hard rock was encountered during our limited investigation, however, beds within the Santiago and Silverado Formations may contain well-cemented layers or lenses that may require moderate to heavy ripping, and may produce oversize material. Depending on the depth of cut, excavations within the Williams Formation may encounter material that requires heavy ripping or may require blasting and will likely produce oversize material.

Groundwater. Planning Area 7 contains no major alluvial drainages. Limited subsurface exploration and review of available geotechnical reports suggest groundwater within the small drainage canyon occurs at a depth of approximately 20 feet below existing ground surface. Groundwater is not considered to be an impact to the proposed project.

Liquefaction. As discussed above, no major alluvial tributaries are located within Planning Area 7. One small tributary canyon located at the southern margin of the planning area north of Gabino Canyon is mapped within a zone of required investigation for liquefaction (reference (4)). As previously discussed this does not indicate that a liquefaction hazard requiring mitigation is present. Geologic mapping of this portion of the site indicate that alluvial materials in this area are no longer present. These materials were removed as a result of historic mining operations. Therefore, liquefaction within Planning Area 7 is not considered to be an impact.

Soil Creep. Soil creep is not likely to impact Planning Area 7. However, the surficial materials and some of the clayey beds within the Silverado Formation would be most susceptible to the creep phenomenon, if it was to occur. Mitigation measures to reduce the potential impact of soil creep can be implemented during design and grading of the site. Specific measures, such as foundation design, setbacks, and removal and recompaction of creep prone materials, should be determined during the design and grading plan review process.

Erosion Potential/Erodibility. All surficial units, with the exception of the terrace deposits, are considered highly susceptible to erosion. The terrace deposits have a low to moderate erosion potential, with sand lenses and unconsolidated beds more likely to be subject to erosion. Bedrock of the Santiago Formation has a low erosion potential. The Silverado Formation has a high erosion potential, while the Pleasants Sandstone member of the Williams Formation has a moderate erosion potential. Erodibility can be mitigated during grading utilizing conventional grading techniques.

Expansive Soils. Soils generated from excavations of the native soil, slopewash, colluvium, landslide debris, and perched soils will likely be expansive. Portions of the Silverado Formation may also be expansive. Mitigation measures to reduce the potential for expansive soils within the proposed development can be implemented during grading and design and construction of the foundation systems. Specific measures to mitigate expansive soils should be determined during the grading plan review period.

Compactibility of Materials. All on-site native soil, alluvium, slopewash, landslide debris, perched soils, terrace deposits, and Santiago, Silverado, and Williams Formation bedrock are suitable for use as compacted fill.

Corrosivity. Laboratory test results in reference (B) provide preliminary corrosivity data for the bedrock formations within Planning Area 7. Alluvium ranges from moderate to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The terrace deposits range from moderate to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The Santiago Formation ranges from corrosive to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The Silverado Formation ranges from moderate to severely corrosive to ferrous metals and a negligible to moderate sulfate exposure to concrete. The Pleasants Sandstone member of the Williams Formation is severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. No information (e.g., ammonia test results) is available to evaluate corrosivity to copper pipe. Testing for corrosivity to copper pipe should be evaluated in the future. Specific measures to mitigate corrosive soils should be determined during the grading plan review period.

PLANNING AREA 8

Slope Stability.

Cut Slopes. The following geologic constraints exist within Planning Area 8 in regards to planned cut slopes: 1) bedrock units within Planning Area 8 generally dip gently to the west, 2) most of the planning area is underlain by sandstone of the Santiago and Williams Formations, 3) two strands of the Mission Viejo fault crosses the western portion of the planning area, and 4) scattered small-sized landslides have been mapped within the planning area. Cut slopes that are affected by these constraints will likely require stabilization or buttressing. All westerly facing cut slopes will likely require buttressing to mitigate unsupported bedding orientations. Cut slopes that expose sandstone will likely require stabilization or buttressing to prevent erosion or raveling of the slope face. In areas where the Mission Viejo fault may be exposed in the cut slopes, stabilization will likely be required to mitigate the fractured nature of the bedrock. Although only two landslides are mapped within the planning area, cut slopes that will expose landslide debris will require stabilization or buttressing to prevent slope failure. This corrective grading and slope stabilization can be accomplished utilizing conventional grading techniques. Given the underlying bedrock formations, the strength of fills materials derived from these bedrock formations and our experience with adjacent developments, the magnitude of corrective grading necessary to stabilize the planned cut slopes within Planning Area 8 will be significantly less than will be required for Planning Area 1.

Fill Slopes. Within Planning Area 8, the material generated for fills will consist primarily of silty sands and sandy silts derived primarily from the surficial materials and bedrock of the Santiago and Williams Formations. These materials should have higher strength values than the material within Planning Area 1. We anticipate that the maximum fill slope height constructed at a 2:1 (horizontal:vertical) ratio will be higher than that of Planning Area 1. Future geotechnical investigation and grading plan review, including laboratory testing and geotechnical analyses, will be necessary to determine maximum fill slope height.

Settlement.

Collapsible Soils/Compressible Soils. Collapsible soils and/or compressible soils were encountered during surface mapping throughout Planning Area 8. The native soil, non-engineered fill, alluvium, colluvium, slopewash, landslide debris, portions of the terrace deposits and landslide debris, and weathered portions of the bedrock are generally considered to be collapsible or compressible. In the areas of planned development, removal and recompaction of all collapsible/compressible soils is recommended.

Existing Fills. Isolated areas of undocumented fill materials occur throughout Planning Area 8. These fills generally occur along existing ranch roads. Undocumented fills may occur at some of the facilities associated with the TRW Capistrano Test Site within Planning Area 8. These areas of undocumented fill should be removed to competent, dense, native materials and replaced with engineered fill within areas of planned development.

Rippability. Based on our limited field studies and review of the available geotechnical reports, we anticipate that materials encountered in Planning Area 8 could be excavated with standard construction equipment with moderate to heavy ripping. No hard rock was encountered during our limited investigation, however, beds within the Santiago and Silverado Formations may contain well-cemented layers or lenses that may require moderate to heavy ripping and may produce oversize material. Depending on the depth of cut, excavations within the Williams Formation may encounter material that requires heavy ripping or may require blasting and will likely produce oversize material.

Groundwater. Planning Area 8 contains no major alluvial drainages with the exception of a portion of Blind Canyon. No development within the drainage bottom of Blind Canyon is planned. Therefore, groundwater is not considered to be an impact to the proposed project.

Liquefaction. One very small area of Blind Canyon is mapped in an area of required investigation for liquefaction according to the San Clemente Seismic Hazard Map prepared by the California Geological Survey (reference (4)). As discussed above, no development within Blind Canyon is planned. Therefore, liquefaction potential within Planning Area 8 is considered negligible.

Soil Creep. Soil creep is not likely to impact the development within Planning Area 8. Surficial materials and some of the clayey beds within the Silverado Formation would be most likely to be susceptible to creep, if it was to occur. Mitigation measures can be evaluated during the design and grading process. Specific measures, such as foundation design, setbacks, and removal and recompaction of creep prone materials, should be determined during the design and grading plan review period.

Erosion Potential/Erodibility. All surficial units, with the exception of the terrace deposits, are considered highly susceptible to erosion. The terrace deposits have a low to moderate erosion potential, with sand lenses and unconsolidated beds more likely to be subject to erosion. Bedrock of the Santiago Formation has a low erosion potential. The Silverado Formation has a high erosion potential, while the Pleasants Sandstone member of the Williams Formation has a moderate erosion potential. Erodibility can be mitigated during grading utilizing conventional grading techniques.

Expansive Soils. Soils generated from excavations of the native soil, slopewash, colluvium, and landslide debris will likely be expansive. Portions of the Silverado Formation may also be expansive. Mitigation measures to reduce the potential for expansive soils within the proposed development can be implemented during grading and design and construction of the foundation systems. Specific measures to mitigate expansive soils should be determined during the grading plan review period.

Compactibility of Materials. All on-site native soil, alluvium, slopewash, colluvium, landslide debris, perched soils, terrace deposits, and Santiago, Silverado, and Williams Formation bedrock are suitable for use as compacted fill.

Corrosivity. Laboratory test results in reference (B) provide preliminary corrosivity data for the bedrock formations within Planning Area 8. Alluvium ranges from moderate to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The terrace deposits range from moderate to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The Santiago Formation ranges from corrosive to severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. The Silverado Formation ranges from moderate to severely corrosive to ferrous metals and a negligible to moderate sulfate exposure to concrete. The Pleasants Sandstone member of the Williams Formation is severely corrosive to ferrous metals and a negligible sulfate exposure to concrete. No information (e.g., ammonia test results) is available to evaluate corrosivity to copper pipe. Testing for corrosivity to copper pipe should be evaluated in the future. Specific measures to mitigate corrosive soils should be determined during the grading plan review period.

PLANNING AREA 9

Slope Stability.

Cut Slopes. The following geologic constraints exist within Planning Area 9 in regards to planned cut slopes: 1) bedrock units within Planning Area 9 generally dip gently to the west, 2) the eastern portion of the planning area is underlain by the Trabuco Formation, and 3) several landslides have been mapped within the planning area. The branch of the Mission Viejo fault that crosses the site is located west of the development area, and therefore is not a constraint. Cut slopes that are affected by these constraints will likely require stabilization or buttressing. All westerly facing cut slopes will likely require buttressing to mitigate adverse bedding orientations. Cut slopes that expose Trabuco Formation will likely require stabilization or buttressing, due to the weak nature of the material. Cut slopes that will expose landslide debris will require stabilization to prevent slope failure. This corrective grading and slope stabilization can be accomplished utilizing conventional grading techniques.

