Appendix B
Geology and Soils

Volume 1

Report of Geotechnical Studies
Proposed Newport Banning Ranch Development
City of Newport Beach/County of Orange

Prepared for:

Newport Banning Ranch LLC

Prepared By:

GMU Geotechnical, Inc.
July 2011

Report of Geotechnical Studies
Proposed Newport Banning Ranch Development
City of Newport Beach/County of Orange
Volume 1

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◆ VOLUME I ◆

REPORT OF GEOTECHICAL STUDIES PROPOSED NEWPORT BANNING RANCH DEVELOPMENT CITY OF NEWPORT BEACH COUNTY OF ORANGE

July 2011

GMU PROJECT 06-163-00

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INTRODUCTION

PURPOSE

This report presents the results of preliminary geotechnical studies of the soil and geologic conditions for the proposed development at Newport Banning Ranch (NBR). The primary purpose of this study was to address and evaluate geological and geotechnical issues that may affect the proposed NBR development.

SCOPE

The scope of our studies was as follows:

1. Review of geological and geotechnical reports previously prepared for the project site and adjacent properties.

2. Interpretation of historic aerial photographs and topographic maps.

3. Completion of appropriate geologic mapping.

4. Performance of a fault investigation that included:

    - A photolineament study to locate potential zones of surface fault rupture.
    - Excavation and logging of approximately 5,000+ lineal feet of fault trenching.
    - Twenty-one Cone Penetration Soundings (CPT) and two adjacent rotary wash-type borings in the recent alluvial sediments.
    - Age-dating assessment of surface sediments and soils (pedogenic profiles) and relative fault activity.

5. Excavation of nine additional bucket auger type borings and six backhoe test pits to augment existing geotechnical data.

6. Performance of geotechnical laboratory tests to compliment existing test data, to evaluate potential geotechnical constraints, and to determine typical engineering properties of the soil and rock materials that may be encountered during grading.

7. Preparation of a geologic map and cross sections.

8. Geological and geotechnical engineering analysis of background data, subsurface data, and laboratory testing data.

9. Preparation of this report that summarizes our findings in regards to potential geologic hazards, geotechnical design constraints, and outlines preliminary recommendations about the feasibility of project development.

LOCATION

The proposed NBR development area is east of the Santa Ana River, approximately ⅛- to ¼-mile north of the coastline in western coastal Orange County (see Plate 1 -- Location Map). The site is bounded by the Santa Ana River to the west, the westward extension of West 19th Street to the north, existing commercial and residential development to the east, and West Coast Highway to the south. Most of the site is in unincorporated Orange County, with the remainder in the City of Newport Beach.

SITE DESCRIPTION

TOPOGRAPHY

The site is comprised of two main topographic areas: 1) lowlands located in the northwest portion of the site, and 2) an uplifted mesa (i.e., Newport Mesa) in the remainder of the site (see Plate 1 -- Location Map). The lowlands are about one-third of the site and range in elevation from approximately elevation 1.0 to 10.0 feet. Mesa elevations range from approximately 50 feet in the southwestern portion to approximately 105 feet in the east central portion (Plate 7).

The Newport Mesa has been incised in several areas to form arroyos of various sizes. Two main arroyos occur in the southern portion and the northern portion of the mesa, respectively. Based on historical survey maps from 1874, the major arroyos pre-date development and are largely the result of natural processes. Slopes that descend from the mesa top to the lowlands and adjacent West Coast Highway average 30 to 40 degrees with locally flatter and steeper sections. These slopes are eroded forming gullies and ravines. Slopes that descend into the main arroyos are relatively flatter than the outer bluff slope faces and generally average approximately 20 degrees in steepness.

PREVIOUS ON-SITE GRADING AND IMPROVEMENTS

The top of the Newport Mesa was used for agriculture in the late 1920's and 1930's and has been a producing oil field since approximately 1943/44 based on review of air photos. There are, and were, several hundred oil wells located throughout the site. Most oil production facilities are in the central portion of the mesa and adjoining lowland area. The current oil operator is now removing surface facilities and abandoning wells. Farming and oil production have produced several cut pads and near-vertical cut slopes, areas of non-engineered loose fills, and numerous excavations. Additionally, the site contains oil and gas production equipment and appurtenances (i.e., pipelines, tanks, etc.). Currently, there are approximately 90 active oil wells and related appurtenances within the proposed NBR development. Roads are also present across the mesa and lowland areas of the site in connection with the development of the oil production areas. There is also a deep, abandoned road cut along the southeastern property boundary (Plate 7).

OFFSITE IMPROVEMENTS

The NBR site is bordered by existing developments along portions of the northern, eastern, southern, and southwestern boundaries (Plate 7). Development along the eastern boundary consists of two single-family residential developments, several mobile home parks, and various light commercial and professional office-type developments. A recent development, The California Sea-Breeze, is adjacent to the northern section of the eastern property line, and contains two mechanically stabilized earth (MSE) retaining walls on the property line. These walls range in height from a few to approximately 33 feet. In addition to the aforementioned residential and commercial developments, a water filtration plant also exists in a "boxed out" area along the southern portion of the eastern boundary (Plate 1 -- Location Map). Developments along the north and east direct their surface drainage via engineered structures through the NBR site into existing arroyos and eventually into the lowlands.

A condominium development called the "Newport Crest" is adjacent to the southeastern project boundary. Additional residential developments include the Lido Sands south of the site and across West Coast Highway, the Newport Shores southwest of the site, and the Newport Terrace along the northern property boundary near the eastern corner. The northern portion of the property is also bounded by the County's Talbert Regional Park. The western boundary of the site is bordered by the Army Corps of Engineers (ACOE) Santa Ana River marsh restoration project constructed adjacent the Santa Ana River channel (see Plate 1 -- Location Map).

PLANNED DEVELOPMENT AND GRADING

Land use within the NBR development is illustrated on Plate 2.1 – Land Use Plan, and land uses are summarized on Plate 2.2. – Land Use Table. The proposed development consists of creating several residential areas, roadways, a resort hotel, parks, trails, and open space (see Plate 2.1 and 2.2 – Land Use Plan). Limited portions of the site will remain active oil production areas as noted on Plate 2.1. Open space areas will occupy the remainder of the project, especially within the lowlands and the major arroyos.

The planned development will incorporate a comprehensive runoff management plan that includes water quality and drainage features designed to treat and reduce runoff. Water quality features will consist of bioswales, permeable pavement, and other improvements designed to promote soil-based infiltration processes. Drainage improvements will minimize runoff to arroyos, re-direct runoff away from bluffs, and reduce flow rates and volumes in the Oxbow Loop below the bluffs.

The proposed development will be accessed via roadways from West Coast Highway to the south as well as Whittier Avenue and 15th, 16th, and 17th Streets to the east.

The Land Use Plan discussed above is supported by Vesting Tentative Tract Map No. 17308 within the City of Newport Beach, Orange County. GMU prepared a geotechnical review of the Vesting Tentative Tract Map grading plans (GMU Geotechnical, 2009). The planned grading shown on the Tentative Tract Map includes making design cuts and fill up to about 25 and 45 feet, respectively, to create mass graded areas for residential and commercial sites, parks, trails, arterial and collector streets, and landscape areas. Graded slopes of up to about 65 feet in maximum height are shown at gradients of 2:1, or flatter. The existing bluff that is oriented south and west will remain, although portions that have experienced local erosion will require restoration.

The mass graded areas are shown to surface drain at a minimum 2% gradient. Preliminary slope drainage devices and three water quality basin/cleansing areas are shown on the plan. Currently, no storm drains or other drainage improvements (i.e., bio-swales, etc) are shown. However, a separate Watershed Assessment plan, which includes storm drains, bio-swales, basins and other water quality improvements has been developed by Fuscoe Engineering and will be part of the project rough grading plans which will be reviewed at a future date when the rough grading plans are finalized.

PREVIOUS REPORTS AND TECHNICAL STUDIES

GEOTECHNICAL AND FAULT STUDY EVALUATIONS

Previous geotechnical studies were performed by various consultants including: Woodward-Clyde Consultants (1985), The Earth Technology Corporation (1986), Pacific Soils Engineering, Inc. (1993), and Leighton & Associates (1997, 1998). Woodward-Clyde Consultants prepared a report entitled "Preliminary Geotechnical Engineering Study, Long Range Planning Program," while Pacific Soils Engineering completed an overall "Geotechnical Feasibility Investigation." Leighton and Associates prepared two more specific geotechnical reports addressing settlement and liquefaction potential of previously considered school site locations in the lowlands area. These school sites are no longer considered in the lowlands area.

Several surface fault investigations have been performed in the area of the NBR development. Specifically, these were by: Guptill and Heath (1981), Earth Technology Corporation (1986), Law/Crandall, Inc. (1993, 1994), Converse Consultants Orange County (1994), Magorien and Shlemon (1995), Shlemon and others (1995), and Earth Consultants International (1997).

Relevant information and findings from both the previous geotechnical and fault studies are discussed in subsequent sections of this report.

ENVIRONMENTAL STUDIES

Environmental studies for the NBR, including soil and groundwater investigations, date back to 1984. Past reports and data are summarized in a Summary Environmental Restoration Report and a Phase I Description report prepared by GeoSyntec Consultants in 1996. In general, the main environmental findings include: 1) groundwater below the site has been intruded by seawater with limited impacts to groundwater by oil production related facilities, 2) the soil vadose zone (i.e., zone of partial saturation above the groundwater table) has been impacted in the vicinity of wells, tanks, mud pits, etc. with crude oil, and 3) some of the oil production tank bottom materials (crude oil and sand forming asphalt-like materials) have been used for dust and erosion control at the site.

As part of an approved development project, the oil operator will consolidate oil production activities to three areas. During the consolidation process, oil related facilities will be removed. The consolidation operations include removal of structures and equipment related to crude oil production, including oil wells, pipelines, drill rigs, tank farms, a steam generating plant, compressed air plant, generators, and an equipment maintenance facility, as well as other structures and equipment. Oil well removal, or abandonment, operations and petroleum-impacted soil remediation are being conducted in accordance with California Division of Oil, Gas and Geothermal Resources, Orange County Health Care Agency, and Orange County Regional Water Quality Control Board guidelines. The removal and restoration activities generally conform to environmental restoration plans developed by the leaseholder and land owners/developers, discussed with the appropriate oversight agencies, and conducted in consultation with Geosyntec Consultants.

The oil consolidation and remediation operation will yield materials including bio-remediated soils, asphalt-like materials, and concrete from abandoned oil production facilities. It is anticipated that these materials will be utilized in fills placed as part of the planned grading and/or in the construction of roadways.

REGIONAL GEOLOGIC AND TECTONIC SETTING

REGIONAL FAULTING

Three regional fault systems potentially affect design of the proposed NBR development: the Compton Thrust Ramp in the Los Angeles area; the Newport-Inglewood fault zone (NIFZ), a portion of which borders and locally infringes on the site; and the San Joaquin Hills Blind Thrust, an inferred blind fault potentially underlying the San Joaquin Hills and postulated to extend immediately south of the proposed development.

Compton Thrust Ramp

Shaw and Suppe (1996) inferred the existence of the northwest-trending southwest-vergent Compton Thrust Ramp (CTR) from deep, seismic-reflection profiles and from construction of retrodeformable cross sections. They believe regional Quaternary structures within the LA Basin, including the Newport Inglewood Fault Zone (NIFZ), are controlled, in part, by a growth fold(s) within a fault-bend fold above the base of the buried (i.e., no geomorphic expression) CTR (see Plate 3.1 -- Regional Faulting: Compton Thrust Ramp). The east side upthrust as defined by Shaw and Suppe (1996) ramps up from a central LA Basin decollement that appears to connect to the Elysian Park ramp farther to the northeast. The structure strikes approximately N60W and dips to the NE from 20 to 25 degrees. Approximately 25 miles of dip-slip displacement has been inferred on the CTR during the last 2.5 million years. A portion of the southern or upper end of the CTR, as currently mapped, lies beneath the Torrance-Wilmington oil field. Within the oil field, structural relief in late Pliocene and Quaternary horizons is interpreted as fault-bend folding. Davis and others (1989) similarly believe anticlines within the Torrance oil field resulted from fault-bend folding above a thrust ramp. The depth of the CTR, as postulated by Shaw and Suppe, lies between 3 miles and 6 miles. Horizontal offsets in the fold trend suggest the CTR can be divided into three segments. The segments from north to south are the Baldwin Hills, Central, and Santa Ana (see Plate 3.1 -- Regional Faulting - Compton Thrust Ramp). The segments, if active (i.e., Holocene), may rupture in separate earthquakes or multi-segments may possibly rupture together. Recent studies suggest a lack of activity on the thrust during the Holocene (Mueller and Suppe, 1996; Rockwell and others, 1996). The CTR was removed as a seismic source from the 2008 National Seismic Hazard Maps and California Uniform Earthquake Rupture Forecast based on Mueller (1997), which documented lack of fault deformation in deposits as old as 15-20 ka. In contrast, Leon et al. (2009) utilized a combination of high-resolution seismic reflection profiles and borehole excavations to conclude that the CTR has had Holocene earthquakes and thus is active. The lateral extent of the two end segments (i.e., Baldwin Hills and Santa Ana) is poorly constrained. The NBR development is potentially located above the Santa Ana Section. Although the CTR does not pose a risk of surface rupture within the NBR development, it is potentially active and may therefore contribute to ground motion at the site.

Newport-Inglewood Fault Zone

The Newport-Inglewood fault (NIFZ) is a structural zone containing numerous faults and fault splays or branches and anticlinal uplifts that are believed to have been created by movement on the Compton Thrust Ramp. The zone strikes generally N45W and near surface dips range between 70 and 90 degrees. The surface trace is discontinuous in the Los Angeles Basin, but the zone is marked by distinct geomorphic features extending from Culver City to Signal Hill. South of Signal Hill, the zone parallels the coastline until just south of Newport Bay, where it heads offshore (see Plate 3.2 – Regional Faulting: Newport-Inglewood Fault zone).