Fill Slopes. Within Planning Area 9, the material generated for fills will consist of silty sands and sandy silts derived from the surficial materials and the Williams, Ladd, and Trabuco Formations. These materials should have higher strength values than the material within Planning Area 1. We anticipate that the maximum fill slope height constructed at a 2:1 (horizontal: vertical) ratio will be higher than that of Planning Area 1. Future geotechnical investigation and grading plan review, including laboratory testing and geotechnical analyses, will be necessary to determine maximum fill slope height.

Settlement.

Collapsible Soils/Compressible Soils. Collapsible soils and/or compressible soils were encountered during surface mapping in portions of Planning Area 9. The native soil, alluvium, slopewash, landslide debris, portions of the terrace deposits, and weathered portions of the bedrock are generally considered to be collapsible or compressible. In the areas of planned development, removal and recompaction of all collapsible/compressible soils is recommended.

Existing Fills. Isolated areas of undocumented fill materials may occur within Planning Area 9.

These fills generally occur along existing ranch roads or in small, isolated pockets within the site. Areas of undocumented fill should be removed to competent, dense, native materials and replaced with engineered fill within areas of planned development.

Rippability. Based on our limited preliminary investigation, we anticipate that materials encountered in Planning Area 9 may be excavated with standard construction equipment with moderate to heavy ripping. Bedrock of the Williams and Ladd Formations will likely contain zones of well-cemented material that may require blasting and will produce oversize material. Bedrock of the Trabuco Formation will produce a significant amount of oversize material due to its conglomeratic nature.

Groundwater. Groundwater may occur in shallow depths within the major drainages in Planning Area 9, particularly in the areas adjacent to Verdugo and Gabino Canyons. Water may occur in laterally discontinuous perched zones within the surficial deposits and the bedrock formations. Groundwater depths should be taken into consideration during design of the planned development.

Liquefaction. Portions of the alluvial areas within Planning Area 9 are mapped within zones of required investigation for liquefaction according to the Cañada Gobernadora Seismic Hazard Map prepared by the California Geological Survey (reference (3)). As noted above, groundwater may occur at moderate depths within the alluvium of Planning Area 9. Liquefaction potential at the site can be mitigated by removal and recompaction of the soils and by raising grades. Other techniques, including deep dynamic compaction or stone columns, could be utilized in areas where removal and recompaction and raising grades are not sufficient to mitigate the potential for liquefaction.

Soil Creep. Soil creep may occur within the surficial materials on natural slopes or on cut slopes where these soils are exposed. Portions of the finer grained beds of the bedrock units may be susceptible to creep, particularly the weathered portions of these materials. Due to the weathered nature of these bedrock materials, and the expansive nature of the surficial soils, creep may impact the development. Mitigation measures can be determined during the design and grading process. Specific mitigation measures, such as foundation design, setbacks, and removal and recompaction of creep prone materials, should be determined during the design and grading plan review process.

Erosion Potential/Erodibility. All surficial units within Planning Area 9, with the exception of the terrace deposits, are considered highly susceptible to erosion. The terrace deposits have a low to moderate erosion potential, with sand lenses and unconsolidated beds more likely to be subject to erosion. Bedrock of the Pleasants Sandstone member of the Williams Formation has moderate erosion potential, while the Schulz Ranch member has a high erosion potential. The Holz Shale member of the Ladd Formation has high erosion potential, while the Baker Canyon member of the Ladd Formation has very low erosion potential. The Trabuco Formation has high erosion potential. Erodibility can be mitigated during grading utilizing conventional grading techniques.

Expansive Soils. Soils generated from excavations of the native soil, slopewash, and landslide debris will likely be expansive. Some of the finer-grained units within the Williams and Ladd Formations may be expansive. Mitigation measures to reduce the potential for expansive soils within the proposed development can be implemented during grading and design and construction of the foundation systems. Specific measures to mitigate expansive soils should be determined during the grading plan review period.

Compactibility of Materials. All on-site native soil, alluvium, slopewash, landslide debris, Williams, Ladd, and Trabuco Formation bedrock are suitable for use as compacted fill.

Corrosivity. No information is currently available to evaluate the corrosivity of the bedrock formations within Planning Area 9. No information (e.g., ammonia test results) is available to evaluate corrosivity to copper pipe. Testing for corrosivity to copper pipe should be evaluated in the future. Specific measures to mitigate corrosive soils should be determined during the grading plan review period.

PLANNING AREAS 10 THROUGH 13

Planning Areas 10 through 13 are designated as open space, and are not part of the scope of this report.

SUPPORTING DATA

The Plates and Appendix which complete this report are listed in the Table of Contents.

Respectfully submitted,

GOFFMAN, McCORMICK & URBAN, INC.

Patrick J. Jenks, CEG 1989
Engineering Geologist
Project Manager

Gary K. Urban, GE 2237
President

EXISTING DATA/PRIOR STUDIES

PUBLISHED MAPS AND REPORTS

Several published maps and reports were used as guidelines for our geotechnical studies. These reports and maps are listed below:

(1) Blanc, R.P., and Cleveland, G.B., 1968, Natural Slope Instability as Related to Geology, San Clemente Area, Orange and San Diego Counties, California, CDMG Special Report 98.

(2) California Geology Survey, 1997, Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117.

(3) California Geology Survey, Seismic Hazard Zones Map, Cañada Gobernadora Quadrangle, release date September 23, 2002.

(4) California Geology Survey, Seismic Hazard Zones Map, San Clemente Quadrangle, release date June 21, 2002.

(5) California Geology Survey, Seismic Hazard Zones Map, San Juan Capistrano Quadrangle, release date December 21, 2001.

(6) Morton, P.K., 1970, Geology of the Northeast Quarter and Northwest Quarter of the Cañada Gobernadora Quadrangle, Orange County, California, CDMG Preliminary Report 10.

(7) Morton, P.K., 1974, Geology and Engineering Geologic Aspects of the South Half of the Cañada Gobernadora Quadrangle, Orange County, California, CDMG Special Report 111.

(8) Morton, P.K., Edgington, W.J., and Fife, D.L., 1974, Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California, CDMG Special Report 112.

(9) Morton, P.K., and Miller, R.V., 1981, Geologic Map of Orange County, California, Showing Mines and Mineral Deposits, CDMG Bulletin 204.

(10) Agnew, D.C. and Sieh, K.E.,1978, A Documentary Study of the Felt Effects of the Great California Earthquake of 1857: Bulletin of the Seismological Society of America, v. 68, p. 1717-1729.

(11) Bender, E.E., 2000, Late Quaternary uplift and earthquake potential of the San Joaquin Hills, southern Los Angeles Basin, California: Comment and Reply: Geology, v. 28, p. 383.

(12) Bolt, B.A., 1971, The San Fernando Valley, California, Earthquake of February 9, 1971: Data on Seismic Hazards: Bulletin of the Seismological Society of America, v. 61, p. 501-510.

(13) Boore, D.M., Joyner, W.B., and Fumal, T.E., 1993, Estimation of response spectra and peak accelerations from western North American earthquakes: An interim report: U.S. Geol. Survey Open File Report 93-509, 72p.

(14) Boore, D.M., Joyner, W.B., and Fumal, T.E., 1997, Equations for estimating horizontal response spectra and peak acceleration from western North America earthquakes: A summary of recent work: Seismological Research Letters, v. 68, p. 128-153.

(15) Byerly, P., 1942, Seismological Notes: Bulletin of the Seismological Society of America, v. 32, p. 61-65.

(16) Cornell, C.A., 1968, Engineering seismic risk analysis: Bulletin of the Seismological Society of America, v. 58, p. 1583-1606.

(17) Grant, L.B., Muellar, K.J., Gath, E.M., Cheng, H., Edwards, R.L., Munro, R., and Kennedy, G.L., 1999, Late Quaternary uplift and earthquake potential of the San Joaquin Hills, southern Los Angeles Basin, California: Geology, v. 27, p. 1031-1034.

(18) Hart, E.W., and Bryant, W.A., 1997, Fault-rupture hazard zones in California: CDMG Special Publication 42, 38p.

(19) Hauksson, E., 1994, The 1991 Sierra Madre Earthquake Sequence in Southern California: Seismological and Tectonic Analysis: Bulletin of the Seismological Society of America, v. 84, p. 1058-1074.

(20) Hauksson, E. and Jones, L., 1988, The July 1986 Oceanside (M_L = 5.3) earthquake sequence in the Continental Borderland, Southern California: Bulletin of the Seismological Society of America, v. 78, p. 1885-1906.

(21) Jacoby, G.C. Jr., Sheppard, P.R., and Sieh, K.E., 1988, Irregular Recurrance of Large Earthquakes Along the San Andreas Fault: Evidence from Trees: Science, v. 241, p. 196-199.

(22) Jennings, C.W., 1994, Fault activity map of California and adjacent areas: CDMG Data Map No. 6, scale 1:750,000.

(23) Jones, L.M., Sieh, K.E., Hauksson, E., and Hutton, L.K., 1990, The 3 December 1988 Pasadena, California earthquake: Evidence for strike-slip motion on the Raymond Fault: Bulletin of the Seismological Society of America, v. 80, p. 474-482.