Geomorphic expression of the NIFZ locally includes warped or displaced surfaces, scarps, troughs, deflected drainage channels, air photo lineaments, and closed depressions on the mesas. The onshore segment of the NIFZ extends south from Beverly Hills to Newport Bay. North of Signal Hill, the NIFZ is defined by a discontinuous chain of low hills. South of Seal Beach, the NIFZ is marked by several relatively youthful, low-lying and tilted and uplifted surfaces including, from north to south, Landing Hill (i.e., Seal Beach area) and Bolsa Chica, Huntington Beach, and Newport mesas. Signal Hill, an uplifted structural feature north of Seal Beach, is believed to be approximately 200,000 years old based on ages of marine shells (Forrest and others, 1997).

Recently, as noted above, Shaw and Suppe (1996), Davis and others (1989), constructed retrodeformable cross-sections across the L.A. area. They interpret the NIFZ zone as, respectively: 1) a multi-sectioned zone of strike-slip faulting that has been offset at depth (5 to 6 miles) and translated 2½ miles to the southwest along the Compton Thrust Ramp, and 2) an expression of fault-propagation folding above a deeply buried thrust fault. Two sections of the NIFZ are defined by a northerly trend increase in the strike of the zone north of Signal Hill. This boundary is also north of the aftershock zone of the 1933 Long Beach Earthquake (Hauksson, 1987). Separate portions of the fault southerly of Signal Hill have been named (Hauksson, 1987) and from north to south include the Cherry Hill, Northeast Flank, Reservoir Hill, Seal Beach, and North and South Branch faults (see Plate 3.2 – Regional Faulting: Newport-Inglewood Fault zone). The near-surface expression of the Cherry Hill fault, as exposed in Signal Hill trenches, is a thrust that clearly displaces Pleistocene and probable Holocene sediments and soils (pedogenic profiles). Additionally, the presence of deeply incised windgaps (abandoned channels) provides geomorphic evidence that Signal Hill has been subject to at least 80 feet of uplift and folding since latest Pleistocene time (Mills and Shlemon, 1992). The south section of the NIFZ continues at least as far south as Newport Bay. South of the site, the NIFZ trends offshore and appears to be continuous with submarine faults (sometimes identified as the offshore Newport-Inglewood or as the South Coast Offshore fault) and locally coincides with a submarine canyon. The coastal end of the submarine canyon is located near the end of the Newport pier. Farther to the south the NIFZ is believed to connect to the northern offshore segment of the Rose Canyon fault which cuts through San Diego (Fischer, 1992). In the San Diego area, the southern most segment shows evidence of Holocene surface rupture.

Estimates of the amount of right-lateral displacement on the NIFZ vary. For example, total displacement (horizontal along strike of the fault) has been estimated to be approximately 1.8 miles with offsets decreasing to the north. However, Forrest and others (1997) note approximately six miles of offset in the last seven million years. The sense of vertical separation is both east- and west-side-up on individual faults, but appears to be west-side up across the width of the entire zone of deformation. Slip rate estimates, depending on fault segment, range from a low of 0.34 mm/yr (.013 in/yr) to a high of 1.0 to 2.0 mm/yr (.04 to .08 in/yr) (Freeman and others, 1992; Grant and others, 1997; Shlemon and others, 1995). Forrest and others (1977) estimated that the NIFZ is capable of large earthquakes with up to one meter of offset and recurrence in 1200 to 3000 years. At least two large events are inferred to have occurred within the last 2,000 to 4,000 years (Grant and others, 1997; Shlemon and others, 1995); and Peterson and others (1996) suggested a Mw 6.9 earthquake for each segment of the NIFZ. Accordingly, based on a maximum estimated slip rate of 2 to 5 mm/yr (.08 to .2 in/yr) and a moment magnitude of less than 7.0, the NIFZ is deemed a "Class B" fault.

San Joaquin Hills Blind Thrust

The site is about 4.6 km from the San Joaquin Hills Blind Thrust (SJHBT), an inferred, low-angle fault system (e.g., blind thrusts) suggested by Grant et al. (1999). Blind thrust faults normally do not break the ground surface during sizeable earthquakes. The existence of the SJHBT is postulated from comparison of an early 20th Century topographic survey with recent geodetic measurements in the Newport Back Bay and from uplifted marine terraces within the San Joaquin Hills (Grant et al., 1999). The blind thrust fault is modeled to dip westerly from about 1 mile deep below the east side of the San Joaquin Hills, intersecting the Newport-Inglewood fault at a depth of about 5 miles.

Direct evidence of the SJHBT, such as seismicity data, geophysical data, or deep boring logs, does not exist. However, the existence of the SJHBT has been incorporated into the seismic hazard models of CGS, USGS, and Caltrans.

SEISMICITY AND EARTHQUAKE HISTORY

Since 1920, approximately 16 earthquakes M4.0 or larger have occurred along the NIFZ north of Newport Bay. Barrows (1974) noted that the majority of the events are associated with the section of the NIFZ near the NBR development area. The largest event within the NIFZ was the

M_L 6.3 1933 Long Beach earthquake. The earthquake occurred at 5:54 P.M. and nucleated between Huntington Beach and Newport Bay (Hauksson and Gross, 1991). The rupture propagated to the northwest from a depth of 8 miles. The focal mechanism, based on recorded seismograms, indicates right-lateral motion with a small normal component on a NW striking, 80 degree NE-dipping nodal plane. Reports of coseismic surface faulting are questionable. However, elevation changes of approximately -0.39 to +0.59 feet detected shortly after the earthquake are attributed to coseismic deformation (Castle and Buchanan-Banks, 1989). The largest aftershock (M_L 5.4) occurred seven months after the main shock near Signal Hill. The NBR development area appears to be within the southern limits of the 1933 aftershock zone.

The most recent earthquake greater than M4.0 occurred on May 17, 2009, near Lennox and Inglewood, California. According to the Preliminary Earthquake Report by the USGS, this earthquake event registered a magnitude (Mw) of 4.7 and was located at 33.937°N, 118.345°W, which is about 49 km northeast of Banning Ranch. The earthquake occurred at a depth of 15.1 km. Although the earthquake location is consistent with the NIFZ, and unofficial USGS comments in the media suggested the earthquake may have occurred on the NIFZ, the USGS did not conclusively assign the earthquake to the NIFZ.

SEISMIC WATER WAVES

Seiches

A seiche is a free, coseismic oscillation of the surface of water in an enclosed or semi-enclosed basin such as a lake or harbor. The closest enclosed bodies of water to the site are the Santa Ana River and the slough-like areas created by the ACOE Santa Ana River marsh restoration project. However, neither of these bodies of water is close enough and/or large enough to represent a significant hazard to the NBR development. Consequently, the potential seiche hazard is not significant.

Tsunamis

Tsunamis or seismic sea waves that have affected coastal southern California are generally produced by submarine fault rupture. Historical records indicate that the coast, from San Pedro to Newport Bay, has been affected by six significant tsunamis since 1868 (Vasily Tito, National Oceanographic and Atmospheric Administration, Personal Communication, June 1998). The largest waves were on the order of 6 to 8 feet. The most extensive recent damage occurred in harbor areas such as Los Angeles (Alaska - 1964, Chile - 1960).

Legg et al. (2004) investigated the tsunami hazard associated with the Catalina fault offshore of Southern California. They simulated tsunamis based on coseismic deformation of the sea floor and estimated that coastal runup values are 1.4 to 4.0m, although runup could exceed 7m depending upon amplification due to bathymetry and coastal configuration. Large earthquakes on the Catalina fault are relatively infrequent, with recurrence intervals of several hundred to thousands of years (Legg et al., 2004).

Tsunami Inundation Maps

In 2009, the California Emergency Management Agency, California Geological Survey, and University of Southern California partnered in an effort to create tsunami inundation maps for California. The tsunami inundation maps were generated through a modeling process that utilizes the Method of Splitting Tsunamis (MOST). This computational program models tsunami evolution and inundation based on bathymetry and topography. The modeling also utilizes a variety of tsunami source events, including "realistic local and distant earthquakes and hypothetical extreme undersea, near-shore landslides" (California Emergency Management Agency et al., 2009). Using the source, bathymetry, and topography, the tsunami modeling yields a maximum inundation line. It is important to note that the published map does not represent inundation from a single event. Rather, it is the result of combining inundation lines from multiple source events. Therefore, the entire inundation region will not likely be inundated during a single tsunami event (California Emergency Management Agency et al., 2009).

The Tsunami Inundation Map states that the "tsunami inundation map was prepared to assist cities and counties in identifying their tsunami hazard. It is intended for local jurisdictional, coastal evacuation planning uses only." Furthermore, the map conveys that it is not intended for regulatory purposes. With respect to probability, the map states that it contains "no information about the probability of any tsunami affecting any area within a specific period of time."

A Tsunami Inundation Map for Emergency Planning was published for the Newport Beach Quadrangle (California Emergency Management Agency et al., 2009). In considering the Tsunami Inundation Map with respect to the proposed Banning Ranch development, it is critical to note three points: (1) the map is only intended for emergency planning and evacuation planning; (2) the map does not convey any information with respect to probability or timing of tsunami events; and (3) the inundation line is a conservative combination of multiple source events.

An excerpt of the Tsunami Inundation Map for the Newport Beach Quadrangle is attached as Plate 4. The tsunami inundation line is mapped near the toe of the bluffs that divide the upland and lowland areas of the NBR development. The structural and habitable developments planned at NBR are located on the uplands area, which is outside of the tsunami inundation area. This is consistent with our reference (1) report, which concluded that significant protection is provided from potential tsunamis.

Tsunami Hazard Assessment

Based on our evaluation of the Tsunami Inundation Map, we conclude that the structural and habitable developments planned at NBR are outside of the Tsunami Inundation Area and will be sufficiently protected from potential tsunamis. Protection from potential tsunamis is also based on the fact that: (1) the closest section of the NBR development to the ocean is the southwestern portion of the mesa which exists approximately 800 feet away at an elevation of approximately 50 feet; and (2) natural and constructed barriers, such as homes and West Coast Highway, exist between the ocean and the site.

Although the upland/mesa area is judged to be protected from tsunami inundation, the lowland/floodplain areas may be subject to tsunamis. However, the probability and severity of tsunami inundation in the lowland areas cannot be estimated based on current available information.

SITE GEOLOGY

GEOMORPHOLOGY

The proposed NBR development is located along the western edge of Newport Mesa and extends into the eastern margin of the Santa Ana River flood plain. U.S. Coast Survey topographic mapping from the 1870's shows the Santa Ana River flood plain as a low-lying swampy area between La Mesa (Newport Mesa) on the east and Las Bolas (Huntington Beach Mesa) on the north and west. Several branches or channels meander across the flood plain, flowing around willow swamps, then turning southeast at or near the coast. The channels join near the ocean then flow into "Bitter" Lake at the south edge of the site. The map indicates that direct flow into the ocean at the mouth of the Santa Ana River was blocked by beach deposits. The river, continuing to flow southeasterly parallel to the coast, enters Newport Bay, flowing into the ocean at the eastern edge of the bay. In the 1870's, a relatively wide channel that appears to have been blocked by sedimentation or other natural process formed a shallow lake along the western edge of Newport Mesa. The lake was drained by several smaller channels along its western edge. The western-facing bluffs along the edge of Newport Mesa are approximately 50 feet to 90 feet above the flood plain. The mesa gently slopes toward the west and south. The upper terrace surface appears to be of at least two separate ages and elevations, separated by a northwest-trending paleo-shoreline (see Appendix F). Several northwest-trending and west-draining channels incise deeply into the mesa. Aerial photos taken in the 1920's and 1930's show relatively small, distal fans developing at the edge of the flood plain. Several of the fans were deeply eroded during the 1938 flood.

NORTH BRANCH OF THE NIFZ

From about Signal Hill on the north to the Bolsa Chica area of Huntington Beach on the south, the NIFZ is generally expressed by a northwest-trending (~N45W), relatively narrow zone (0.6 to 1.2 miles wide) of near-surface, mainly strike-slip faults (Plate 5 -- Local Geomorphology and North Branch of the Newport-Inglewood Fault Zone). To the south, however, particularly from the Huntington Mesa, across the Santa Ana River Gap and through the Newport Mesa, the NIFZ makes a distinct turn in trend (~N60W). Here also the fault diverges into numerous splays that form an approximately 3-mile-wide zone (Castle and Buchanan-Banks, 1989). These widely spaced faults, mostly identified as controlling subsurface oil-field structures, are collectively (and informally) designated as the "North Branch" of the NIFZ (Barrows, 1974; Bryant, 1988). The NBR development area is located within this "North Branch" zone.

Pacific Soils Engineering (PSE; 1996) emplaced cone penetration test (CPT) lines across an alignment of oil wells thought to identify the location of a North Branch splay along the east side of the Santa Ana River floodplain in Huntington Beach (near Beach Boulevard and Adams Avenue). Although not precluding presence of a deep-seated fault, the CPT data showed that the Pleistocene-Holocene contact was unbroken and could be readily traced over the presumed fault alignment. Therefore, this splay of the NIFZ North Branch was determined to be "not active" for purposes of commercial development.

In contrast, as reported in Mills and Shlemon (1988), PSE exposed a thrust fault that bordered the southwest flank of a 36-foot-high pressure ridge, one of three aligned topographic features that delimit the NIFZ North Branch on the Huntington Beach Mesa near Yorktown Avenue and Seabluff Drive. Soil-stratigraphic evidence showed that the last near-surface displacement was probably Holocene in age; and therefore, that particular North Branch splay of the NIFZ was concluded to be active.

STRATIGRAPHY

Three basic stratigraphic units are present within the NBR development area: the San Pedro Formation (Qsp), marine terrace deposits (Qtm), and river alluvium (Qal) (see Plate 7 -- Geologic Map and Plates 8.1 through 8.14 -- Geologic Cross Sections). The distribution of these units in map view and in cross section rely on extensive surficial geologic mapping and drill hole data. Some cross sections also rely on subsurface contact projections that are consistent with other observations throughout the project. For example, the subsurface geology for Cross Section 5-5' is consistent with that of Cross Section 6-6'. Specifically, the geologic contacts on Cross Section 5-5' are constrained at the surface, and then projected into the subsurface at orientations consistent with other cross sections that have drill hole data. The remaining cross sections were constructed in a similar manner.

The San Pedro Formation and overlying marine terrace deposits occur beneath the elevated or mesa areas of the site, with alluvial deposits spread across the flood plain of the Santa Ana River. Surficial colluvium (Qcol) and man-made, artificial fill (af) mantle portions of these three basic units throughout the site. Each mapped unit is described below.