(24) Jones, L., Mori, J., and Hauksson, E., 1995, The Landers Earthquake: Preliminary Instrumental Results: Earthquakes and Volcanoes, v. 23, p. 200-208.

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(26) Kramer, S.L., Geotechnical earthquake engineering: Prentice Hall, Englewood Cliffs, New Jersey, 653p.

(27) Lander, J.F., ed., 1968, Seismological Notes: March and April 1968: Bulletin of the Seismological Society of America, v. 58, p. 1709-1714.

(28) Laughlin, H., Arnold, R., and Kew, W.S.W. 1923, Southern California Earthquake of July 22, 1923: Bulletin of the Seismological Society of America, v. 13, p. 105-106.

(29) McGuire, R.K., 1976, Fortran program for seismic risk analysis: U.S. Geol. Survey Open File Report 76-67, 90p.

(30) Magistrale, H., Jones, L., and Kanamori, H., 1989, The Superstition Hills, California, Earthquakes of 24 November 1987: Bulletin of the Seismological Society of America, v. 79, p. 239-251.

(31) Person, W.J., ed., 1988, Earthquakes: May - June 1988: Earthquakes and Volcanoes, v. 20, p. 196-198.

(32) Person, W.J., ed., 1986, Earthquakes: July - August 1986: Earthquakes and Volcanoes, v. 19, p. 32-35.

(33) Person, W.J., ed., 1990, Earthquakes: January - February 1990: Earthquakes and Volcanoes, v. 22, p. 179-181.

(34) Petersen, M. D. and Wesnousky, S.G., 1994, Fault slip rates and earthquake histories for active faults in southern California: Bulletin of the Seismological Society of America, v. 84, p. 1608-1649.

(35) Petersen, M. D. and eight others, 1996, Probabilistic seismic hazard assessment for the State of California: CDMG Open File Report 96-08.

(36) Rymer, M.J., ed., 1992, The 1992 Landers Earthquake and Surface Faulting: Earthquakes and Volcanoes, v. 23, p. 209-218.

(37) Shaw, J.H., and Shearer, P.M., 1999, An elusive blind-thrust fault beneath metropolitan Los Angeles: Science, v. 283, p. 1516-1518.

(38) Sieh, K.E., 1978, Slip along the San Andreas Fault associated with the great 1857 earthquake: Bulletin of the Seismological Society of America, v. 68, p. 1421-1448.

(39) Sieh, K.E., Stuiver, M. and Brillinger, D., 1989, A More Precise Chronology of Earthquakes produced by the San Andreas Fault in Southern California: Journal of Geophysical Research, v. 94, p. 603-623.

(40) Steinbrugge, K., and Moran, D.F., 1954. An Engineering Study of the Southern California Earthquake of July 21, 1952, and its Aftershocks: Bulletin of the Seismological Society of America, v. 44, p. 201-462.

(41) Teng, T., and Aki, K., eds., 1996, The Northridge, California Earthquake of January 17, 1994: Bulletin of the Seismological Society of America, v. 86, p. S1-S361.

(42) Townley, S.D., 1918, The San Jacinto Earthquake of April 21, 1918: Bulletin of the Seismological Society of America, v. 8, p. 45-62.

(43) Townley, S.D., 1927, Seismological Notes: Bulletin of the Seismological Society of America, v. 17, p. 255-263.

(44) Townley, S.D., 1939, Earthquakes in California, 1769 to 1928: Bulletin of the Seismological Society of America, v. 29, p. 21-252.

(45) Ulrich, F.P., 1941. The Imperial Valley Earthquakes of 1940: Bulletin of the Seismological Society of America, v. 31, p. 13-31.

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(47) Wesnousky, S.G., 1986, Earthquakes, Quaternary faults, and seismic hazards in southern California: Journal of Geophysical Research, v. 19, p. 12587-12631.

(48) Wood, H.O., 1933. Preliminary Report on the Long Beach Earthquake of March 10, 1933: Bulletin of the Seismological Society of America, v. 23, p. 43-56.

(49) Wood, H.O., 1937, The Terwilliger Valley Earthquake of March 25, 1937: Bulletin of the Seismological Society of America, v. 27, p. 305-312.

GEOTECHNICAL CONSULTANTS REPORTS

Reports by various geotechnical consultants were reviewed for this geotechnical study. These reports are listed below:

(A) Leighton and Associates, Inc., Geology Report, Foothill Transportation Corridor – South, County of Orange, California, Project No. 950292-01, dated April 15, 1996.

(B) Leighton and Associates, Inc., Preliminary Geotechnical Report, Foothill Transportation Corridor – South, CP Alignment, Counties of Orange and San Diego, California, Project No. 950292-02, dated September 27, 1996.

(C) Leighton and Associates, Inc., Preliminary Geotechnical Report, South Orange County Transportation Infrastructure Improvement Project, Central Corridor – Complete Alternative, Project No. 950292-004, dated June 28, 2002.

(D) Leighton and Associates, Inc., Preliminary Geotechnical Report, South Orange County Transportation Infrastructure Improvement Project, Alignment Seven Corridor – Complete Alternative, Project No. 950292-010, dated August 9, 2002.

(E) Leighton and Associates, Inc., Preliminary Geotechnical Report, South Orange County Transportation Infrastructure Improvement Project, Far East Corridor – Talega Variation Alternative, Project No. 950292- 009, dated October 23, 2002.

(F) Leighton and Associates, Inc., Preliminary Geotechnical Report, South Orange County Transportation Infrastructure Improvement Project, Far East Corridor – Complete Alternative, Project No. 950292 – 006, dated November 27, 2002.

(G) Saddleback Constructors, Foothill Transportation Corridor – South, Geotechnical Design Report, Design Section 3, State Route 241, dated September 1999.

(H) Saddleback Constructors, Foothill Transportation Corridor – South, Geotechnical Design Report, Design Section 4, State Route 241, dated September 1999.

(I) Tetra Tech, Geologic Summary Report for the Capistrano Test Site, dated July 1987.

(J) Goffman, McCormick & Urban, "Geotechnical Review of Preliminary Grading Plans, Planning Area 5, Revision No. 3, Covenant Hills, Ladera Ranch, Orange County, California," dated March 21, 2002 (GMU Project No. 99-32-00).

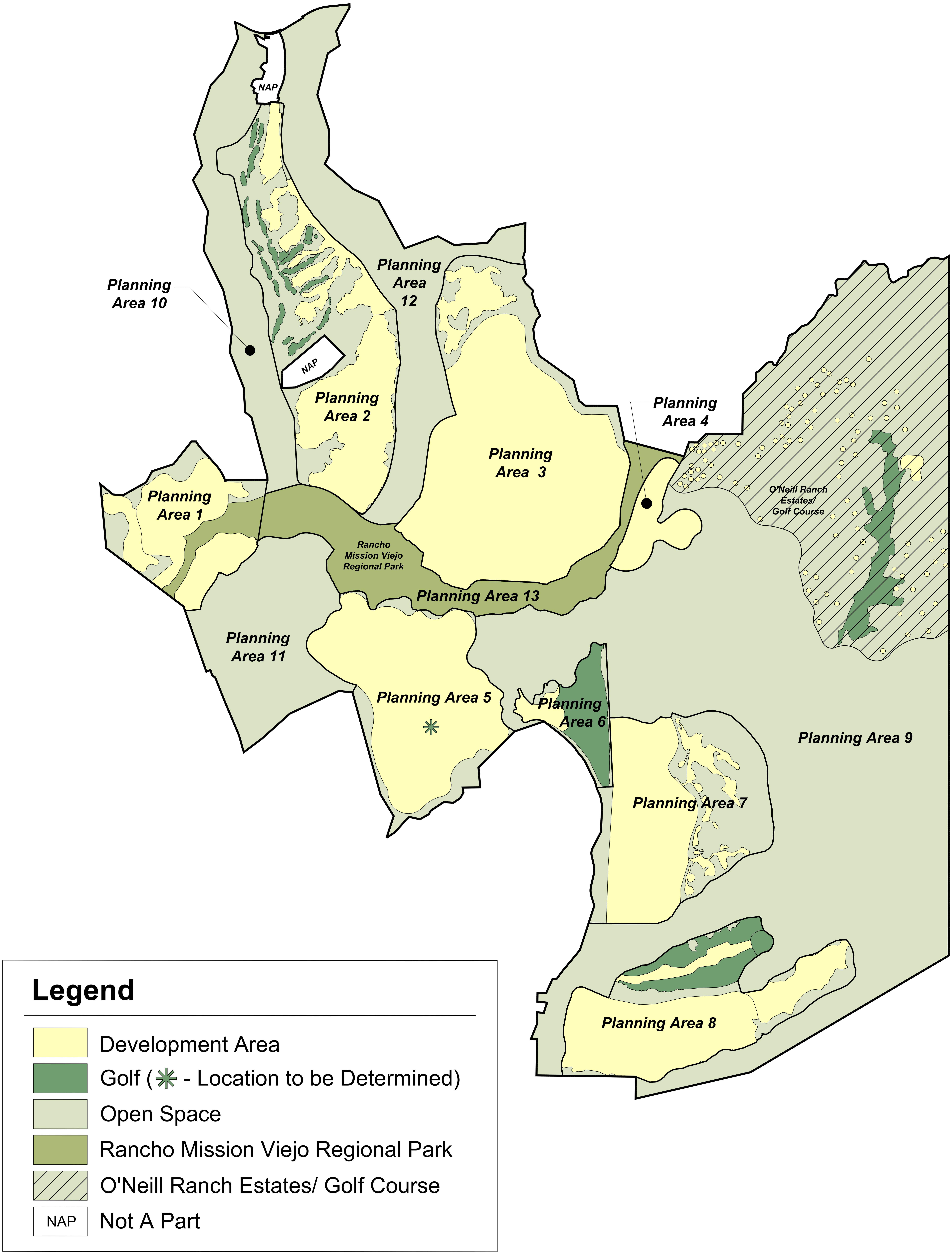
(K) Goffman, McCormick & Urban, "Geotechnical Reconnaissance Report, Foothill Transportation Corridor – South, BX and CP Alignments, Orange County, California," dated May 13, 1996 (GMU Project No. 94-02).

AERIAL PHOTOGRAPHS

Aerial photographs reviewed for this study are listed below:

Flight Number	Photo Number	Date
AXK/AXN	49-101 through 49-103	6-14-38
AXK	50-11 through 50-16	6-14-38
AXK	50-81 through 50-84	6-14-38
AXK	55-18 through 55-21	6-21-38
AXK	55-86 through 55-88	6-21-38
AXM/AXK	58-16 through 58-18	7-2-38
AXK-4K	41 through 47	12-14-52
AXK-5K	144 through 148	2-26-53
C22867	189 through 191, 438 through 440	3-23-57
C23023	47 and 48	2-21-58
2	149 through 156, 167 through 171	3-30-67
72202	334 through 340	11-24-72
218	13-22 through 13-28 14-25 through 14-29 15-22 through 15-27	4-8-83
C85	15-14 through 15-21 16-11 through 16-18	1-15-92

C90	4-138 through 4-140 5-147 through 5-152 6-214 through 6-217	5-14-93
C102-42	177 through 179	1-28-95
DMI-02-027	1-1 to 1-13	3-30-02
DMI-02-027	2-1 to 2-12	3-30-02
DMI-02-027	3-1 to 3-8	3-30-02
DMI-02-027	4-1 to 4-6	3-30-02



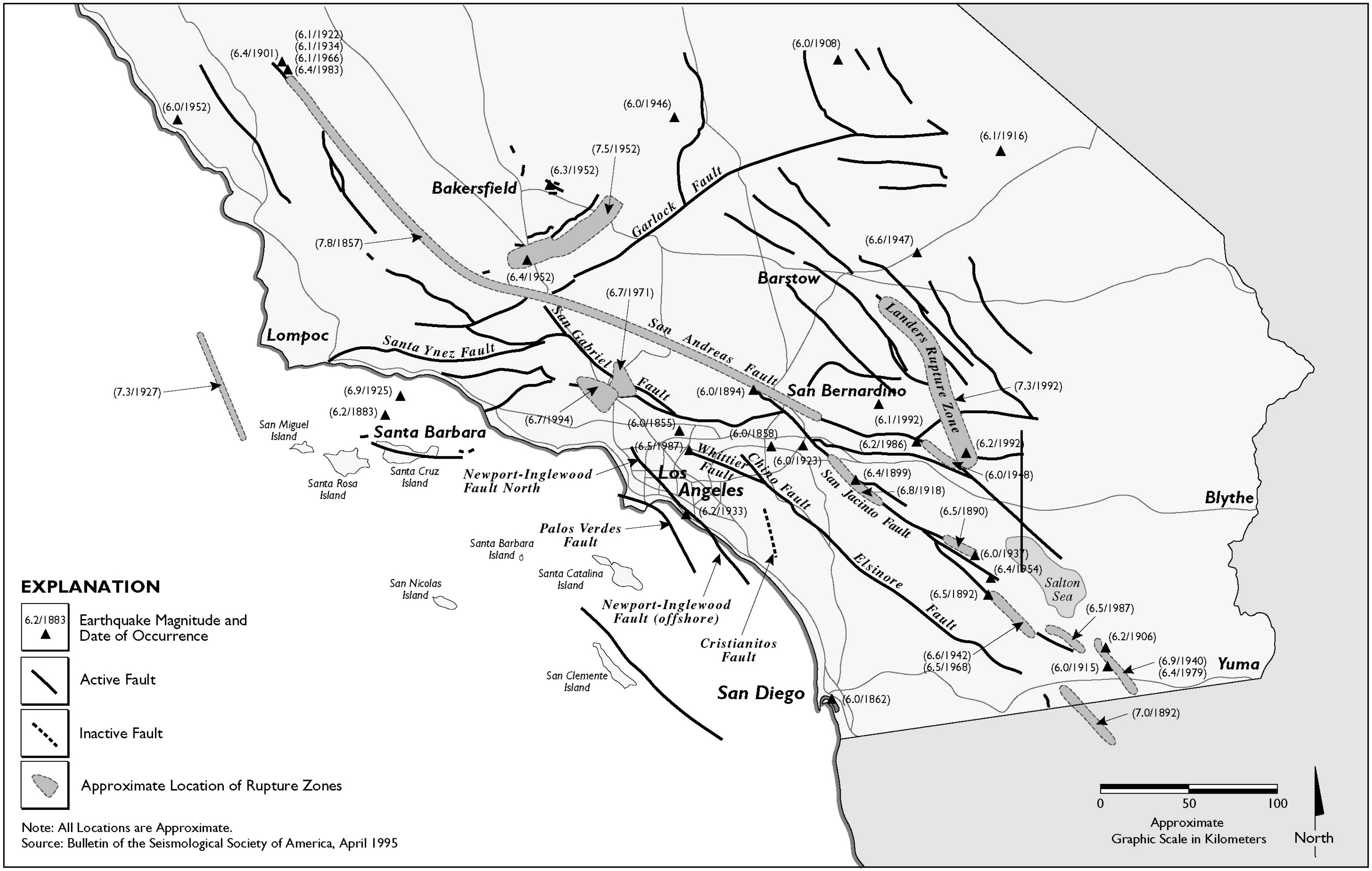
The Ranch Plan

Rancho Mission Viejo

0 1000 2000 4000

May 26, 2004

Plate 1



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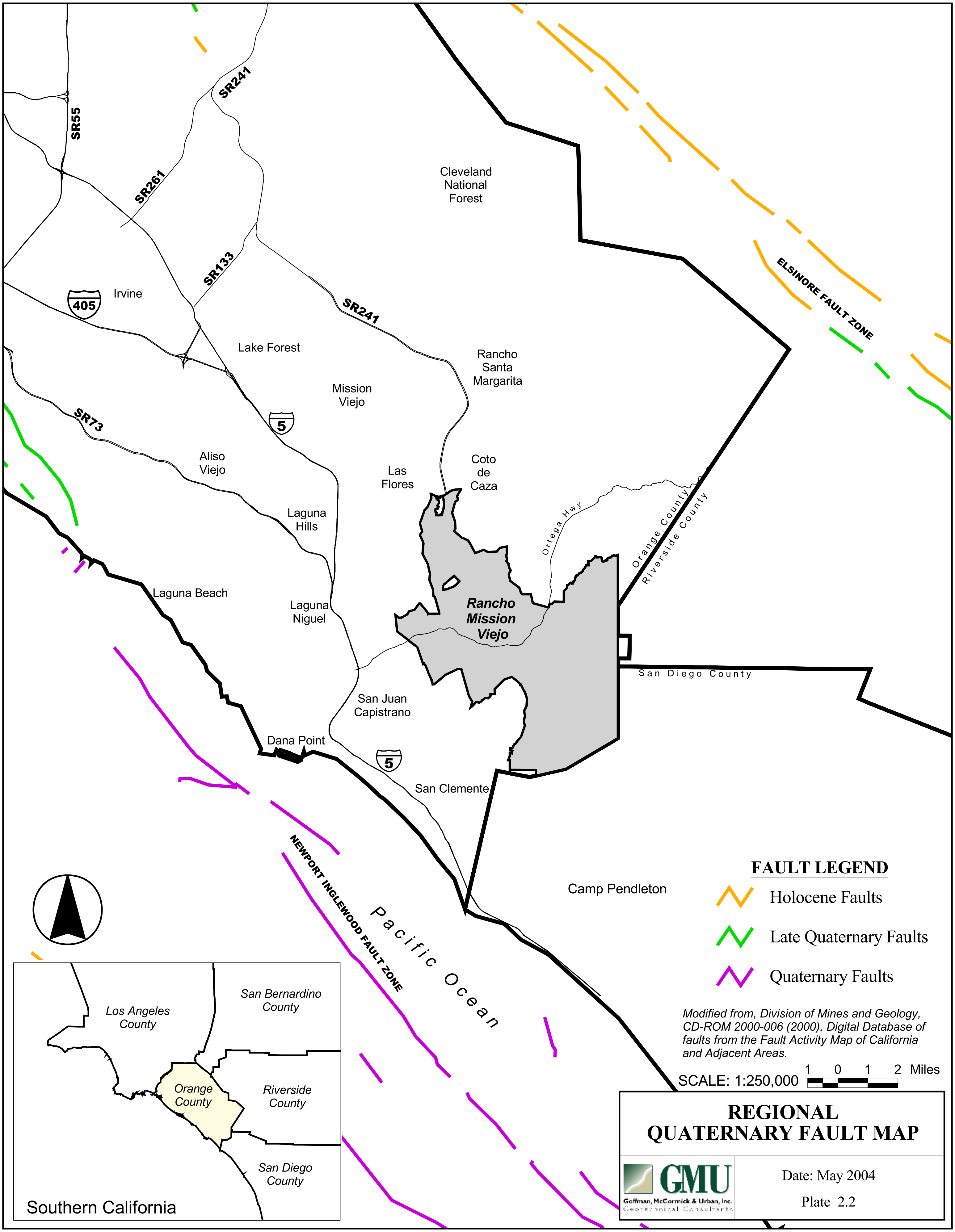
REGIONAL SEISMICITY:
Location of Major Active Surface Faults, Significant Inactive Faults, and Major Earthquake Epicenters (M>6.0)