The San Pedro Formation

The San Pedro Formation is the oldest geologic unit exposed within the NBR development area and is generally believed to correlate with similar lower Pleistocene sediments in other parts of the Los Angeles Basin. Exposures are visible along the base of the bluff bordering the lowlands and along West Coast Highway (see Plate 7 -- Geologic Map). San Pedro Formation sediments were also encountered in a limited number of borings and trenches.

Lithologically, this moderately indurated "bedrock" unit consists mainly of gray and dark gray to reddish yellow-stained siltstone and clayey siltstone, with friable, interbedded fine- to coarse-sandstone interbeds. The variable lithologies are attributed to a wide range of depositional, near-shore environments, including near-shore fluvial, lagoonal, deltaic, shallow marine, and backbay tidal flat environments. These depositional environments yielded lenticular and laterally discontinuous depositional units that are laminated to thinly bedded. Bedding is generally well-defined in exposures but, as noted above, is laterally discontinuous due to the depositional characteristics of the formation.

Many angular unconformities and eroded paleo-channels occur within this unit. The paleo-channel walls are locally steep and planar and can be easily mistaken for faults. However, close examination of nearby cut exposures usually reveal one or more of the following features indicative of a non-fault origin: 1) continuous, unbroken strata beneath the ancient channel, 2) unfaulted sand lamellae across the channel walls, and/or 3) near-horizontal, terrace-like abrasion surfaces that have been cut into the top of the San Pedro Formation to form an unconformity with the overlying marine terrace deposits.

Marine Terrace Deposits

Most sediments beneath the elevated portion of the NBR development area consist of marine terrace deposits (Qtm). These deposits overlie an abrasion platform 20 to 30 feet above the river channel, and extend to the top of the mesa for a total thickness of approximately 40 to 50 feet. Sediments above the abrasion platform locally contain rounded cobbles, shells, and angular rocks with mollusk borings similar to materials found in the tidal zone today. The marine terrace sediments, although lithologically similar, were deposited in two distinct stages. These stages are discussed in "Fault Dating Techniques" (Appendix F).

Marine terrace deposits were exposed in all of the recently excavated fault trenches (i.e, Trenches TR-1 through TR-23; Plate 7). These deposits are predominantly light gray, soft, friable, thin to thick bedded sands, with light olive brown silt to clayey silt interbeds. Locally, the sand beds vary from yellowish brown to red brown, whereas the finer-grained interbeds were generally darker. The coarser beds were essentially uncemented-like beach sand, which caved in some trenches. The finer-grained silty and clayey interbeds were generally well-defined, continuous, and easy to trace across trench walls.

Many depositional features, such as cross bedding, fine-grained lamellar beds, and scattered shells, also occur in the marine terrace deposits. Abundant secondary features, such as carbonate nodules, iron oxide-stained beds, and dark mineral banding, were also noted. Shell-rich beds and lenses were encountered in the northern parts of the mesa.

River Alluvium (Qal)

Holocene alluvial deposits overlie a late Pleistocene channel of the lower Santa Ana River west of the Newport Mesa at a depth of approximately 100 feet (Shlemon, et. al., 1995). These relatively young sediments are gravel, sand, and clay deposits that form a grossly fining-up sequence. Near the bluffs, they appear to be locally interbedded with tongues of colluvium derived from the adjacent bluffs.

Colluvium (Qcol)

Colluvium has accumulated along the base of the bluff slopes and fills gullies, ravines, and arroyos that drain the mesa. A relatively thick apron of colluvium has accumulated at the base of the bluff slopes (Plate 7). The distal end of these materials probably extends into and intertongues with river alluvium present along the western side of the site. Most colluvium was deposited during latest Pleistocene and early Holocene time when the lower Santa Ana River (local base level) was more deeply incised and graded to the last glacio-eustatic lowstand of sea level, some ~330 feet below the present (Appendix F). These relatively young deposits consist essentially of homogenous, non-descript sandy and silty clays. Bedding is indistinct and few stratigraphic features are observable. These materials are generally too young for site fault-dating assessment.

Soil Development

Thick soils (pedogenic profiles) are present on the marine terrace deposits that immediately underlie the Newport Mesa and the NBR development area. These soils, up to 10 feet thick, are very strongly developed. They are typically characterized by very thick, dark reddish-brown, blocky to prismatic structure in the subsoil (argillic or "Bt" horizons); by many, moderately thick clay films on ped faces; and by an overlying greyish or "bleached" zone (eluvial or "E" horizon; see Appendix F). The very strong development of these soils stems from their antiquity (relict paleosols), and from the likely addition of eolian fine sand and local colluvium (composite profiles) during the Pleistocene (Appendix F). Based on their strong relative profile development, the NBR development area soils in the western part of the Newport Mesa are at least about 100 ka (i.e., 100,000 year old); and those composite profiles in the eastern part of the Mesa are probably about 200 ka old (Appendix F); see also Shlemon, 1985; Guptill and others, 1989; Freeman and others, 1992; Magorien and Shlemon, 1995; ECI, 1997).

The Newport Mesa soils thus prove to be excellent stratigraphic markers for dating the last time of fault displacement. For example, where the thick argillic horizons are unbroken, as displayed in trench exposures, any underlying fault is reasonably deduced as being pre-Holocene in age. In contrast, where tectonic displacement extends through the argillic horizons, and into overlying sediments upon which the "E horizon" has developed, last observed fault displacement is conservatively judged to have taken place in Holocene time.

Man-made Fill

Several areas of shallow (1 to 3 feet thick) and relatively deep fills occur throughout the site. Many of these areas are now concealed by roads, pipelines, or other oil field structures. Many fill areas are associated with the construction of oil drilling pads and/or other oil-related facilities. Where they are known or inferred to be more than 2 feet thick, they are indicated on the attached Geologic Map, Plate 7. The fills observed in the general area are comprised of a wide variety of materials, from "clean" reworked natural soils to concrete and other construction debris.

GEOLOGIC STRUCTURE

On-site geologic structures include slightly to moderately folded and inclined strata, and high-angle faults with vertical displacements less than a few feet. The lowermost stratigraphic unit, the San Pedro Formation, generally dips between 5 and 15 degrees towards the southwest, west, and northwest with locally steeper inclinations of up to approximately 25 degrees (see Plate 7 -- Geologic Map and Plates 8.1 through 8.14 -- Geologic Cross Sections). Several folds within this formation are exposed along the bluff face in the north-central portion of the site, where fold axes are relatively tight but essentially unfaulted. Well-defined, fissile, and horizontally continuous bedding planes are not typical within the underlying San Pedro Formation due to the relatively young age of the formation, the environment of deposition, fold structures, and the primary sediment types. As discussed previously, the varying depositional environments yielded lenticular and laterally discontinuous depositional units, thereby limiting the lateral continuity of bedding plane structures.

The marine terrace deposits are distinguished from the underlying San Pedro sediments by their more gently inclined strata. For example, several trenches exposed terrace deposits with near-horizontal strata a few inches thick that could be laterally traced for more than 300 feet. Slight folding or arching of these strata was noted adjacent to mapped faults. These gently arched or warped beds appear to be related temporally with regional stresses and associated fault displacements.

HISTORIC SLOPE STABILITY

Interpretation of aerial photographs taken in the 1920's and 1930's indicate that several western-facing slopes along the edge of the mesa have experienced slope failure. The failures are generally shallow slump-type features concentrated in the terrace sediments overlying the San Pedro Formation. Geologic mapping also identified several recent slump-type features along the bluffs (see Plate 7 -- Geologic Map). These features most likely resulted from uncontrolled surface runoff, erosion, and normal bluff retreat and possibly from past seismic events. Evidence of larger, older slope failures (i.e., large translational or rotational failures) was not found.

HYDROGEOLOGY

The proposed development is located within the Orange County Groundwater Basin, which underlies the Orange County Coastal Plain. The Orange County Ground Water Basin is composed of three intra-connected confined aquifer systems, the Lower, Middle, and Upper aquifer systems (GeoSyntec Consultants, 1996; California Department of Water Resources, CDWR, 1967). The lower aquifer system is a series of hydraulically interconnected aquifers overlying the non-water-bearing formations of consolidated sedimentary and basement rock. The Middle Aquifer system is composed of a series of aquifers predominantly of the water-bearing San Pedro Formation. The Main Aquifer, the predominant aquifer within the Middle Aquifer system, is comprised of coarse sand and gravel with interbedded layers of finer deposits. This is the primary source of groundwater for Orange County. The Upper Aquifer system is made up of discontinuous lenses of coarse sand and gravel confined by lenses of clay sediments. The Talbert Aquifer is the uppermost confined aquifer in the Upper Aquifer system. Local fine-grained sediments give rise to perched or quasi-perched water above the Talbert Aquifer.

Groundwater levels below the NBR site in both the lowlands area and the Newport Mesa are deduced from observations in exploratory borings performed by various investigators from 1985 through 1998 and in groundwater monitoring wells installed by GeoSyntec in 1994. In the lowlands, groundwater generally occurs within a few feet of MSL as shown in the geotechnical exploratory borings of Woodward-Clyde, Leighton and Associates, and GMU Geotechnical, Inc. (i.e., this study). Pacific Soils also noted groundwater at MSL in their boring HB-1, but noted groundwater in boring HB-2 at approximately 6.0 MSL at the mouth of the southernmost, major arroyo. More definitively, groundwater was determined to be at approximately MSL by readings taken in three groundwater monitoring wells installed within the lowlands area by GeoSyntec.

Groundwater below the mesa area was noted by Pacific Soils at an elevation of approximately 10 feet in their boring B-6 (Plate 7). However, a groundwater monitoring well installed by GeoSyntec on the mesa indicated groundwater at approximately MSL. Consequently, the groundwater noted by Pacific Soils may be related to either a local condition, to perched water, or to capillary rise. Consistent with the aforementioned groundwater observations, seepage in the existing bluff faces was not observed during GMU's 1998 exploration program.

In the mesa area, the groundwater flow direction appears to be toward the bluffs (i.e., to the west in the northern portion of the NBR site and to the south along West Coast Highway) while in the lowlands area, the direction of groundwater flow in the upper aquifer appears to be mainly toward the south parallel to the Santa Ana River (GeoSyntec, 1996).

FLOODING AND COASTAL EROSION

In the late 1800's, the Santa Ana River channel was along the western edge of the mesa (U.S. Coast Survey, 1874 and U.S. Geological Survey, 1901). Near the coast, the channel appears to have been blocked forming a lake at the base of the bluff. The lake was drained by several small channels. At the coast, the channels combined into a larger one that drained to the southeast into Newport Bay. On the 1874 U.S. Coast Survey map, the coastal channel along the south edge of the site is labeled "Bitter Lake". From at least the 1870's to the present, the bluffs appear to have been protected from direct wave action by a barrier bar or spit.

Between 1894 and 1927, the Santa Ana River was channelized. The new channel was relocated, generally less than three-quarters of a mile west of the base of the bluffs. Aerial photos taken in March 1938 show flood waters over the banks of the constructed channel and eroding the bluffs and alluvial fans along the western edge of the mesa. Receding flood waters deposited a thin blanket of sediment at the western edge of the site. Based on previous site visits, low areas east of the modern channel have been flooded during heavy rainfall events.

According to the local Flood Insurance Rate Map (FIRM) the 100 year flood level occurs at elevation 10 MSL. Given that proposed development areas are planned either on the mesa at elevations between approximately 50 MSL and 105 MSL, and/or in transition areas, which occur between the lowland open space area and the mesa (i.e., elevations between 10 MSL and 50 to 105 MSL), flooding is not anticipated to be a significant geotechnical design constraint.

OIL FIELD SUBSIDENCE

Woodward-Clyde Consultants (WWC) (1985) evaluated the potential for oil field subsidence at the NBR site. They incorporated data from previous oil field subsidence studies at the Wilmington oil field in Long Beach, the Huntington Beach oil field, and survey data along coastal Orange County performed by the County Surveyor. WWC concluded that ground subsidence from oil field operations has not been identified in the West Newport oil field possibly due to: 1) relatively thin oil producing horizons, 2) a natural water drive that may be replacing some of the removed hydrocarbons, and 3) partial replacement of hydrocarbon fluids by steam injection. This conclusion is consistent with the lack of evidence of ground subsidence (i.e., ground cracking etc.) noted during this investigation, which included approximately 1 mile of fault trenching across the site.

Oil field subsidence is not anticipated to be a significant geotechnical design constraint based on: (1) the WWC evaluation, (2) the lack of ground subsidence documented in the GMU investigation, (3) the general lack of subsidence impacts on oil production, and (4) the planned abandonment of production oil wells within structural areas of the planned NBR development.

BLUFF SLOPE RETREAT

Historically, bluff retreat in the NBR development area has been caused by: 1) Santa Ana River flooding; 2) direct wave action; 3) slope failure; 4) rainfall and channel development on the mesa; and 5) oil field activities (i.e., earthwork for oil field facility construction). However, since the 1940's, primarily owing to improvements in the Santa Ana River channel, oil field activities and slope failures (i.e., shallow slumps), along with rainfall and channel development on the mesa have been the only significant factors. Of these three, oil field activities have probably had the greatest effect.

To calculate reasonable distances for bluff-building setbacks, historical bluff retreat was analyzed. The rate of the historical bluff retreat was estimated by comparing the topography over a 33-year period, as surveyed by the U.S. Geological Survey in 1932 and in 1965. Earlier topographic maps from 1874 and 1894 were not used because they do not have a common datum. The 1932 and 1965 topographic surveys used the 1927 North American datum. The contour interval for both maps is 5 feet. For comparison, the center of the 75-foot contour lines were digitized and plotted to the same scale. The distance between the 75-foot contour lines was measured at several locations and was determined to be approximately 30 to 40 feet wide. The relative horizontal distance between the contour lines was measured at 10 locations. The measurements were made along the westerly bluff, generally between 16th Street and 18th Street. Average bluff slope retreat was estimated at approximately 2 feet per year. Potential error due to the width of the contour lines and the digitizing process is approximately ±1.1 feet per year. The rate ranged from 0.6 feet per year to 4.2 feet per year.