Plate
2.1

P4-1/1/2002



REGIONAL
QUATERNARY FAULT MAP

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Date: May 2004

Plate 2.2

Geologic Legend

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May 2004	Plate 3.1

Rancho Mission Viejo Boundary

Planning Area Boundary

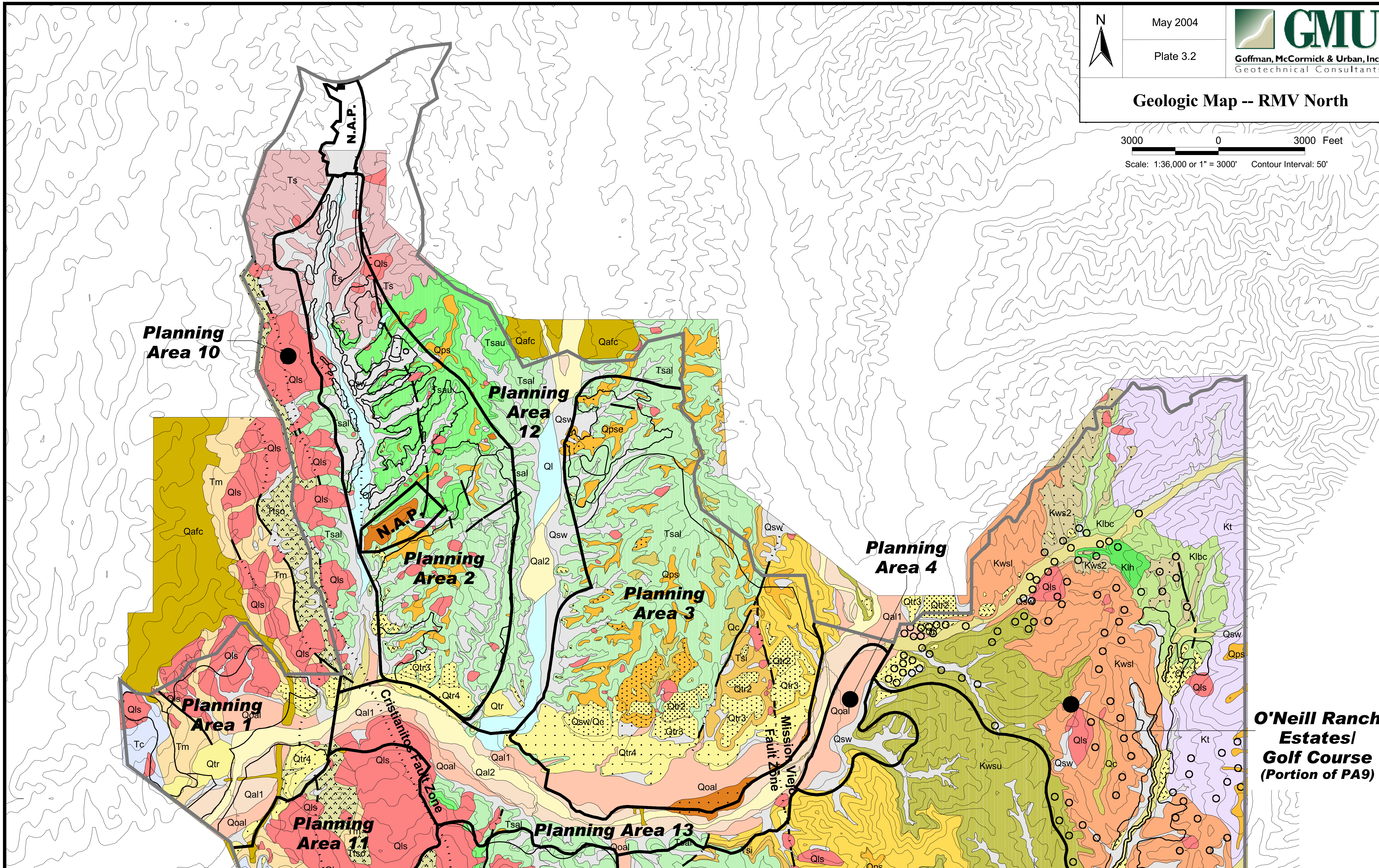
Development Area Boundary

Geologic Contact

Fault, dotted where buried

N.A.P. Not A Part

Qaf	Artificial Fill
Qafc	Engineered Fill
Qafu	Undocumented Fill
Qal	Recent Alluvium
Qal2	Differentiated Alluvium, Younger
Qal1	Differentiated Alluvium, Older
Qac	Alluvium/Colluvium
Qsw	Slopewash
Qsw/Qc	Slopewash/Colluvium
Qls	Landslide Debris
Qoal	Older Alluvium
Qps	Perched Soil
Qps/Qc	Perched Soil/Colluvium
Qpse	Perched Soil/Expansive
Qc	Colluvium
Ql	Lake Deposits
Qt	Terrace Deposits, Undifferentiated
Qtr	River Terrace Deposits
Qtr4	River Terrace Deposits, number denotes order of deposition
Qtr3	River Terrace Deposits, number denotes order of deposition
Qtr2	River Terrace Deposits, number denotes order of deposition
Qtr1	River Terrace Deposits, number denotes order of deposition
Tc	Capistrano Formation
Tm	Monterey Formation
Tt	Topanga Formation
Ttso	Topanga Formation, San Onofre Breccia
Ts	Sespe Formation
Tsau	Santiago Formation, upper beds
Tsal	Santiago Formation, lower beds
Tsi	Silverado Formation
Kwp	Williams Formation, Pleasants Sandstone Member
Kws	Williams Formation, Shulz Ranch Member
Kwsu	Williams Formation, Shulz Ranch Member, upper beds
Kwsl	Williams Formation, Shulz Ranch Member, lower beds
Kws2	Williams Formation, Shulz Ranch Member, conglomerate-fanglomerate facies
Klh	Ladd Formation, Holz Shale Member
Klbc	Ladd Formation, Baker Canyon Member
Kt	Trabuco Formation



May 2004
Plate 3.2
GMU
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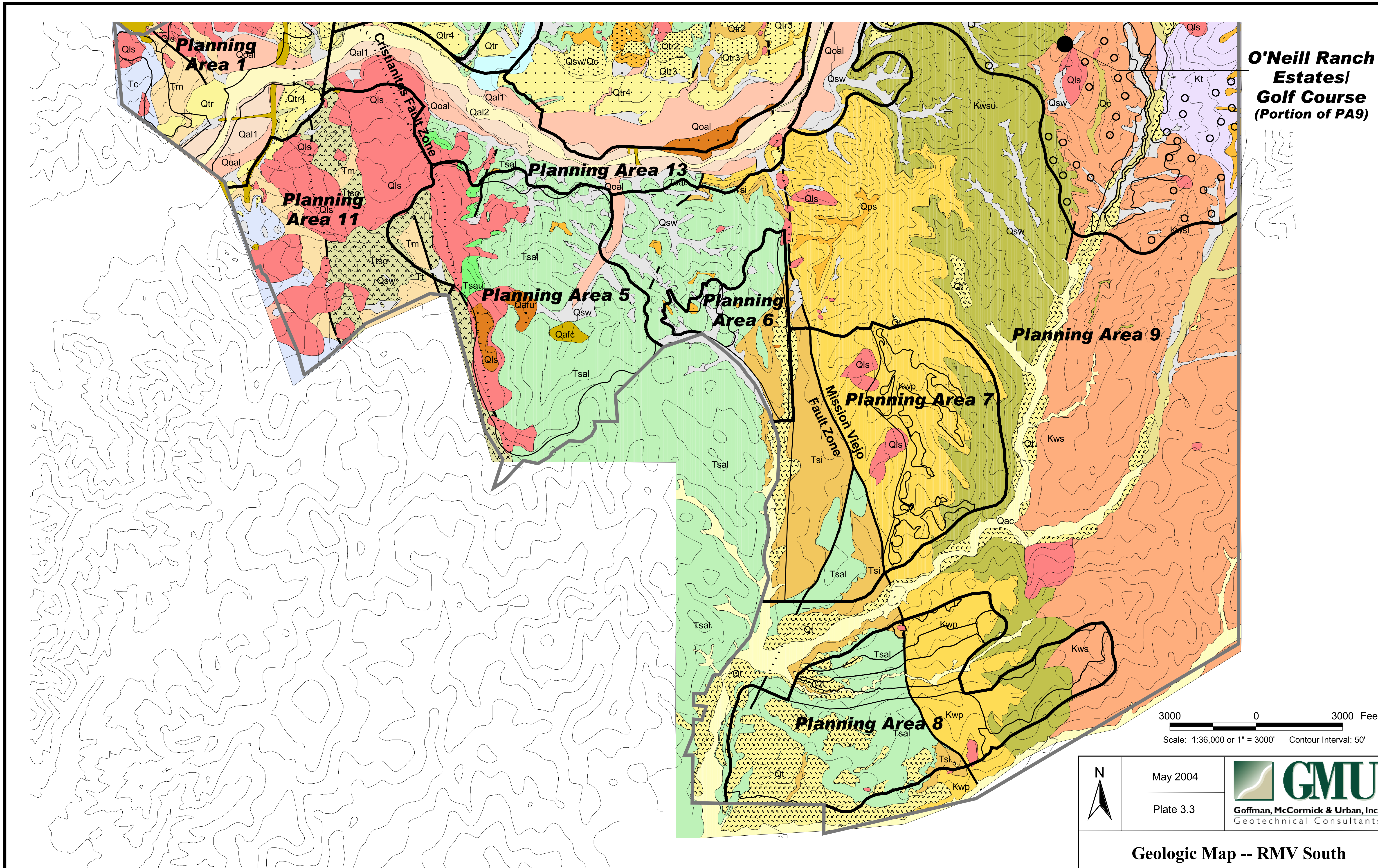
Geologic Map -- RMV North
3000 0 3000 Feet
Scale: 1:36,000 or 1" = 3000' Contour Interval: 50'
N
Planning Area 10
Planning Area 12
Planning Area 2
Planning Area 3
Planning Area 4
Planning Area 1
Planning Area 11
Planning Area 13
O'Neill Ranch Estates/ Golf Course (Portion of PA9)
N.A.P.
Cristianitos Fault Zone
Mission Viejo Fault Zone