The estimated historic bluff slope retreat rates are greatly affected by the flood of 1938 and grading of the mesa for oil production facilities. It should be noted that completion of the Prado and Mentone Dams has now greatly reduced the Santa Ana River flood potential, and hence lessened potential bluff retreat. Examination of the 1965 U.S. Geological Survey Quadrangle and the 1993 air photos indicate that the largest bluff retreat rates are associated with oil field activities along the upper edge of the mesa. Earthwork for oil production increased bluff slope retreat rates by physically modifying the terrain and locally increasing runoff and associated erosion. The largest erosion rates were measured due west of the western terminus of 18th Street. A relatively large pad and access road were graded at that location. Consequently, the historic bluff retreat rates are greatly skewed by man-made processes that will not be present following development.

The proposed development will improve surface drainage conditions and will mitigate most of the surface drainage over the top of the bluff slope face. The runoff management plan will also serve to reduce flow rates and volumes within the Oxbow Loop, thereby reducing flood potential below the bluffs. Consequently, bluff slope retreat will be significantly reduced such that rational development setbacks can be determined.

GROUND MOTION

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. Given the proximity of the site to several active and potentially active faults (Table 1; see discussion below), the site 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. Ground motion at the site has been quantified using probabilistic and deterministic seismic hazard analyses. These analyses are presented below as "Probabilistic Seismic Hazard Analysis" and "Caltrans Seismic Hazard Analysis."

Probabilistic Seismic Hazard Analysis (PSHA)

A probabilistic seismic hazard analysis (PSHA) of horizontal ground shaking was performed to evaluate the likelihood of future earthquake ground motion occurring at the site. 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 *EZ-FRISK* ver. 7.32 was used to make the mathematical computations for this analysis. The software program *EZ-FRISK* is based on earlier work of McGuire (1976) but has been updated and modified to analyze earthquake sources as 3D planes using modern attenuation relationships.

The PSHA utilized seismic sources and attenuation equations consistent with the 2008 USGS National Seismic Hazard Maps (Peterson et al., 2008). At least 26 seismogenic faults are located within a radius of 80 kilometers of the site coordinates (USGS Newport Beach 7-1/2 minute quadrangle, Latitude 33.6327°N, Longitude 117.9439°W). The "Maximum Moment Magnitude" presented in Appendix A of CGS OFR 96-08 (revised 2003) and the CGS California Fault Parameters web page are taken to represent the maximum earthquake each of the 26 faults presented in Table 2 are capable of generating under the current tectonic regime.

The PSHA computations were performed for peak horizontal ground acceleration (PHGA) using equally-weighted USGS variants of the following Next Generation Attenuation relationships: Boore and Atkinson (2008), Campbell and Bozorgnia (2008), and Chiou and Youngs (2007). These attenuation relationships require that the site be categorized according to material type in the upper 30 meters of the site. Review of the boring logs and available geologic literature indicate that the upper 30 meters of the site is predominantly underlain by artificial fill, marine terrace deposits, and bedrock of the San Pedro Formation. Therefore, the site is categorized with a Soil Profile Type D. This corresponds to an average shear wave velocity of 275 meters/second. The specified risk level for this analysis is a ~475 ARP hazard level (i.e., 10 percent probability of exceedance in 50 years). The site coordinates used in the PSHA were 33.6327° North Latitude and 117.9439° West Longitude. The PSHA included contributions of earthquake events with magnitude of 5.0 or greater.

Table 2 - Fault Table[1]

Fault Name	Distance (km)	Seismology Parameters		
		Maximum M_W	Fault Type[2]	Slip Rate (mm/yr)
Newport-Inglewood (L.A. Basin)	0.5	7.1	rl-ss	1.0
San Joaquin Hills Blind Thrust	4.6	6.6	bt	0.5
Newport-Inglewood (Offshore)	5.4	7.1	rl-ss	1.5
Palos Verdes	19.1	7.3	rl-ss	3.0
Puente Hills Thrust	33.3	7.1	bt	0.4
Whittier	33.6	6.8	rl-ss	2.5
Chino-Central Avenue	37.1	6.7	rl-r-o	1.0
Elsinore - Glen Ivy	37.6	6.8	rl-ss	5.0
Coronado Bank	40.5	7.6	rl-ss	3.0
San Jose	45.6	6.4	ll-r-o	0.5
Elysian Park Thrust (upper)	50.6	6.4	r	1.3
Elsinore – Temecula	55.2	6.8	rl-ss	5.0
Raymond	56.7	6.5	ll-r-o	1.5
Sierra Madre	56.8	7.2	r	2.0
Cucamonga	58.3	6.9	r	5.0
Verdugo	58.7	6.9	r	0.5
Hollywood	60.2	6.4	ll-r-o	1.0
Clamshell-Sawpit	60.8	6.5	r	0.5
Santa Monica	64.8	6.6	ll-r-o	1.0
Malibu Coast	70.2	6.7	ll-r-o	0.3
Rose Canyon	74.4	7.2	rl-ss	1.5

San Jacinto - San Bernardino	76.6	6.7	rl-ss	12.0
San Jacinto - San Jacinto Valley	78.4	6.9	rl-ss	12.0
Northridge (E. Oak Ridge)	78.8	7.0	bt	1.5
Sierra Madre (San Fernando)	78.8	6.7	r	2.0
Anacapa-Dume	79.8	7.5	r-ll-o	3.0

[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 results of the PSHA are included in Appendix D. The PHGA at the specified risk level of ~475 ARP is 0.37g. Seismic design of structures, excluding bridges, should be performed in accordance with the 2010 CBC. The appropriate seismic design parameters are provided in a subsequent section of this report (see Preliminary Seismic Design and Foundation Considerations).

Caltrans Seismic Hazard Analysis

For design of a potential pedestrian bridge for the NBR project, ground motions at the site were also evaluated in accordance with current Caltrans procedures. The Caltrans-based analysis evaluated ground motions at the site using Caltrans ARS Online Version 1.0.4 (http://dap3.dot.ca.gov/shake_stable/index.php). Caltrans ARS Online is a web-based program that calculates deterministic and probabilistic acceleration response spectra based on Appendix B of Caltrans Seismic Design Criteria. Given site coordinates, the ARS Online program generates deterministic spectra for nearby fault sources and a probabilistic spectrum based on the 2008 USGS National Hazard Map for 5% probability of exceedance in 50 years (i.e., 975 year return period). The design ARS curve is then taken as the upper envelope of the deterministic and probabilistic response spectra. The program also accounts for soil type and near source adjustments to the ARS curves.

For the NBR project, site coordinates used in the analysis were 33.6327° North Latitude and 117.9439° West Longitude. Consistent with the PSHA described above, the site is categorized as Soil Profile Type D. This corresponds to an average shear wave velocity of 275 meters/second. Based on these parameters, the Caltrans ARS Online program calculates ARS curves for the deterministic and probabilistic response spectra. The calculated ARS curves and site data are included in Appendix D. At short periods (i.e., <0.8 sec), the deterministic response spectrum for the San Joaquin Hills blind thrust is the controlling curve, indicating a PGA of 0.60g. At longer periods (i.e., >0.8 sec), the deterministic response spectrum for the Newport-Inglewood fault zone is the controlling curve.

SEISMIC HAZARD ZONES

Two seismic hazard zones mapped by the State of California have been mapped within the NBR development area. These zones are shown on the "Seismic Hazard Zone Report for the Anaheim and Newport Beach 7.5-Minute Quadrangles, Orange County, California" (California Division of Mines and Geology, 1997). The map indicates that alluvial sediments in the lowlands area have been zoned as being prone to liquefaction; and the slopes descending from the mesa to the lowlands and West Coast Highway may be subject to earthquake-induced landslides. Specifically, the liquefaction hazard zones are defined as: "Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required." Similarly, the Earthquake-Induced Landslide zones are defined as: "Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693 (c) would be required."

The liquefaction zoning is consistent with previously performed site-specific geotechnical engineering analyses and is discussed in more detail in a subsequent section of this report. The potential for earthquake-induced landslide is evaluated in the "Slope Stability" section of this report.

FAULT INVESTIGATION AND FINDINGS

BACKGROUND

Except for a few Holocene fault-bounded low hills on the Huntington Beach Mesa (Mills and Shlemon, 1998), most North Branch splays have little obvious geomorphic expression, particularly where projected southward across the Santa Ana River floodplain and into the NBR development on the Newport Mesa. An exception is a low (3 feet) sinuous escarpment that trends northwest across the Newport Mesa, essentially conforming to the regional strike of many North Branch faults (Plate 5 -- Local Geomorphology and North Branch of the Newport-Inglewood Fault Zone). This, however, was previously trenched (Earth Technology Corporation, 1986) and demonstrated to be an erosional feature, rather than a fault, the product of a ~100 ka high sea-level stand that cut into older marine sediments. This conclusion was also verified during the present investigation by placement and logging of several trenches across the escarpment (e.g., TR-15; Appendix E). Accordingly, the North Branch faults on the NBR development have heretofore been excluded from State of California "active fault zones" (Bryant, 1988).

Recently, however, CPT and seismic investigations for expansion of a sewage disposal facility in the Santa Ana River floodplain, approximately ¼-mile west of the site (Plate 6 -- Faults Mapped in the Newport Banning Ranch Area by Previous Investigators), revealed the presence of several, closely spaced North Branch faults, most of which substantially offset Holocene sediments (Law-Crandall, 1994; Shlemon and others, 1995). A reasonable projection of these faults, along strike to the southeast, suggests that they do not impinge upon the NBR development area. Nevertheless, a myriad of other, so-called North Branch splay faults can be projected toward or occur adjacent to the NBR development area. One of these, the "West Mesa fault," (Plate 6 -- Faults Mapped in the Newport Banning Ranch Area by Previous Investigators) occurs immediately east of the NBR development area (i.e., in the boxed-out area along the eastern property boundary), where trench exposures showed that only two, field-observable paleoseismic events occurred within about the last 200 ka; the last, however, probably taking place in Holocene time (Converse Consultants, 1994; Magorien and Shlemon, 1995).

Another North Branch splay, as partially exposed in a cut along West Coast Highway, was previously deemed "active" (Guptill and Heath, 1981); but later trenching and detailed soil-stratigraphic analyses showed that, in reality, last near-surface displacement occurred long before Holocene time (Guptill and others, 1989; Freeman and others, 1992).

INVESTIGATIVE APPROACH AND METHODOLOGY

In order to demonstrate whether or not active (Holocene) faults extend across the NBR development area, our basic approach was to: 1) expose, by trenching, the generally continuous marine terrace deposits on the mesa across any possible fault trace, and 2) where actual or suspected offset strata are found, trace the offset beds up, or vertically, into the thick, argillic soil horizons where relative ages could be evaluated. This required placement of trenches on the mesa in areas of thick, natural soil development – areas free of significant colluvial deposits, man-made fill, or grading. In addition, a series of cone penetration soundings were performed in limited areas to investigate the possibility of determining fault age using Holocene sediment correlations.

A series of trenches was excavated by Earth Technology Corporation (ETC; 1986) across portions of the central and southern areas within the NBR development area (Plate 7 -- Geologic Map). However, their trench locations were widely separated and did not address the question of whether active faults may be present across the entire NBR development area.

Several long trenches or series of trenches (T-1 through T-14c, Plate 7) were excavated by Earth Consultants International (ECI; 1997) (see Appendix E for trench logs). Two ECI trenches (T-1 and T-2) were placed near the West Mesa fault. Based on review of ECI trench logs, their findings appeared to be reasonable with respect to the presence or absence of significant faults. In addition, our recent trenches exhumed portions of the ECI trenches (T-8b, T-9a, T-13, etc.)

and indicated a general agreement with field conditions. However, the ECI trenches did not extend across all potential fault trends and were restricted to the west-central portion of the NBR development area. Unfortunately, gaps remained between and around their trenches owing to the presence of pipelines, thick colluvium, and sensitive habitat areas. Also, many of the ECI trenches were positioned subparallel to, rather than perpendicular to, fault trends. Both previous fault studies, by ETC (1986) and ECI (1997), were limited in scope and areal extent. Large areas within the NBR development area, such as the northern, eastern, and extreme southern parts, remained uninvestigated. Accordingly, in this investigation, we used the ETC (1986) and ECI (1997) data where applicable, but greatly relied on the new, extensive trench exposures and detailed mapping of bluff-face outcrops.

Prior to trench excavation, a geologic map of the NBR development area was prepared on a topographic base provided by Fuscoe Engineering at a scale of 1"=200' feet, with 2- and 10-foot contour intervals. Stereographic pairs of vertical aerial photographs, used initially to assess photolineaments, were utilized to help identify geologic units, in particular, areas of deep fill and colluvium to avoid during trenching. Emphasis was placed on mapping continuous, unbroken strata exposed in natural and man-made cut slopes. Several areas were identified that required cleaning with a backhoe to extend exposures of unfaulted sediments. A special symbol was used on the geologic map to indicate the presence of continuous, unfaulted beds along these exposures (see Plate 7 -- Geologic Map).

Trenches were excavated in 1998 with a John Deere 710D tractor backhoe, using a 3-foot-wide bucket, to an average depth of approximately 10 feet (see Appendix A for trench logs). Long, continuous trench alignments were excavated in segments a few hundred feet in length with right-angle "T" trenches emplaced about every 100 feet for safety and for providing "three dimensional" exposures of terrace sediments and soils (i.e., TR-17A through TR-17D). The segments were parallel and overlapped to provide stratigraphic continuity.

All trenches were shored in accordance with CalOSHA guidelines. Prior to shoring, a few sections of the trench walls caved and required trench relocation. After shoring, the shady southern trench wall was scraped of smeared soil to expose a fresh surface. In most trenches it was necessary to scrape and clean only the lower portion of the trench wall where continuous, unfaulted strata were present. Coarser-grained deposits generally required less scraping. Once fully exposed, the key strata contacts, planar features, and any apparent offsets of deposits were carefully marked with colored flagged nails for recording purposes. A string level line was then established along the wall to be logged. Five-foot stations were marked on the trench wall with spray paint. Graphic trench logs were prepared at a scale of 1" = 5', with a few at 1"=10' by a Certified Engineering Geologist (CEG) who recorded the features, carefully measured from the level line and station numbers. Discrete, sharp contacts were generally recorded to an accuracy of about one-tenth of a foot. Trench walls were then photographed. At completion, Fuscoe Engineering surveyed the trench locations and key fault crossings.

To complement the previous trenches by ETC (1986) and ECI (1997) and "close off" any potential fault trends, we excavated between and extended many of their trenches. For example, Trenches TR-1 and TR-2 from this study were positioned where a concentration of faults was suspected in the north-central portion of the mesa (Plate 7 -- Geologic Map). Trenches TR-8a, TR-8b, TR-9, and TR-9a (Plate 7 -- Geologic Map) were emplaced to further assess a fault reported by ECI and fill-in between their trenches T-5a and T-11, respectively. Trench TR-15, in the south, was positioned to overlap a potentially active fault described by ECI in T-2, and extend the trench westward (Plate 7 -- Geologic Map).

In addition to trenching, a backhoe was used to better expose unfaulted strata along natural bluff and cut exposures at the north portion of the site: at ECI Trench T-5a, below TR-2, and below TR-12 and 12A. These broad, cut-face exposures significantly reduced the area that would have required trenching (Plate 7 -- Geologic Map).

Twenty-one CPT probes with two correlation borings were also performed in the recent alluvial deposits within the lowlands. The probes were roughly perpendicular to anticipated north- to northwest-trending faults. The location of these explorations are shown on Plate 7 -- Geologic Map.

FAULTING

Many faults in the site displace the San Pedro Formation and overlying marine terrace deposits. Almost all faults have remarkably similar characteristics; they trend between north 15 and 55 degrees west, dip steeply to the southwest, and have normal displacements of less than 2 feet down to the southwest. Horizontal component offset could not be determined, but was evident along most faults based on abrupt changes of bed thickness across the fault. Most faults do not displace the thick argillic soil horizons that have developed on the marine terrace deposits atop the mesa. There are no faults observed with northeast strike and very few faults with north strike.

As documented on the trench logs (Appendix E), apparent vertical displacements across most faults were less than 1 foot, with a few offsets measured at about 2 feet. However, a 7-foot-wide zone of faults, recorded in TR-2, was bounded by vertical faults with at least 5 feet of apparent vertical displacements (the height of the trench wall). Within this narrow zone, there was a web pattern of fracture-like, oxide-stained, cross-cutting features, each with fractions of an inch to a few inches of apparent offset.

Nearly all fault planes were sharp, fracture-like, thin and indistinct, with no trace of gouge, clay, or other infilling. Several faults displayed a "flowering upward" pattern, where a single fault trace at a depth of 8 to 12 feet below the natural ground surface "flowers" upward into a wide, branching set of multiple fault traces (TR-6b and TR-15), a feature suggesting recency of displacement.

The faults exposed in trenches, as well as those observed in outcrops, mainly occurred in concentrated zones, or bands, several feet to tens of feet wide. A few isolated, individual fault traces, however, were encountered throughout the site (i.e., in TR-3, TR-6A, and TR-20 and 20A). An excellent example of fault distribution and spacing can be seen in the 2400-foot-long alignment of trenches TR-15, TR-16, and TR-17A through D across the southern part of the site (Plate 7 -- Geologic Map). This series of continuous, overlapping excavations exposed five discrete zones of faults up to 200 feet in width separated by through-going, fault-free terrace deposits that were traced unbroken for 100 to 550 feet. These zones of multiple fault traces apparently do not continue along their trend more than a few hundred feet. For example, a myriad of fault traces exposed in the bluff face near ECI trenches T-3A and T-3B did not extend southeastward into trenches placed directly across their projections.

Several individual fault traces, however, could be traced for hundreds of feet along trend. A fault in TR-15 (Station 48) was traced along strike to TR-20, some 1000 feet to the northwest, although several en-echelon "step-overs" (i.e., parallel faults that are offset) apparently occur along the fault trace. Also, an individual fault at TR-6 was traced to TR-21, about 400 feet to the southeast, and may extend northwest through TR-1 -- a total distance of approximately 1800 feet. These individual fault traces displayed some evidence of offset of the ~80-200 Ka paleosols or younger units (Appendix E and F). Although not demonstrably shown to have Holocene surface rupture, these faults are conservatively treated herein as "active" by currently documented CGS definition.

The California State Mining & Geology Board (SMGB) is presently re-evaluating setback-zone and structural requirements appropriate to mitigate possible surface faulting. Based on evolving standards of practice, a Technical Advisory Committee for the SMGB is now proposing structural mitigation (usually strengthened foundations) for well characterized faults with less than ~4 inches vertical or ~12 inches of lateral displacement. These criteria would therefore encompass several "non-significant," on-site faults presently deemed to require setbacks. Thus, depending on the revised requirements, some presently recommended fault setback zones may ultimately be reduced, if not entirely eliminated. The new SMGB guidelines are anticipated to be formally adopted in late 2010.

Faults That Could Not Be Proved Inactive

Two fault segments were encountered that displayed evidence of offset of the ~80-200 Ka paleosols or younger units. One fault segment exists at the central part of the NBR development area, at Trenches TR-6a, 6b, and 6c, and the other exists at the southeast site corner, at TR-15 (Plate 7 -- Geologic Map). These segments comprise the Newport Mesa fault system and are deemed the "North" and the "South" segments, respectively.

It is important to note that these fault segments were not demonstrably shown to have Holocene surface rupture, and therefore are not demonstrably "active." However, these faults could not be proven to be pre-Holocene (i.e., "inactive") due to uncertainty in dating the latest fault rupture events. For conservatism, faults that could not be proved inactive, and which exhibited evidence for offset of the ~80-200 Ka paleosols or younger units, are treated herein as "active" with respect to recommendations for fault setback zones.

The Newport Mesa North Segment. At TR-6a, a single fault trace offset the base of the thick argillic (Bt) soil horizon 1 to 2 feet, down to the southwest. Subsequently, other trenches placed along trend nearby (TR-6b, 6c) confirmed displacements of up to 3 feet at the base of the Bt soil horizon. Further, the uppermost colluvial and eolian deposits (Appendix F), upon which an E horizon has formed, infills deep, V-notched erosion gullies into the Bt horizon, and may also slightly thicken to the southwest, potentially a result of early Holocene displacement. The fault was traced to the southeast and was intercepted by trenches TR-18 and TR-21, 220 and 350 feet, respectively, from the offset soils in TR-6c. However, trench TR-21 exposed unbroken Bt and E soil horizons over the fault trace (Appendix E). Northwest of Trench TR-6a, no soil horizons are present that would be suitable to constrain the age of faulting. For conservatism, however, the fault trace was projected to the northwest through a faulted cut exposure and into Quaternary faults exposed in TR-1 and TR-2, for a total length of approximately 1500 feet (Plate 7 -- Geologic Map).

The Newport Mesa South Segment. At trench TR-15, three faults that could not be proved inactive were exposed at Stations 0+48, 1+70, and 1+90 to 1+95 (Appendix E). Each fault trace "flowers" upward and downdrops the Bt and/or underlying soil horizons 1 to 2 feet. Similar to the fault in Trenches TR-6a through 6c, a "V"-notch is eroded into the top of the Bt soil horizon and is infilled with E-horizon fine sands at the upward projection of the faults. The same features were apparently encountered in ECI (1997) Trench T-2 a short distance to the southeast, but they do not continue on trend to TR-22. This zone of possible Holocene faults attenuated to only one fault trace through Tr-19, 270 feet to the northwest, and did not affect the Bt horizon in TR-20, placed about 900 feet from TR-15.

Trench TR-22 does, however, expose a possible active fault trending about N20-25W (Appendix E, Station 3+15). This fault may be the continuation of one of the possible active faults exposed northward in Trench TR-15. For conservatism, the trace of the possible active TR-22 fault is projected to the southern NBR development boundary (Plate 7 -- Geologic Map). In addition, for conservatism, a parallel fault located at Station 3+35 is also treated as active. In sum, the total length of the Newport Mesa south segment faults is less than about 1500 feet.

Gap in Newport Mesa Fault Segments. Although the Newport Mesa south segment faults appear to align with the possible faults in TR-6A to the north, their strikes of N20W, N27W, and N50W do not match the trend of the Newport Mesa north segment. The north and south segments therefore appear to be either different tectonic features or, more likely, the expression of right, en-echelon steps along a low-slip fault (Plate 7 -- Geologic Map). Within the gap area, fault traces were identified but were conclusively shown to be inactive (see trenches TR-20 and TR-21, Appendix E).

SUMMARY OF FAULT INVESTIGATION FINDINGS

Many splays of the NIFZ North Branch project into and were encountered in the NBR development area. Most are concentrated in discrete zones, but others occur as isolated traces. The faults are generally less than a few hundred feet long. Apparent vertical separation of ~200 ka (i.e., 200,000 years old) terrace sediments and soils is very low, usually less than about 7 feet. Additionally, they have very low recurrence intervals; in some cases, only one or two events within about the past 200 ka. The characteristics and style of faulting throughout the NBR development area are remarkably consistent. Nearly all individual fault traces trend northwest to southeast (North 20 to 50 degrees west), most dip steeply to the southwest and display normal displacements of less than 2 feet, down to the southwest. All appear as sharp, indistinct, fracture-like breaks with no gouge or infilling. All but two fault alignments are demonstrably pre-Holocene (i.e., "inactive") and do not affect pre-Holocene soil horizons and/or terrace deposits.

Within the NBR development area, two discrete fault segments of the NIFZ North Branch could not be proved inactive: (1) the Newport Mesa North Segment between about TR-18 on the south, to TR-1 and possibly beyond on the north; (2) and the Newport Mesa South Segment, well exposed in TR-15, TR-19, and TR-22 (Plate 7 -- Geologic Map). These segments are generally less than about 1800 feet long, and separated by an approximately 1300-foot-long interval of clearly unbroken late Pleistocene to early Holocene sediments and soils (Plate 7 -- Geologic Map).

Within the NBR development area, the possible activity of the Newport Mesa North and South Segment faults abruptly terminates, a phenomenon occurring elsewhere near major active, strike-slip faults (Shlemon and others, 1998). Comparable to the demonstrably pre-Holocene faults in the NBR development area, these segments have low apparent slip rates and low recurrence. Further, in contrast to frequent Holocene recurrence, and the relatively large vertical separation of North Branch splays that underlie a nearby Waste Treatment facility, the Newport Mesa North and South segments are relatively benign. Although they have no obvious geomorphic expression, trench data nevertheless indicate that the Newport Mesa North and South Segment faults may be active based on present State of California criteria. Accordingly, for purposes of safety and for conformance with State law, a structural setback is warranted.

GEOTECHNICAL INVESTIGATION AND FINDINGS

GEOTECHNICAL EXPLORATION SUMMARY

Previous Exploration by Others

Most of the previous geotechnical explorations were performed in the lowlands area of the site. Past exploration consists of two hollow stem auger borings and four CPT soundings by Woodward-Clyde in 1985, two hollow stem auger borings by Pacific Soils in 1993, along with six hollow stem and 10 CPT soundings by Leighton & Associates in 1997. Most borings exist outside the area of the planned development areas but serve to characterize the geotechnical properties of the flood plain or recent alluvial deposits. Previous geotechnical explorations on the mesa are the seven bucket auger borings drilled by Pacific Soils (1993).

Exploration by GMU Geotechnical

In addition to fault trenching, geotechnical exploration by GMU Geotechnical included nine bucket auger borings and six backhoe test pits. The bucket auger borings were spread out across the mesa and the backhoe test pits were placed in the arroyo bottoms. The borings on the mesa augmented previously placed borings by Pacific Soils and provided additional subsurface data to evaluate potential geotechnical constraints. The backhoe test pits were placed to preliminarily evaluate potential corrective grading removals in the minor arroyo bottoms.

LABORATORY TESTING

Geotechnical laboratory testing characterized the materials in the proposed development area. Atterberg limit, expansion index, and hydrometer tests were performed to determine soil index properties. Consolidation and hydro-collapse tests were performed to evaluate the potential for consolidation, and direct shear tests were performed to develop a strength model to analyze both existing natural slopes and proposed slopes. In addition, chemical testing and compaction testing were performed to further characterize the on-site soil and rock materials.

SUMMARY OF GEOTECHNICAL ENGINEERING ANALYSES AND FINDINGS

Slope Stability

To evaluate the stability of the bluff slopes, Cross Sections 4-4', 6-6', and 9-9' were selected for analysis since they are representative of general and worst-case conditions (i.e., highest and steepest slope) at the site. Given the lack of continuous and planar bedding within the San Pedro

Formation and terrace deposits, the stability analyses were performed using arcuate failure searches. Buoyant conditions representative of soils below groundwater were modeled below an elevation of 0 feet. Stability analyses were also performed for a typical fill slope up to 65 feet high.

Shear Strength Model. Based on variability of the terrace deposits and the underlying San Pedro Formation sediments, as well as their lithologic similarities, we developed a strength model that used a single average ultimate design strength for static conditions and a single peak design strength for pseudo-static conditions (see Appendix C). Shear strength test data used to derive the shear strength parameters used in our analyses are included in Appendix B. The shear strength data is also summarized in Appendix C. Strengths were determined under saturated conditions.

Static Analyses. The static stability analyses indicated that the slopes in their current condition possess static safety factors in excess of 1.5 against rotational failure (see Appendix C). The bluff slopes therefore meet the County of Orange static stability requirements.

Pseudo-Static Analyses. To address slope stability under dynamic conditions (i.e., conditions during a seismic event), we performed pseudo-static slope stability analysis on each cross section. The analyses utilized a seismic coefficient of .15g (i.e., the minimum coefficient required by the County of Orange). In addition, potentially liquefiable alluvial soils near the toe of the bluffs were conservatively assumed to have "zero" strength in the pseudo-static analyses. The results, also summarized in Appendix C, indicate that safety factors for deep-seated dynamic stability are in excess of 1.1. The bluff slopes therefore meet the County of Orange dynamic stability requirements.

We also performed a parametric pseudo-static slope stability analysis for Cross Section 6-6'. This analysis indicates that the pseudo-static safety factor approaches unity (i.e., 1.0) with a ground acceleration of .51g. This suggests that only accelerations above .51g would contribute to the mobilization of significant deep-seated slope movements. The probabilistic seismic hazard analysis contained herein indicates that the peak ground acceleration (PGA) corresponding to a 10 percent probability of exceedance in 50 years (i.e., a 475 year return period) is 0.37g, and the PGA for 5 percent probability of exceedance in 50 years (i.e., a 975 year return period) is 0.50g. Given this, the potential for deep seated slope failure during a seismic event is considered low.