O'Neill Ranch Estates/ Golf Course (Portion of PA9)
Planning Area 1
Planning Area 11
Planning Area 13
Planning Area 5
Planning Area 6
Planning Area 7
Planning Area 8
Planning Area 9
Cristianitos Fault Zone
Mission Viejo Fault Zone
3000 0 3000 Feet
Scale: 1:36,000 or 1" = 3000'
Contour Interval: 50'
N
May 2004
Plate 3.3
GMU
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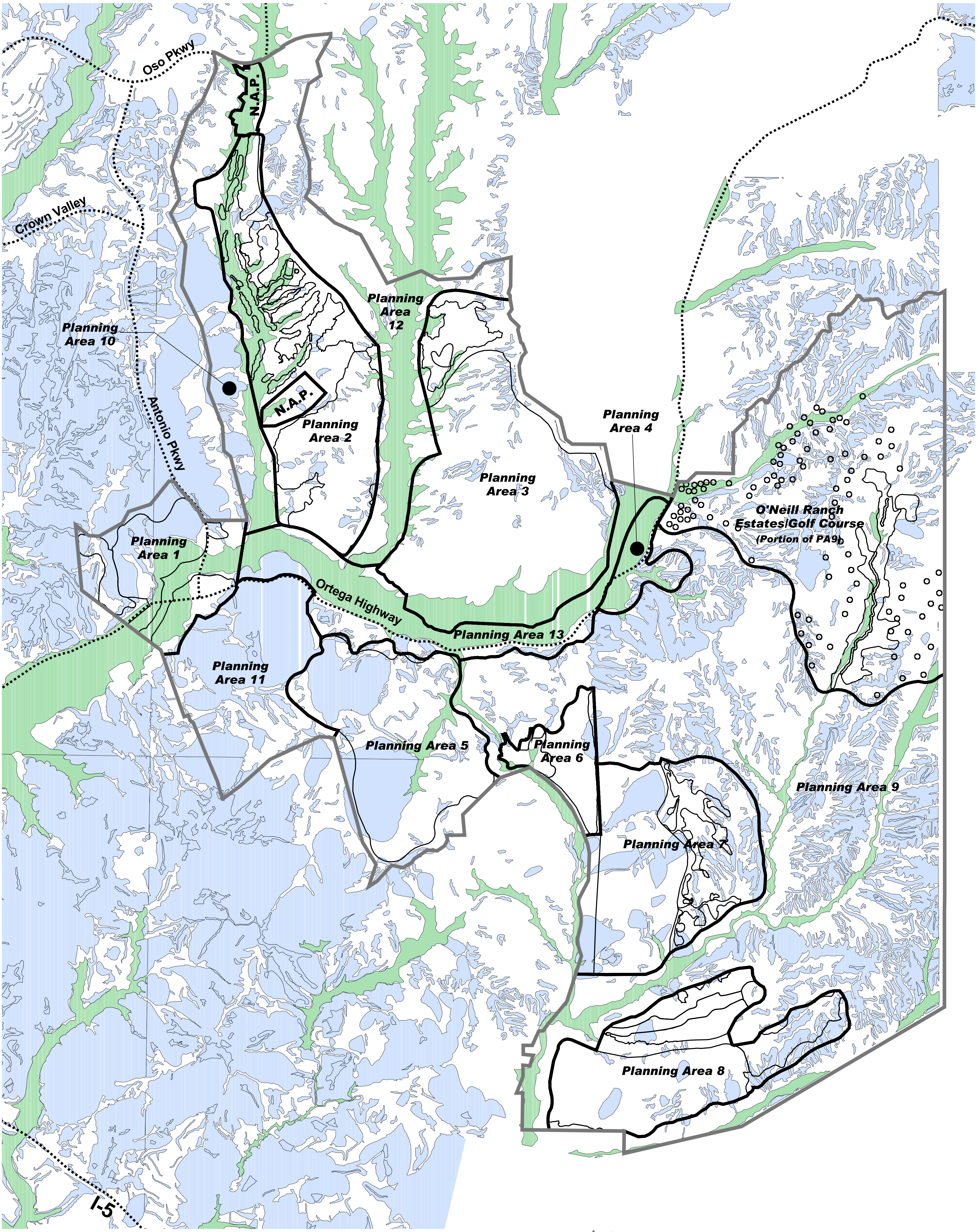
Geologic Map -- RMV South



Rancho Mission Viejo Boundary

Planning Area Boundaries

Development Area Boundaries

Areas potentially susceptible to earthquake-induced landslides

Areas potentially susceptible to liquefaction

N.A.P. Not A Part

Seismic Hazard Map Source:
1) California Geology Survey, Seismic Hazard Zones Map, Canada Gobernadora Quadrangle, release date Sept 23, 2003.
2) California Geology Survey, Seismic Hazard Zones Map, San Clemente Quadrangle, release date June 21, 2002.
3) California Geology Survey, Seismic Hazard Zones Map, San Juan Capistrano Quadrangle, release date Dec. 21, 2001.

N

2000 0 2000 4000 Feet

California Geological Survey
Special Publication 117 Seismic Hazard Zones

Rancho Mission Viejo

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May 2004

Plate 4

APPENDIX

Logs of Subsurface Exploration

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MAJOR DIVISIONS			Group Letter	Symbol	TYPICAL NAMES
COARSE-GRAINED SOILS More Than 50% Retained On No.200 Sieve. Based on The Material Passing The 3-Inch (75mm) Sieve. Reference: ASTM Standard D2487	GRAVELS 50% or More of Coarse Fraction Retained on No.4 Sieve	Clean Gravels	GW		Well Graded Gravels and Gravel-Sand Mixtures, Little or No Fines.
			GP		Poorly Graded Gravels and Gravel-Sand Mixtures Little or No Fines.
		Gravels With Fines	GM		Silty Gravels, Gravel-Sand-Silt Mixtures.
			GC		Clayey Gravels, Gravel-Sand-Clay Mixtures.
	SANDS More Than 50% of Coarse Fraction Passes No.4 Sieve	Clean Sands	SW		Well Graded Sands and Gravelly Sands, Little or No Fines.
			SP		Poorly Graded Sands and Gravelly Sands, Little or No Fines.
		Sands With Fines	SM		Silty Sands, Sand-Silt Mixtures.
			SC		Clayey Sands, Sand-Clay Mixtures.
FINE-GRAINED SOILS 50% or More Passe The No.200 Sieve. Based on The Material Passing The 3-Inch (75mm) Sieve. Reference: ASTM Standard D2487	SILTS AND CLAYS Liquid Limit Less Than 50%		ML		Inorganic Silts, Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts With Slight Plasticity.
			CL		Inorganic Clays of Low To Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays.
			OL		Organic Silts and Organic Silty Clays of Low Plasticity
	SILTS AND CLAYS Liquid Limit 50% or Greater		MH		Inorganic Silts, Micaceous or Diatomaceous Fine Sandy or Silty Soils, Elastic Silts.
			CH		Inorganic Clays of High Plasticity, Fat Clays.
			OH		Organic Clays of Medium To High Plasticity, Organic Silts.
HIGHLY ORGANIC SOILS			PT		Peat and Other Highly Organic Soils.