Stability Discussion. The stability results also show that the lowest safety factors were obtained for shallow rotational failures near the face of the bluff slope. This result is consistent with observations of past and recent shallow slumps that have most likely occurred on bluff slope faces due to uncontrolled runoff and resulting over-saturation of the bluff slope face and possibly past seismic shaking. Thus, although the bluff slopes possess an adequate safety factor against gross failure for wet conditions, saturation and resulting pore pressures at the bluff face along with strong seismic shaking may lead to additional shallow slumping. In addition, continued natural weathering of the bluff face will serve to reduce soil strength which will also increase the potential for shallow slumping. However, improved drainage conditions from the proposed development will reduce the potential for bluff face material saturation to occur and thus will serve to reduce but not eliminate the shallow slumping potential from present conditions.

Because the proposed cut slopes are flatter than the existing bluff slopes, all cut slopes are anticipated to be grossly stable. However, where cut slopes expose San Pedro Formation sediments, local warping may yield local wedge conditions where bedding is daylighted. This will require corrective grading.

To evaluate proposed fill slopes on the project, a 65-foot high 2:1 fill slope was analyzed using the remolded fill strengths outlined in Appendix C. A surficial stability analysis is also included in Appendix C. The fill slope analyses indicate that fill slopes up to 65+ feet high will be grossly and surficially stable under static and pseudo-static conditions. Furthermore, fill slopes that are less than 65 feet high will also be grossly and surficially stable.

Liquefaction

The only on-site soils subject to liquefaction are recent alluvial deposits in the lowland area (see Plate 7 -- Geologic Map). The San Pedro Formation bedrock and overlying terrace are either too dense and/or above the water table. Colluvial deposits, where saturated, may be locally subject to liquefaction. However, these materials, where present in development areas, will be removed down to competent terrace or San Pedro Formation materials.

Leighton and Associates, Inc. (L&A - 1997) performed a detailed liquefaction analysis for a previously proposed school building site in the lowland alluvial area. This analysis is considered approximately representative of conditions throughout the lowlands (Plate 1). Using an earthquake magnitude of 7.1 and a peak site acceleration of 0.46g, which corresponds to a 949-year return period or a 10 percent probability of exceedance in 100 years (i.e., required conditions for a school site), L&A concluded that: 1) local soil zones within the alluvium are subject to liquefaction and seismic settlement, 2) related deformations due to seismic settlement and/or lateral spreading will be low, and 3) the magnitude of settlements would be in the range of 1 to 6 inches. Utilization of a smaller peak ground acceleration, consistent with residential development (i.e., 475 year return period or 10 percent probability of exceedance in 50 years), will yield seismic settlement magnitude values slightly less than those estimated by L&A.

Based on the current land use plan (Plate 2.1), proposed residential development is located on the mesa above the lowlands area that is susceptible to liquefaction. Consequently, liquefaction remediation in these areas will not be required from a building code perspective (i.e., life safety) and most likely will not be economically justified. GMU should review the final grading plan to be used, along with the final site plan, to assess liquefaction potential in the vicinity of planned structural improvements. If liquefaction remediation is deemed necessary, the type of remediation will depend on the local soil conditions, the planned grades, and the type and extent of corrective grading. If, after detailed site-specific analysis of the proposed conditions, remediation is required, options are anticipated to include "Stone Columns", and/or "Compaction Grouting." Compaction grouting will serve to densify the underlying sandy soils subject to liquefaction thus reducing the potential for liquefaction and reducing the seismic settlement potential. Stone columns would serve to densify the soil, reduce the potential for the build-up of excess pore pressures during a seismic event, and provide vertical support should adverse seismic settlements occur. The vertical extent of the stone columns and/or compaction grouting may need to extend to a depth of liquefiable materials (i.e., approximately 30 feet).

Compressible and Collapsible Soils

Generally, from a soil compressibility standpoint, the soils on the mesa can be broken down into four categories: 1) recent alluvial deposits, 2) existing artificial fills, 3) colluvial soils, and 4) terrace deposits.

The recent alluvial deposits contain zones of highly compressible materials in the upper 15 feet. The zones appear to range between approximately 1 foot to approximately 5 feet in thickness depending on location. These materials will undergo significant time-related settlements upon loading. L&A (1997) estimated that a 10-foot fill surcharge in an area within the lowlands (Plate 1) would induce settlements of up to about 8 inches and take over one year to complete. As previously discussed, the current development plan (Plate 2.1) does not include structural development within the lowlands area where the recent alluvial deposits are most common; these areas are currently planned for open space and trails. However, remediation options will need to be considered if future structural improvements are planned over top of recent alluvial deposits within the lowlands area.

In this regard, remediation options would most likely be required to limit both the time for settlement as well as the settlement magnitude. Remediation options would include: 1) surcharge fills, 2) soil mixing, and 3) stone columns. Surcharge fills involve the placement of a fill surcharge greater than the height of the planned fill which will serve to reduce the time for settlement. Soil mixing consists of mixing soils insitu with additives (i.e., usually cement or lime) to strengthen the soft soils and thus reduce the magnitude of consolidation. The use of lime columns will also serve to increase the permeability of the soil and thus will aid in reducing the time required for settlement. Stone columns can also be used in fine-grained soils utilizing a technique called "vibro-replacement". This method may be especially suited for areas where both liquefaction mitigation as well as compressible soil mitigation are necessary. In this regard, stone columns placed in granular soils to mitigate liquefaction can be extended to the surface to improve the compressibility characteristics of the overlying soft soils. Final remediation design will depend on a myriad of variables such as the planned grade elevations, construction timing requirements, etc., and will require detailed area specific analysis and design when final grading plans are developed.

Due to the fact that the existing artificial fills are either stockpile fills or unengineered, they should be considered as potentially highly compressible.

The colluvial soils are present at the base of the mesa slopes and in ravines and arroyos. The colluvial soils are essentially a combination of slope wash and talus deposits. Where observed in the fault trenches, the colluvial soils were locally porous and soft. Consequently, the colluvial soils should be considered as moderately to highly compressible.

The terrace deposits contain an upper soil zone that ranges from a few feet in thickness to over 10 feet in thickness. Based on consolidation testing, these materials should be considered to possess a low to moderate consolidation potential.

Collapsible soils are defined as soils that undergo a significant reduction in volume when inundated with water. This phenomena is commonly referred to as "hydro-collapse." The recent alluvial sediments in the lowland area are not susceptible to hydro-collapse due to the high water table and the fact that the area has been flooded or under water numerous times in recent geologic times. Based on geotechnical laboratory testing, the terrace deposits and underlying San Pedro Formation sediments posses a low potential for hydro-collapse. However, upper sections of the terrace deposits are locally porous and thus may be subject to adverse hydro-collapse deleting settlements that may necessitate locally deeper corrective grading removals. Additional mitigation of hydro-collapse can be achieved by reducing deep infiltration via design of positive surface drainage, subdrains below bioswales, etc. Based on limited test data, the colluvial soils appear to also possess a low potential for hydro-collapse, but based on their depositional characteristics should be considered as locally subject to moderate levels of hydro-collapse.

Expansive Soils

To evaluate the expansion potential of on-site materials that will most likely influence proposed structures, several expansion index (EI) tests were performed. The results indicate that on-site soils possess a low to medium expansive potential. These results are also supported by plasticity data which indicates low plasticity.

Corrosion Potential

To characterize the on-site soil corrosion potential, several suites of corrosion tests were performed. The test suite consisted of pH, soluble sulfates, soluble chlorides, and minimum resistivity. Soluble sulfate concentrations are used to determine the potential for sulfate attack to concrete while the pH, chloride concentration, and minimum resistivity results are used to evaluate the potential for ferrous metal corrosion.

The sulfate concentrations indicate that although the terrace deposits in general possess negligible levels of sulphate, moderate levels may exist in various soils throughout the site. Minimum resistivity and chloride contents indicate that the on-site soils should be considered as severely corrosive to ferrous metals. The potential for ferrous metal corrosion is also exhibited by corrosion of buried pipelines.

Excavation Characteristics

Rippability. The surficial soil materials underlying the site can be excavated with scrapers and other conventional grading equipment.

Trenching. We expect that excavation of utility trenches can be accomplished utilizing conventional trenching machines and backhoes. Trench support requirements will be limited to those required by safety laws or other locations where trench slopes will need to be flattened or supported by shoring designed to suit the specific conditions exposed.

Volume Change. Our estimate as to the change in volume of on-site materials excavated and placed as compacted fill at an average relative compaction of 92% is as follows:

Upper 5 feet terrace deposits/soils
above terrace deposits ....assume about 0-5% loss
Colluvium ....assume about 5-10% loss
Alluvium ....assume about 15-20% loss
Artificial fills...assume about 10-30% loss

It should be noted that although the above values are approximate, they represent our best estimate of lost yardage which would likely occur during grading.

CONCLUSIONS

1. Based on geotechnical fault studies which have been completed to date, it is our opinion that it is geotechnically feasible to accomplish the proposed development as presently

planned, provided that the recommendations presented in subsequent sections of this report are followed.

2. The main geotechnical constraints for the project are: 1) fault setback, 2) bluff slope repair and setback, 3) compressible soils, and 4) overall site seismicity. Preliminary recommendations for the mitigation of these constraints are contained in the following sections of this report.

RECOMMENDATIONS

FAULT SETBACK

The State of California requires that a setback for habitable structures must encompass active (Holocene) faults (Hart, 1999). Of the various NIFZ North Branch splays encountered in the NBR development area, only two relatively short segments, the Newport Mesa North and the Newport Mesa South, could not be proved inactive (Plate 7 -- Geologic Map) and thus are conservatively treated herein as active faults. Note that the Newport Mesa North and South Segments were not demonstrably shown to be active.

The width of a fault setback zone is usually variable, depending on the width and geometry of individual faults, the number and spacing of outcrops and trenches for control, and the relative uncertainty of fault projection. In the absence of trenches or outcrops, a 50-foot-wide zone, on either side of a fault or its geomorphic expression, is normally established. The Newport Mesa fault segments, however, are of such low recurrence and separation that no geomorphic expression is apparent. Accordingly, for general planning, a conservative, variable width is provided, one that ranges from about 40 feet where the North Segment is constrained by outcrops and trench exposures (near TR-11), to over 100 feet where projections of the South Segment are unconstrained by exposures south of TR-22 and TR-23 (Plates 9, 9.1, and 9.2).

Additional conservatism is provided by extending the setback zones well beyond the southern and northern termini of the North and South segments, respectively. Specifically, the potentially "active" fault in TR-18 (North Segment) does not extend to TR-21 (Plate 7). Nevertheless, the recommended setback zone almost reaches TR-21, rather than ending midway between the two trenches (Plate 9.1 -- Fault Setback Zone, Newport Mesa North Segment). Similarly, the fault setback zone at TR-19 is extended fully almost 500 feet northward toward TR-20, where a demonstrably unbroken pre-Holocene stratigraphy precludes reasonable northward extension of the South Segment (Plate 9.2 -- Fault Setback Zone, Newport Mesa South Segment). Because of the conservative interpretation of trench data and resulting setback geometry discussed above, if additional trenches were performed, the length and width of the presently recommended setback zones could likely be reduced.

The "gap" in fault setback zones for the Newport Mesa North Segment and South Segment is based on trench exposures at TR-20 and TR-21, which conclusively indicate fault inactivity. In order to verify the absence of active faulting within the gap area, an additional fault trench is recommended about 400 feet northwest of TR-20. If no active faulting is observed in the additional trench, then the fault setback zones will not need to be extended further into the gap area. If active faulting is discovered in the additional trench, then the fault setback zones will need to be modified appropriately.

BLUFF SLOPE REPAIR AND SETBACK

Natural bluff areas will remain at various locations throughout the site (see Plate 2.1 – Land Use Plan). Given the high erosion potential of sediments comprising the bluff slope face and that shallow slumping will locally continue to occur on the bluff slope faces following development, a development setback from the top of slope along with local bluff erosion repair/improvement will be required.

Several areas of the bluff edge have suffered from erosion, resulting in incised gullies and ravines. The project proposes to restore some portions of the eroded bluff slope using careful grading techniques. The bluff restoration can be achieved by one of two methods depending on the size of the erosion gully. Large gullies can be repaired by filling the erosion gully and creating a manufactured slope face that ties in with the natural bluff face. The slope gradient of the manufactured slope should match the existing bluff face. In cases where the existing slope face is steeper than 2:1, slope reinforcement will be required such as geogrids or geo-fabrics. Small gullies may require more small-scale grading methods, including hand labor, in order to restore the natural slope. In addition to the grading, drainage that flows toward the bluff edge will be intercepted at the trail system and redirected. The grading and drainage improvements, combined with the installation of carefully chosen native landscape materials, will help to reduce future erosion of the bluffs.

The existing slopes along the southern site boundary adjacent to West Coast Highway contain one recent erosional gully and one large erosional ravine. The recent relatively shallow erosional gully should be repaired via standard grading methods. Given the gentle side slopes of the erosional ravine along West Coast Highway and the thick vegetative cover, the employment of a development setback should be sufficient to protect proposed structures.

Following bluff repairs and improvements, a development setback from the top of the mesa slope is recommended. In the natural slope areas, a setback for private property and infrastructure (i.e., roads and utilities, etc.) is recommended to be 50 feet from the top of the bluff where the top of the bluff is defined as the point at which the bluff face slope flattens to a gradient of 5:1 (11.3 degrees) or flatter. This requirement meets or exceeds the City of Newport Beach bluff setback requirements contained in the City of Newport Beach's General Plan. Structures and grading within the 50-foot setback zone should be limited to trails, lighting, and minor grading for surface drainage control. Planting within the setback area should be restricted to a plant palette such that permanent irrigation is not required. In addition, a minimum building setback for habitable structures of 10 feet from the development setback (i.e., 60 feet from the top of slope) is also recommended.

In the erosion gully/ravine repair areas where engineered fill slopes are created, no specific setback is required so long as the constructed fill slope is properly vegetated and maintained. If vegetation adequate to minimize significant erosion is restricted from being utilized, a 25-foot development setback is recommended. As with the setback in natural areas, the development setback should apply to private property and infrastructure. No specific building setback other than those contained in the County Code will be necessary.

SITE PREPARATION AND GRADING

General

All site preparation and grading should be performed in accordance with the County of Orange and the City of Newport Beach grading code requirements along with the recommendations presented in this report.

Clearing

All significant organic material such as weeds, brush, tree branches, roots, construction debris, and any other decomposable materials should be removed from areas to be graded.