ADDITIONAL TESTS

DS = Direct Shear
HY = Hydrometer Test
TC = Triaxial Compression Test
UC = Unconfined Compression
CN = Consolidation Test
(T) = Time Rate
EX = Expansion Test
CP = Compaction Test
PS = Particle Size Distribution
EI = Expansion Index
SE = Sand Equivalent Test
AL = Atterberg Limits
FC = Chemical Tests
RV = Resistance Value
SG = Specific Gravity
SU = Sulfates
CH = Chlorides
MR = Minimum Resistivity
pH
(N) = Natural Undisturbed Sample
(R) = Remolded Sample

SAMPLE SYMBOLS

Undisturbed Sample (California Sample)
Undisturbed Sample (Shelby Tube)
Bulk Sample
Unsuccessful Sampling Attempt
SPT Sample

10: 10 Blows for 12-Inches Penetration
6/4: 6 Blows Per 4-Inches Penetration
P: Push
(13): Uncorrected Blow Counts ("N" Values) for 12-Inches Penetration- Standard Penetration Test (SPT)

GEOLOGIC STRUCTURE

B = Bedding
C = Contact
J = Joint
S = Shear
F = Fracture
Flt = Fault
= Groundwater
= Seepage

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LEGEND TO LOGS
ASTM Designation: D 2487
(Based on Unified Soil Classification System)

Plate
A-1

P3-1/1/2002

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
380			WILLIAMS FM, Pleasants Sandstone Member (Kwp)	C: N65E, 18SE	SILTY FINE SAND (SM), brown, moist, very dense						
			Silty sandstone, massive, no fracturing observed, upper contact diffuse, generally planar	B: N45W, 9SW	Becomes blue gray						
	25		Orange stained sandy siltstone bed, 4 inches thick, overlies concretion layer, 8 inches thick, at 24 feet		Becomes hard, density increases with depth						
			← Very minor seepage								
375											

DH_REV2 01-75-00.GPJ GM&U.GDT 07/31/03

Project: The Ranch Plan Project Location: Gobernadora Canyon Project Number: 01-75-00	**Log of Drill Hole DH-24** Sheet 1 of 2

Date(s) Drilled	02/21/03	Logged By	LLB	Checked By	PJJ
Drilling Method	Rotary Bucket	Drilling Contractor	Al-Roy Drilling, Inc.	Total Depth of Drill Hole	29.0 feet
Drill Rig Type	EZ-Bore	Diameter(s) of Hole, inches	24	Approx. Surface Elevation, ft MSL	403.5
Groundwater Depth [Elevation], feet		Sampling Method(s)	Not Sampled	Drill Hole Backfill	Cuttings, tamped
Remarks	No groundwater, no caving			Driving Method and Drop	

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	NUMBER OF BLOWS	DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
	0		TERRACE DEPOSITS (Qtr_4) Scattered pebbles, no fracturing observed down to 23 feet		CLAYEY SAND (SC), red brown, moist, dense						
400											
	5										
395			1-foot thick zone of abundant pebbles and cobbles								
	10		Rare pebbles, homogeneous		SANDY SILT (ML), fine grained, red brown, moist, firm to very firm						
390					SILTY SAND (SM), fine to medium grained, red brown, moist, slightly dense						
	15		Abundant pebbles and cobbles		SANDY GRAVEL with SILT (GM), red brown, moist, slightly dense, fine- to medium-grained sands						
385			Scattered boulders down to contact		SANDY GRAVEL with CLAY (GC), red brown, moist, dense						

DH_REV2 01-75-00.GPJ GM&U.GDT 07/31/03

Project: The Ranch Plan Project Location: Gobernadora Canyon Project Number: 01-75-00	Log of Drill Hole DH-23 Sheet 2 of 2

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
380											
375	25		SILVERADO FM (Tsi) Diffuse contact overlying fault, 1-inch thick clay gouge, planar, sheared, plastic, continuous across hole, very minor seepage, fault offsets silty sandstone (west side), fine to medium grained, massive, orange staining, against fine sandy siltstone (east side), massive, fractured, 3-inch spacing (tight); on north wall, terrace/bedrock contact appears to be scour feature, 6-inches deep, depositional contact, no faulting observed at or above contact Both sides of fault becoming unoxidized, fault continues to bottom of hole	C: N35W, 10NE F: N10W, 90	SILTY SAND (SM), light brown to light gray, moist, very dense Becomes light blue gray						

DH_REV2 01-75-00.GPJ GM&U.GDT 07/31/03

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Drill Hole DH-23

Log of Drill Hole DH-23

Date(s) Drilled	02/20/03	Logged By	LLB	Checked By	PJJ
Drilling Method	Rotary Bucket	Drilling Contractor	Al-Roy Drilling, Inc.	Total Depth of Drill Hole	29.0 feet
Drill Rig Type	EZ-Bore	Diameter(s) of Hole, inches	24	Approx. Surface Elevation, ft MSL	402.0
Groundwater Depth [Elevation], feet		Sampling Method(s)	Not Sampled	Drill Hole Backfill	Cuttings, tamped
Remarks	No groundwater, no caving			Driving Method and Drop	

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			TERRACE DEPOSITS (Qtr_4) Scattered pebbles, weathered, no fracturing observed down to 23 feet		CLAYEY SAND (SC), red brown, damp to moist, dense, fine grained						
400											
	5										
395											
	10										
			Abundant pebbles and cobbles, subangular to subrounded, clast-supported		SANDY GRAVEL with SILT (GM), red brown, moist, dense, fine- to medium-grained sands						
390											
			Abundant pebbles and cobbles, as above		SANDY GRAVEL with CLAY (GC), red brown, moist, dense, coarse-grained sands						
	15										
385			Abundant pebbles and cobbles, scattered boulders		CLAYEY GRAVEL with SAND (GC), red brown, moist to wet, very firm						

DH_REV2 01-75-00.GPJ GM&U.GDT 07/31/03

Log of Drill Hole DH-22

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			biotite, poorly bedded, diffuse bedding contacts, upper contact diffuse, undulatory Approximate bedding at 20 feet	B: N35W, 5SW							
375	25										

DH_REV2 01-75-00.GPJ GM&U.GDT 07/31/03

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Project: The Ranch Plan Project Location: Gobernadora Canyon Project Number: 01-75-00	Log of Drill Hole DH-22

Date(s) Drilled	02/20/03	Logged By	LLB	Checked By	PJJ
Drilling Method	Rotary Bucket	Drilling Contractor	Al-Roy Drilling, Inc.	Total Depth of Drill Hole	25.0 feet
Drill Rig Type	EZ-Bore	Diameter(s) of Hole, inches	24	Approx. Surface Elevation, ft MSL	400.0
Groundwater Depth [Elevation], feet		Sampling Method(s)	Not Sampled	Drill Hole Backfill	Cuttings, tamped
Remarks	No groundwater, no caving			Driving Method and Drop	

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	NUMBER OF BLOWS	DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
			TERRACE DEPOSITS (Qtr_4) Occasional pebbles and cobbles, homogeneous, upper 2 feet reworked		SANDY SILT (ML), red brown, damp to moist, firm to very firm						
			Scattered pebbles		CLAYEY SAND (SC), red brown, moist, dense						
395	5										
390	10		Abundant pebbles and cobbles, subangular to subrounded, clast-supported, unconsolidated		SANDY GRAVEL with SILT (GM), red brown, moist, slightly dense						
385	15		Scattered to abundant pebbles and cobbles		SANDY GRAVEL with CLAY (GC), red brown, moist, dense						
			Scattered boulders								
			SILVERADO FM (Tsi) Silty sandstone, interbedded with sandy siltstone beds up to 1 inch thick, abundant	C: N60E, 25-30SE	SILTY SAND (SM), red brown to yellow brown, moist, very dense, fine to medium grained						

DH_REV2 01-75-00.GPJ GM&U.GDT 07/31/03

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Geotechnical Consultants

Project: The Ranch Plan Project Location: Gobernadora Canyon Project Number: 01-75-00	**Log of Drill Hole DH-25** Sheet 1 of 2

Date(s) Drilled	02/21/03	Logged By	LLB	Checked By	PJJ
Drilling Method	Rotary Bucket	Drilling Contractor	Al-Roy Drilling, Inc.	Total Depth of Drill Hole	28.0 feet
Drill Rig Type	EZ-Bore	Diameter(s) of Hole, inches	24	Approx. Surface Elevation, ft MSL	403.0
Groundwater Depth [Elevation], feet		Sampling Method(s)	Not Sampled	Drill Hole Backfill	Cuttings, tamped
Remarks	Not downhole logged due to heavy seepage and severe caving at 25 feet			Driving Method and Drop	

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			TERRACE DEPOSITS (Qtr_4) Scattered pebbles		CLAYEY SAND (SC), red brown, moist, slightly dense, fine grained						
400											
	5										
395											
	10										
390			Abundant pebbles and cobbles		SANDY GRAVEL with SILT (GM), red brown, moist, very firm, fine- to medium-grained sands						
	15										
385											

DH_REV2 01-75-00.GPJ GM&U.GDT 07/31/03

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Drill Hole DH-25

Project: The Ranch Plan
Project Location: Gobernadora Canyon
Project Number: 01-75-00

Log of Drill Hole DH-25

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	NUMBER OF BLOWS	DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
			Abundant pebbles and cobbles, scattered boulders		SANDY GRAVEL with CLAY (GC), red brown, moist to wet, slightly dense to dense						
380											
	25		Heavy seepage and severe caving								
375			Refusal								

DH_REV2 01-75-00.GPJ GM&U.GDT 07/31/03

GMU
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Project: The Ranch Plan	# Log of Drill Hole DH-27
Project Location: Gobernadora Canyon	
Project Number: 01-75-00	

Date(s) Drilled	02/24/03	Logged By	LLB	Checked By	PJJ
Drilling Method	Rotary Bucket	Drilling Contractor	Al-Roy Drilling, Inc.	Total Depth of Drill Hole	30.0 feet
Drill Rig Type	EZ-Bore	Diameter(s) of Hole, inches	24	Approx. Surface Elevation, ft MSL	402.5
Groundwater Depth [Elevation], feet		Sampling Method(s)	Not Sampled	Drill Hole Backfill	Cuttings, tamped
Remarks	Not downhole logged; Heavy seepage and caving from 25 to 27 feet			Driving Method and Drop	