Processing

Once remedial removals are completed where recommended by the project geotechnical consultant, the upper 6 inches of the excavated native soil should be scarified, moisture conditioned, and compacted to at least 90% relative compaction.

Corrective Grading

The need for corrective grading, i.e., removal of existing soil and rock materials from areas to receive fill or where exposed at future design grade in cut areas, should be anticipated as follows:

(a) Existing Non-Engineered Fills: All existing non-engineered fills present on the site should be removed. All trash debris or excessive amounts of organic material should be disposed of offsite. Rock and/or concrete materials of less than 12 inches in maximum diameter may be placed as compacted fill. Based on observations in fault trenches, fills can range in thickness from a few feet to over 20 feet in thickness. Due to the past use of the site as an oil production facility, occurrences of artificial fill are scattered throughout the site.

(b) Colluvial Soils: Colluvial soils contained in swales, ravines, and arroyos should be removed down to competent terrace deposits or San Pedro Formation sediments where fill is to be placed or where remaining in shallow cuts. The thickness of the materials is anticipated to range from a few feet to over 25 feet in thickness.

(c) Recent Alluvial Soils: The recent alluvial deposits will require, as a minimum, remedial removals down to a few feet above the groundwater table. Anticipated removals will range from approximately 4 to 6 feet. Excessive amounts of organic materials or soils should not be incorporated into the fills. Once the removals are completed, additional remediation options (i.e., fill surcharging, etc.) may be necessary depending on the exact location and use of planned development areas.

(d) Terrace Deposits: The upper 3 to 5 feet of the soil horizon along with any locally compressible and/or porous zones within the terrace deposits should be removed and recompacted to provide uniform bearing conditions for proposed structures. Locally deeper removal zones may extend to depths of 5 to 10 feet.

(e) Toe Keys and Fill Support Benches: Keyways or benches should be excavated through any topsoil material, colluvium, and alluvium wherever the toe of a fill slope is located at a natural ground surface having a gradient of 6 horizontal to 1 vertical, or steeper, or in flatter areas where recommended by the geotechnical consultant. Keyway construction and benching should be in general conformance with Plate 10 -- Typical Benching and Keyway. The actual extent of such keyway grading will need to be determined based on actual grading plans and field conditions exposed during grading.

(f) Stabilization Fills: Given that existing terrace deposits and the San Pedro Formation sediments have zones of cohesionless sands, along with the fact that the San Pedro Formation sediments may contain locally daylighted bedding, all cut slopes should be buttressed with a stabilization fill. Stabilization fills should be constructed in general conformance with Plate 11 -- Typical Buttress or Stabilization Fill.

(g) Bluff Slope Erosion Repair: Corrective grading in the area of the large erosion bluff repairs will consist of the removal of all recent slough, talus, and colluvial deposits down to firm in-place San Pedro Formation sediments prior to placement of engineered fill and construction of the fill slope. Grading should be performed in general conformance with Plate 11 -- Typical Buttress or Stabilization Fill.

Grading Observations

During grading observations, full-time geotechnical and environmental observations should be performed so that a diligent search can be made for all non-engineered fills, oil wells, sumps, pipelines, etc. Full-time observations are necessary to provide reasonable assurance that all oil facility structures have been properly mitigated (i.e., as per the 1996 GeoSyntec Environmental Restoration Program) and so that corrective grading can be extended down to appropriate depths.

Offsite Retaining Wall (Hilfiker Wall) Considerations

Where grading is planned adjacent offsite retaining walls (i.e., Hilfiker type mechanically stabilized earth walls adjacent to the northern portion of the eastern property line), the grading limits should be set back sufficiently from the walls so as to not add any surcharge and/or reduce support for the soils supporting the wall system. As an alternative, fill may be considered to be placed adjacent to the walls to reduce the overall wall height and add additional support. Based on the results of borings drilled near the base of the walls, geologic mapping and review of available offsite geotechnical reports, it appears that the walls are founded on dense terrace deposits. Consequently, the surcharge of additional fill will most likely result in tolerable settlements. However, the following items will need to be completed prior to this option being utilized: 1) the wall design plans will need to be made available, 2) the condition of the walls and supporting structures must be reviewed and evaluated, 3) a pre-construction survey will need to be performed, and 4) the wall and supporting structures will need to be monitored during grading operations.

Over-Excavation for Transition Lots

The cut portion of proposed lots or building pads that occur across cut-fill transitions will need to be over-excavated to provide a more uniform bearing condition. For planning purposes, over-excavation should be completed in general accordance with Plate 12 -- Typical Detail -- Over-excavation of Transition Lots.

FILL MATERIAL AND PLACEMENT

Suitability

All on-site soils should be suitable for use as compacted fill if: 1) care is taken to remove all significant organic and other decomposable debris, 2) rock materials larger than 12 inches in maximum diameter are separated and stockpiled, and 3) soils contaminated with crude oil are bio-remediated. Testing for environmental suitability of soil should be performed by a qualified environmental consultant prior to the use of such soils in engineered fills.

Compaction Standard and Methodology

All soil material used as compacted fill or material processed in-place or used to backfill trenches, should be moistened, dried or blended as necessary to achieve a minimum of 2% over optimum moisture content for compaction, and densified to at least 90% relative compaction as determined by ASTM Test Method 1557.

Fill Slope Compaction

Fill slopes should be carefully constructed and backrolled during grading to obtain the specified degree of compaction. These slopes should be either overfilled and trimmed back to expose firm, dense fill or, after "backrolling" during placement, compacted to the specified density by using cable-lowered sheepsfoot and grid rollers. "Track walking" is not a recommended means of finishing and compacting fill slope surfaces.

Use of Oversize Rock or Broken Concrete

A limited amount of concrete or rock materials greater than 12 inches in diameter may be placed within larger deeper fills (i.e., within the minor arroyos) if placed in accordance with the following procedures and as illustrated in Plate 13 -- Recommended Placement Method for Oversize Rock or Concrete.

a. Rock of 12 inches or more in diameter should be placed in rows at least 15 feet apart, 15 feet from the edge of the fill, and 10 feet or more below roadway subgrade. Spaces should be left between each rock fragment to provide for placement and compaction of soil around the fragments.

b. Fill materials consisting of soil at slightly above optimum moisture content and free of oversize material should be placed between and over the rows of rock or concrete. Ample water and compactive effort should be applied to the fill materials as they are placed in order that all of the voids between each of the fragments are filled and compacted to the specified density.

c. Subsequent rows of rock should be placed such that they are not directly above a row placed in the previous lift of fill.

d. Fragments of hard rock should not be used where they will obstruct excavation of storm drains, utility trenches, or other planned or future underground improvements.

Use of Bio-Remediated and Asphalt-like Soils

From a geotechnical perspective, petroleum-contaminated soils that have been bio-remediated and asphalt-like materials may used in compacted engineered fills. However, the suitability and placement location of these materials is beyond the scope of our purview. All environmental regulations concerning the use of these soils beneath habitable structures should be followed. Significant restrictions from a geotechnical engineering standpoint are not anticipated.

SUBDRAINS

General

The construction of subdrains is recommended where free moisture is encountered during corrective grading or as a precautionary measure wherever the presence of future subsurface moisture would be likely to create possible problems with respect to slope stability or saturation of subgrade soils.

Arroyo/Ravine Bottom Areas

Subdrains should be constructed in the bottom of all ravines/arroyos in which fills will be placed. These subdrains should consist of 6-inch-diameter perforated plastic pipe installed in a 3-foot-wide by 3-foot-deep trench. The pipe should be bedded and the trench backfilled using at least 9 cubic feet of permeable filter materials per lineal foot of pipe. The recommended configuration of the subdrain and the specification for the pipe and the filter material are illustrated by Plate 14 -- Typical Canyon Bottom Detail.

Keyway Backdrains and Outlets

Subdrains should be constructed at the rear of stabilization fills and in keyways for the support of sidehill fills. These drains should consist of 4-inch-diameter perforated plastic pipe embedded in 4 cubic feet of filter material per lineal foot of pipe installed in a "V" cut or shallow backhoe trench at the rear of the keyway for the stabilization or sidehill fill. The collector drains should have a minimum gradient of two percent toward the outlet pipe locations. The outlet pipe should consist of non-perforated plastic pipe connected with a "T" to the collector pipe and installed in shallow, narrow trenches excavated through the fill and sloping at a minimum gradient of two percent toward the toe-of-slopes. The outlets should be constructed at intervals of about 200 feet and at each end of the collector system. Subdrain pipe and filter materials should meet County of Orange and City of Newport Beach standards. The standards and details illustrating the configuration of the backdrains are shown on Plate 15 -- Typical Backdrain Type Subdrain.

Dewatering Sumps

Dewatering sumps consisting of 8-inch-diameter perforated or slotted plastic pipe embedded in at least 12 cubic feet of Class 2 permeable filter material should be constructed at the downstream end of keyways or other removal areas where the presence of free moisture requires dewatering prior to and during the placement of fill and daylighting of subdrains is not possible. The subdrain systems should be outletted into these sumps using "T" or "Y" fittings. A submersible pump should be used as necessary to discharge free moisture collected in the sump until such time that the level of the keyway backfill is above the elevation of significant groundwater seepage into the excavation. A generalized sketch illustrating the configuration of the recommended sump is presented as Plate 16 -- Typical Dewatering Sump.

BIOSWALES AND PERMEABLE PAVEMENT

The project design is anticipated to include water quality features such as bioswales, permeable pavement, and other improvements for treatment of runoff through soil-based infiltration processes. Infiltration within the uppermost soils (i.e., ~5 feet below finish grade) is acceptable from a geotechnical perspective, but deep infiltration should be minimized in order to prevent deep saturation of the underlying terrace deposits and San Pedro Formation. Deep saturation can be reduced by installing subdrains below areas of significant infiltration, such as bioswales and permeable pavement. This will allow treated water to be captured and conveyed prior to deep infiltration.

PRELIMINARY SEISMIC DESIGN AND FOUNDATION CONSIDERATIONS

Residential and Commercial Structures

Seismic Design. The site will likely be subject to seismic shaking at some time in the future. Site-specific seismic design parameters were determined using the USGS computer program title "Seismic Hazard Curves and Uniform Hazard Response Spectra, Version 5.1.0." Seismic design of on-site structures (excluding schools and bridges) should be in accordance with the following 2010 CBC criteria:

Parameter	Factor	Value
0.2s Period Spectral Response	S_S	1.81g
1.0s Period Spectral Response	S_1	0.68g
Soil Profile Type	Site Class	D
Site Coefficient	F_a	1.00g
Site Coefficient	F_v	1.50g
Adjusted Spectral Response	SM_S	1.81g
	SM_1	1.02g
Adjusted Spectral Response	SD_S	1.21g
	SD_1	0.68g

Foundation Type. Based on the overall high seismicity of the site along with a potential for medium expansive conditions, the use of standard slab-on-grade foundation systems is not recommended. Foundation systems should consist of some type of rationally designed stiffened foundation system capable of acting as a unit during a seismic event and to resist the effects of expansive soils. Examples of suitable systems would include post-tensioned foundation systems, mat foundations, etc.

Pedestrian Bridge

Seismic Design. For design of a potential pedestrian bridge for the NBR project, ground motions at the site were evaluated in accordance with current Caltrans procedures. The Caltrans-based analysis evaluated ground motions at the site using Caltrans ARS Online Version 1.0.4 (http://dap3.dot.ca.gov/shake_stable/index.php). Caltrans ARS Online is a web-based program that calculates deterministic and probabilistic acceleration response spectra based on Appendix B of Caltrans Seismic Design Criteria. Given site coordinates, the ARS Online program generates deterministic spectra for nearby fault sources and a probabilistic spectrum based on the 2008 USGS National Hazard Map for 5% probability of exceedence in 50 years (i.e., 975 year return period). The design ARS curve is then taken as the upper envelope of the deterministic and probabilistic response spectra. The program also accounts for soil type and near source adjustments to the ARS curves.

For the NBR project, site coordinates used in the analysis were 33.6327° North Latitude and 117.9439° West Longitude. Consistent with the PSHA described above, the site is categorized as Soil Profile Type D. This corresponds to an average shear wave velocity of 275 meters/second. Based on these parameters, the Caltrans ARS Online program calculates ARS curves for the deterministic and probabilistic response spectra. The calculated ARS curves and site data are included in Appendix D. At short periods (i.e., <0.8 sec), the deterministic response spectrum for the San Joaquin Hills blind thrust is the controlling curve, indicating a PGA of 0.60g. At longer periods (i.e., >0.8 sec), the deterministic response spectrum for the Newport-Inglewood fault zone is the controlling curve.

<u>Foundation Considerations</u>. We anticipate that a potential pedestrian bridge could span West Coast Highway. This location would place at least a portion of the bridge overtop potentially liquefiable soils. If the pedestrian bridge is pursued as a project feature, additional geotechnical studies and analyses will be needed to evaluate the subsurface conditions at each bridge abutment. For preliminary purposes, it should be anticipated that bridge abutments will need to be pile supported.

SLOPE LANDSCAPING

Plans for landscaping and irrigation of both natural and graded slopes should be prepared by a qualified landscape architect experienced in utilizing plant materials for long-term reduction of slope erosion hazards.

The use of plant materials requiring the minimum of cultivation and irrigation is recommended. Irrigation of graded slopes must be carefully controlled to prevent saturation of the compacted fill or in-place native soil or rock materials forming the slopes. Any irrigation system should consist of above-ground piping to avoid the need for trenching and disturbance to the slope surfaces.

Planting of the natural slope areas should also be performed with minimum disturbance to the natural topsoil materials present on the slopes. Plant materials should be used which will require minimum irrigation to be come established and no irrigation thereafter. Slope landscaping for graded slopes should be initiated as soon as possible following slope construction.

SURFACE DRAINAGE

Due to the highly erosive nature of both the on-site soil materials and bluff slopes, it is critical that surface drainage be designed to prevent ponding adjacent to, and runoff onto, any graded or natural slopes. Areas within the bluff slope setback zone should contain drainage devices to minimize the surface flow over the bluff slopes. In addition, it is recommended that surface drainage and bluff slope erosion mitigation schemes be undertaken in areas where bluff slopes are to remain natural. This should be undertaken as soon as practical to minimize additional damage prior to development.

PLAN REVIEW AND FUTURE REPORTS

The following additional geotechnical tasks to develop final geotechnical design recommendations are anticipated:

- Consultation during grading plan development.
- Review of rough grading plans.
- Geotechnical exploration, testing, and analysis as necessary to address specific aspects of the rough grading plan.