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			TERRACE DEPOSITS (Qtr_4)		CLAYEY SAND (SC), red brown, damp to moist, dense, fine grained						
400											
	5										
395											
	10										
390											
			Abundant pebbles and cobbles, rare boulders		SANDY GRAVEL with SILT (GM), red brown, moist, dense, fine- to medium-grained sands						
	15										
385											

DH_REV2 01-75-00.GPJ GM&U.GDT 07/31/03

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ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
					Becomes wet						
380			WILLIAMS FM, Pleasants Sandstone Member (Kwp) Silty sandstone, massive, subangular to subrounded, biotitic; seepage along abrupt upper contact Becomes unoxidized at 23 feet	C: N42E, 8SE C: N58E, 7SE	SILTY FINE SAND (SM), orange brown, moist, medium dense to dense SAND (SW) with some SILT, fine to medium grained, blue gray, moist, very dense						
	25										
375											

Project: The Ranch Plan Project Location: Gobernadora Canyon Project Number: 01-75-00	# Log of Drill Hole DH-26

Date(s) Drilled	02/24/03	Logged By	ART	Checked By	PJJ/LLB
Drilling Method	Rotary Bucket	Drilling Contractor	Al-Roy Drilling, Inc.	Total Depth of Drill Hole	28.0 feet
Drill Rig Type	EZ-Bore	Diameter(s) of Hole, inches	24	Approx. Surface Elevation, ft MSL	403.0
Groundwater Depth [Elevation], feet		Sampling Method(s)	Not Sampled	Drill Hole Backfill	Cuttings, tamped
Remarks	Minor caving from 14' to 22.5', slight seepage at 22.5'			Driving Method and Drop	

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	NUMBER OF BLOWS	DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
			TERRACE DEPOSITS (Qtr) Scattered gravels to 2 inch diameter		CLAYEY SAND (SC), mottled light brown and orange, moist, medium dense, scattered gravels						
400			4-inch diameter subrounded cobble								
			6-inch diameter cobble		Becomes mottled red brown and dark brown						
	5										
395											
	10										
			Scattered clay lenses, rare gravels		SILTY SAND (SM), orange brown, moist, medium dense, fine to medium grained						
390											
			Gravel up to 6 inches in diameter, matrix supported, subangular to subrounded		SANDY GRAVEL (GM), medium brown with orange, moist, slightly dense to medium dense, medium- to coarse-grained sands						
	15										
					Increase of silt in matrix, some clay						
385											

GMU
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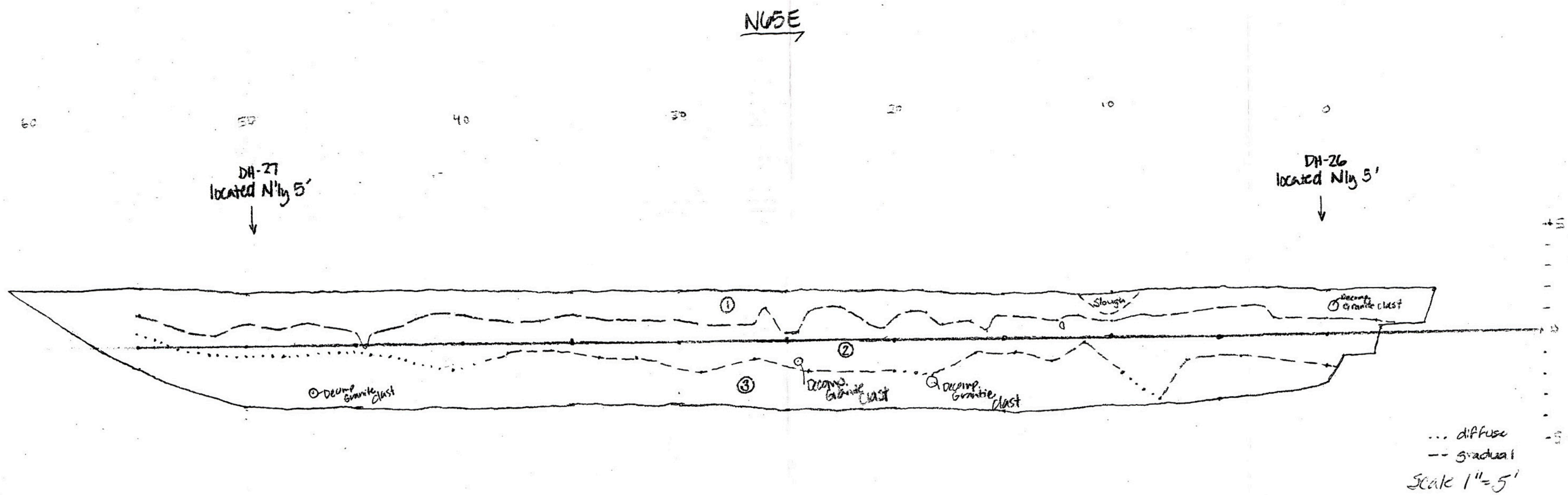
Geotechnical Consultants

Log of Drill Hole DH-27

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
380	25		Scattered boulders Heavy seepage and severe caving below 25 feet		Becomes moist to wet Becomes wet to saturated						
375	30		SILVERADO FM (Tsi) Fine sandy siltstone Unoxidized, color appears mottled with blue gray, gray, and purple gray Refusal		SANDY SILT (SM), fine grained, brown, moist, very firm Becomes blue gray and gray						



TERRACE DEPOSITS (Qtr)

UNIT DESCRIPTION

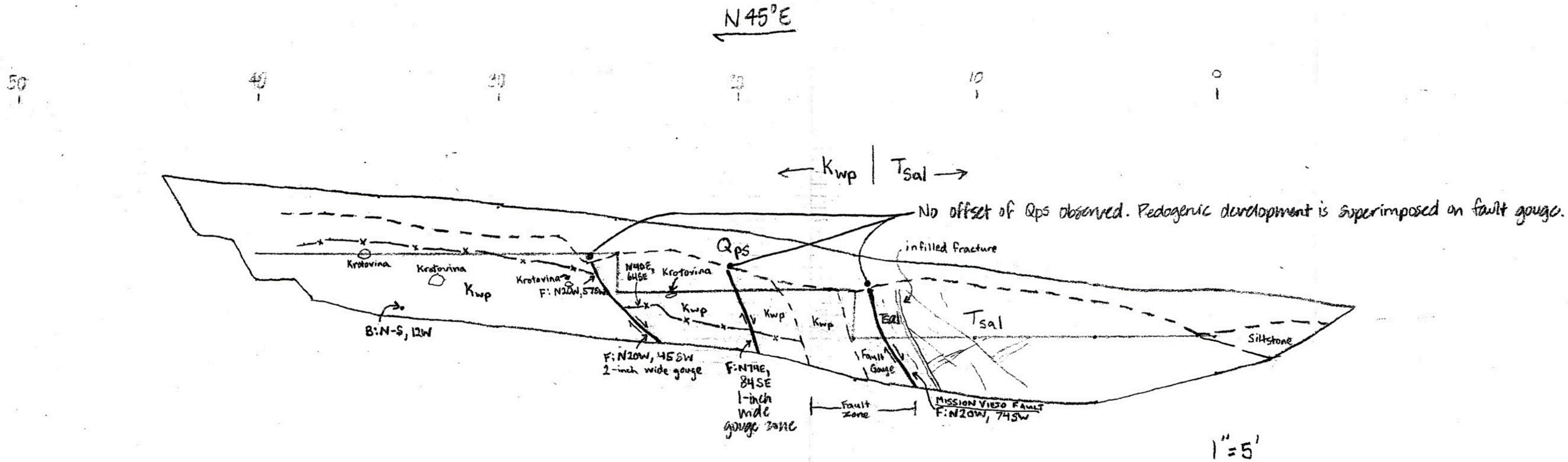
① SANDY CLAY (CL), reddish brown to brown, moist, very stiff, some rootlets, low to moderate porosity, scattered gravels

② SANDY CLAY (CL), w/ pockets of CLAYEY SAND (SC), light brownish gray, dry to damp, pockets of damp to moist, very stiff, rootlets, moderate porosity, scattered gravels, abundant $CaCO_3$ infilling

③ SANDY CLAY (CL), dark reddish brown, damp, hard, some rootlets, low to moderate porosity, scattered gravels, rare cobbles

No fracturing or faulting observed in trench

GMU Goffman, McCormick & Urban, Inc. Geotechnical Consultants	**FAULT TRENCH FT-1**	Plate **A-1**



Qps: SILTY CLAY (CL-ML), drk brown, damp to moist, firm, trace sand where overlying Tsa, some rootlets, low to moderate porosity, well developed soil structure, diffuse lower contact with both bedrock formations.

Tsal: SAND (SW), medium to coarse grained, lt. gray, damp, very dense, massive, iron oxide staining along fractures, rare pebbles with rust-stained weathering rind, some fractures infilled with fine sand

Kwp: FINE SANDY SILT (ML), grayish brown, moist, very stiff to hard, well bedded, weathered, blocky structure, upper 1 foot is highly weathered with carbonate infilling in voids,
Marker bed (—x—x—): SILTY FINE SAND (SM), lt. brown, damp, dense to very dense, 2-4 inches thick

Fault Gouge: CLAY (CL), drk. brown, moist, stiff, highly sheared.

GMU Goffman, McCormick & Urban, Inc. Geotechnical Consultants	FAULT TRENCH FT-2	Plate A-2