A rough grading plan review report will be needed. This report will include: 1) detailed geotechnical analysis of the planned grading, and 2) any needed corrective grading recommendations to accomplish the planned grading.

LIMITATIONS

All parties reviewing or utilizing this report should recognize that: 1) it is an EIR level study and does not contain details normally associated with a rough grading plan review, 2) this study integrates and utilizes geotechnical exploration data performed by others, and 3) the findings, conclusions and recommendations presented represent the results of our professional geological and geotechnical engineering efforts and judgements. Due to the inexact nature of the state of the art of the geotechnical engineering and geological professions and the possible occurrence of undetected variables in subsurface conditions, we cannot guarantee that there are no unknown subsurface conditions which could have an adverse effect on the use of the property. We believe, however, that we have exercised a degree of care comparable to that presently maintained by other professionals in the fields of geotechnical engineering and engineering geology and have performed sufficient observation and testing to provide a rational basis for our opinion that the proposed project is feasible.

Because our conclusions and recommendations are based on a limited amount of current and previous geotechnical exploration performed by others, all parties should recognize the need for possible revisions to our conclusions and recommendations based upon future geotechnical studies and/or observations during grading of the project. The scope of our study included geotechnical engineering and engineering geological aspects only and specifically did not include testing or analysis pertaining to the presence of toxic or hazardous waste materials.

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SUPPORTING DATA

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

Respectfully submitted,

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Air Photos

Fairchild Collection, Whittier College

Date	Flight No.	Frame No.	Scale
1927	C-113	763,764	1"≈1500'
1928	C-278	#2 B:8, B:9	1"≈2000'
5/22/31	C-1590	34,35	1"≈1500'
3/4/38	C-5029	47,48	1"≈2640'

Earth Graphics

Date	Flight No.	Frame No.	Scale
6/10/93	93-125	1 to 9, 11 to 13	1"≈500'

Maps

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Report of Geotechnical Studies
Proposed Newport Banning Ranch Development
City of Newport Beach/County of Orange
Volume 1

Volume 1

Report of Geotechnical Studies

Proposed Newport Banning Ranch Development

City of Newport Beach/County of Orange

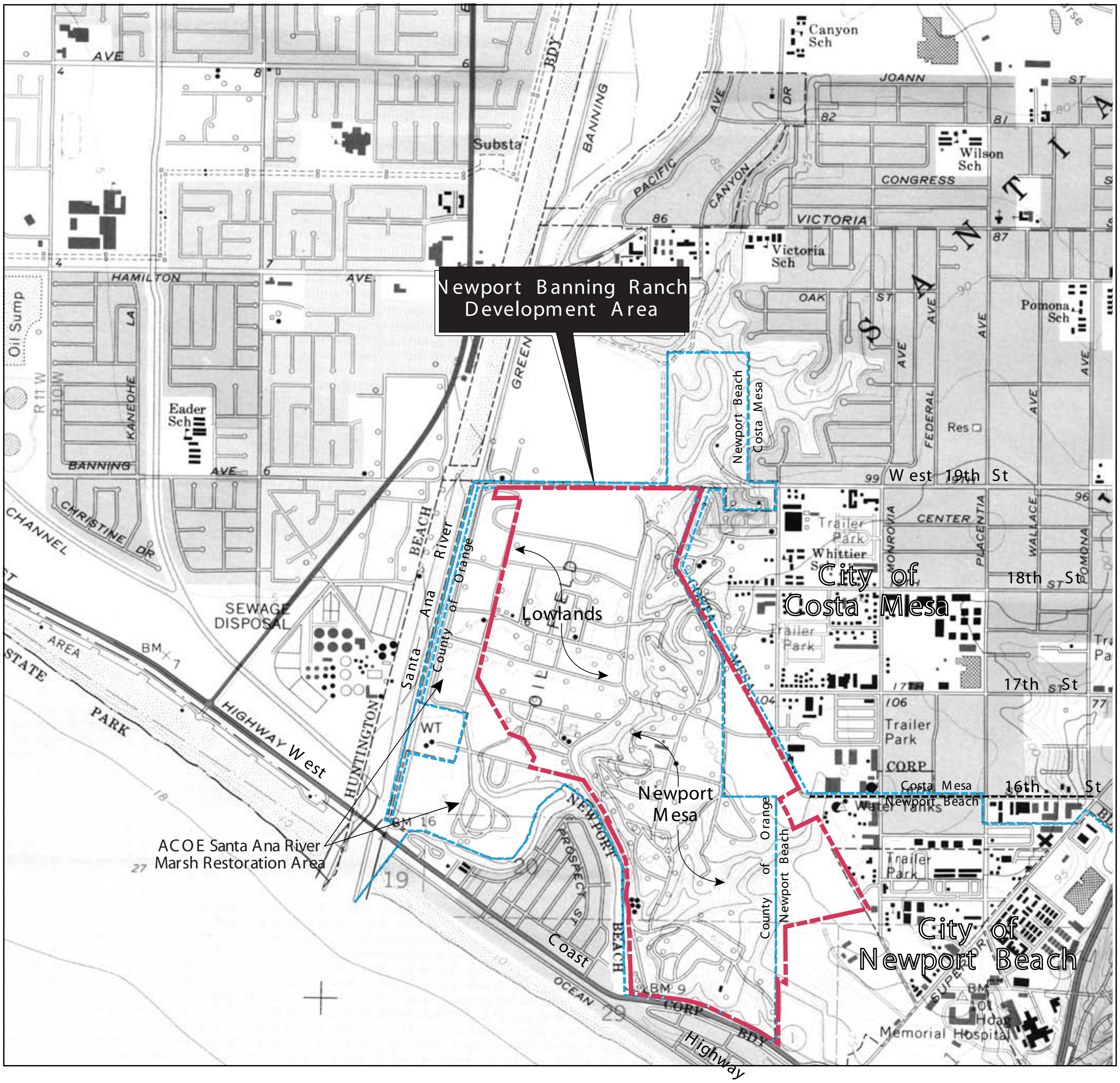
Plates 1 - 8.8

Prepared for:

Newport Banning Ranch LLC

Prepared By:

GMU Geotechnical, Inc.
July 2011



NOTES:
1) The Base Map is a Computer Scanned Image from USGS 7.5 Minute Newport Beach, California Topographic Quadrangle, 1965, Photorevised 1972.
2) All Locations and Dimensions are Approximate.

0 1000 2000 3000

Approximate Graphic Scale:
One Inch Equals 2000 Feet

North

GMU GEOTECHNICAL, INC.

LOCATION MAP			PLATE 1
Project Name: Newport Banning Ranch	Project No: 06-163-00	Date: July 2011	

GMU GEOTECHNICAL, INC.	LAND USE PLAN			PLATE
	Project Name: Newport Banning Ranch	Project No: 06-163-00	Date: July 2011	2.1

LAND USE DISTRICT	SITE PLANNING AREA No.	SITE PLANNING AREA Description	GROSS ACRES [1]	NET ACRES [1]	DENSITY (DU/Gross Ac.)	DWELLING UNITS	COMMERCIAL SQUARE FT. [4]	OVERNIGHT ACCOMMO-DATIONS
OPEN SPACE PRESERVE								
1. UPLAND HABITAT CONSERVATION, RESTORATION, AND MITIGATION AREAS								
UOS/PTF	1a	West Coast Highway Bluff Area	15.3	14.3	--	0	0	0
UOS/PTF	1b	Southern Arroyo CSS / Grassland Area	28.3	28.0	--	0	0	0
UOS/PTF	1c	Scenic Bluff CSS / Grassland Area	13.0	13.0	--	0	0	0
UOS/PTF	1d	Vernal Pool Preservation Area	3.2	3.2	--	0	0	0
UOS/PTF	1e	South Upland CSS / Grassland Area	19.4	18.1	--	0	0	0
UOS/PTF	1f	Northern Arroyo Grassland Area	5.8	5.5	--	0	0	0
UOS/PTF	1g	North Upland CSS / Grassland Area[3]	16.3	13.5	--	0	0	0
UOS/PTF	1h	Minor Arroyo Grassland Area	1.2	1.1	--	0	0	0
		Subtotal	***102.5***	***96.7***	**--**	***0***	***0***	***0***
2. LOWLAND HABITAT CONSERVATION, RESTORATION, AND MITIGATION AREAS								
LOS/PTF	2a	Southerly Habitat Mitigation/Protection Area	75.8	75.8	--	0	0	0
LOS/PTF	2b	Northerly Habitat Mitigation/Protection Area[3]	42.6	40.3	--	0	0	0
		Subtotal	***118.4***	***116.1***	**--**	***0***	***0***	***0***
3. PUBLIC INTERPRETIVE TRAILS								
LOS/PTF	3a	Bluff Toe Trail[2]	--	--	--	0	0	0
LOS/PTF	3b	Lowland Interpretive Trail[3]	7.3	7.1	--	0	0	0
UOS/PTF	3c	Southern Arroyo Trail	0.7	0.7	--	0	0	0
UOS/PTF	3d	Upland Interpretive Trail	1.5	1.5	--	0	0	0
		Subtotal	***9.5***	***9.3***	**--**	***0***	***0***	***0***
4. DRAINAGE MANAGEMENT AREAS								
LOS/PTF	4a	Water Quality Basin	2.2	2.2	--	0	0	0
UOS/PTF	4b	Diffuser Basin / Habitat Area	0.4	0.4	--	0	0	0
		Subtotal	***2.6***	***2.6***	**--**	***0***	***0***	***0***
5. CONSOLIDATED OIL SITES (Interim Use)								
OF	5a	Southerly Oil Operations Site	4.8	4.8	--	0	0	0
OF	5b	Oil Access Road (Non-exclusive Access Easement)	3.1	3.1	--	0	0	0
OF	5c	Northerly Oil Operations Site	8.6	8.6	--	0	0	0
		Subtotal	***16.5***	***16.5***	**--**	***0***	***0***	***0***
6. OIL SITE BUFFERS								
UOS/PTF	6a	Southerly Oil Site Planting Buffer	0.1	0.1	--	0	0	0
LOS/PTF	6b	Northerly Oil Site Planting Buffer	2.7	2.7	--	0	0	0
		Subtotal	***2.8***	***2.8***	**--**	***0***	***0***	***0***
		SUBTOTAL OPEN SPACE PRESERVE	***252.3***	***244.0***	**--**	***0***	***0***	***0***
PARKLANDS								
7. PUBLIC COMMUNITY PARKS								
CP	7a	South Community Park	5.0	3.7	--	0	0	0
CP	7b	Central Community Park	5.9	4.5	--	0	0	0
CP	7c	North Community Park	15.9	13.5	--	0	0	0
		Subtotal	***26.8***	***21.7***	**--**	***0***	***0***	***0***
8. PUBLIC BLUFF PARKS								
BP	8a	South Bluff Park	7.3	6.9	--	0	0	0
BP	8b	North Bluff Park	13.6	10.6	--	0	0	0
		Subtotal	***20.9***	***17.5***	**--**	***0***	***0***	***0***
9. PUBLIC INTERPRETIVE PARKS								
IP	9a	Nature Center	2.2	2.2	--	0	0	0
IP	9b	Vernal Pool Interpretive Area	1.4	0.6	--	0	0	0
IP	9c	Talbert Trailhead Area	0.1	0.1	--	0	0	0
		Subtotal	***3.7***	***2.9***	**--**	***0***	***0***	***0***
		SUBTOTAL PARKLANDS	***51.4***	***42.1***	**--**	***0***	***0***	***0***
VILLAGES AND COLONIES								
10. NORTH FAMILY VILLAGE								
RL	10a	Single-Family Detached Residential	17.1	13.4	6.3	107	0	0
RL/M	10b	Single-Family Detached Residential	11.8	8.1	7.2	85	0	0
RM	10c	Single-Family Detached Residential	8.3	6.0	10.8	90	0	0
RM	10d	Multi-Family Attached Residential	8.8	5.9	15.3	135	0	0
		Subtotal	***46.0***	***33.4***	**--**	***417***	***0***	***0***
11. SOUTH FAMILY VILLAGE								
RL	11a	Single-Family Detached Residential	9.0	7.6	6.6	60	0	0
RM	11b	Single-Family Detached Residential	10.2	6.8	8.0	81	0	0
		Subtotal	***19.2***	***14.4***	**--**	***141***	***0***	***0***
12. URBAN COLONY								
MU/R	12a	Multi-Family Attached Residential/Mixed-Use Commercial	9.8	8.5	37.2	365	37,500	0
MU/R	12b	Multi-Family Attached Residential/Mixed-Use Commercial	11.1	9.8	32.8	365	37,500	0
		Subtotal	***20.9***	***18.3***	**--**	***730***	***75,000***	***0***
13. RESORT COLONY								
VSR/R	13a	Resort Hotel (75 Guest Rooms/ Spa/ Fitness Center/ Restaurants/	5.7	5.2	--	0	0	75
VSR/R	13b	Multi-Family Attached Residential	5.6	5.4	15.6	87	0	0
		Subtotal	***11.3***	***10.6***	**--**	***87***	***0***	***75***
		SUBTOTAL VILLAGES AND COLONIES	***97.4***	***76.7***	**--**	***1,375***	***75,000***	***75***
		TOTAL PROJECT	**401.1**	**362.8**	**--**	**1,375**	**75,000**	**75**

(1) Gross Acres of Site Planning Areas are measured to the centerlines of all public roads where such roads are shown on the Master Development Plan. Net Acres of Site Planning Areas are measured to edges of the right-of-ways of all public roads where such roads are shown on the Master Development Plan (i.e., Net Acres exclude public road rights-of-way).

(2) The Bluff Toe Trail is located within the non-exclusive access easement identified as SPA 5b, Oil Access Road.

(3) The Right-of-Way Reservation for the 19th Street Extension, from the Project Site's easterly boundary to the Santa Ana River, encompasses approximately 3.1 total acres, including approximately 0.6 acres of SPA 1g, 2.3 acres of SPA 2b, and 0.2 acres of SPA 3b.

(4) Up to 2,500 square feet of commercial may be transferred to a Residential Land Use District in accordance with the provisions of Section 4.0, "Implementation and Administration," of the NBR-PC provided the total area of commercial uses for the Master Development Plan does not exceed 75,000 square feet.

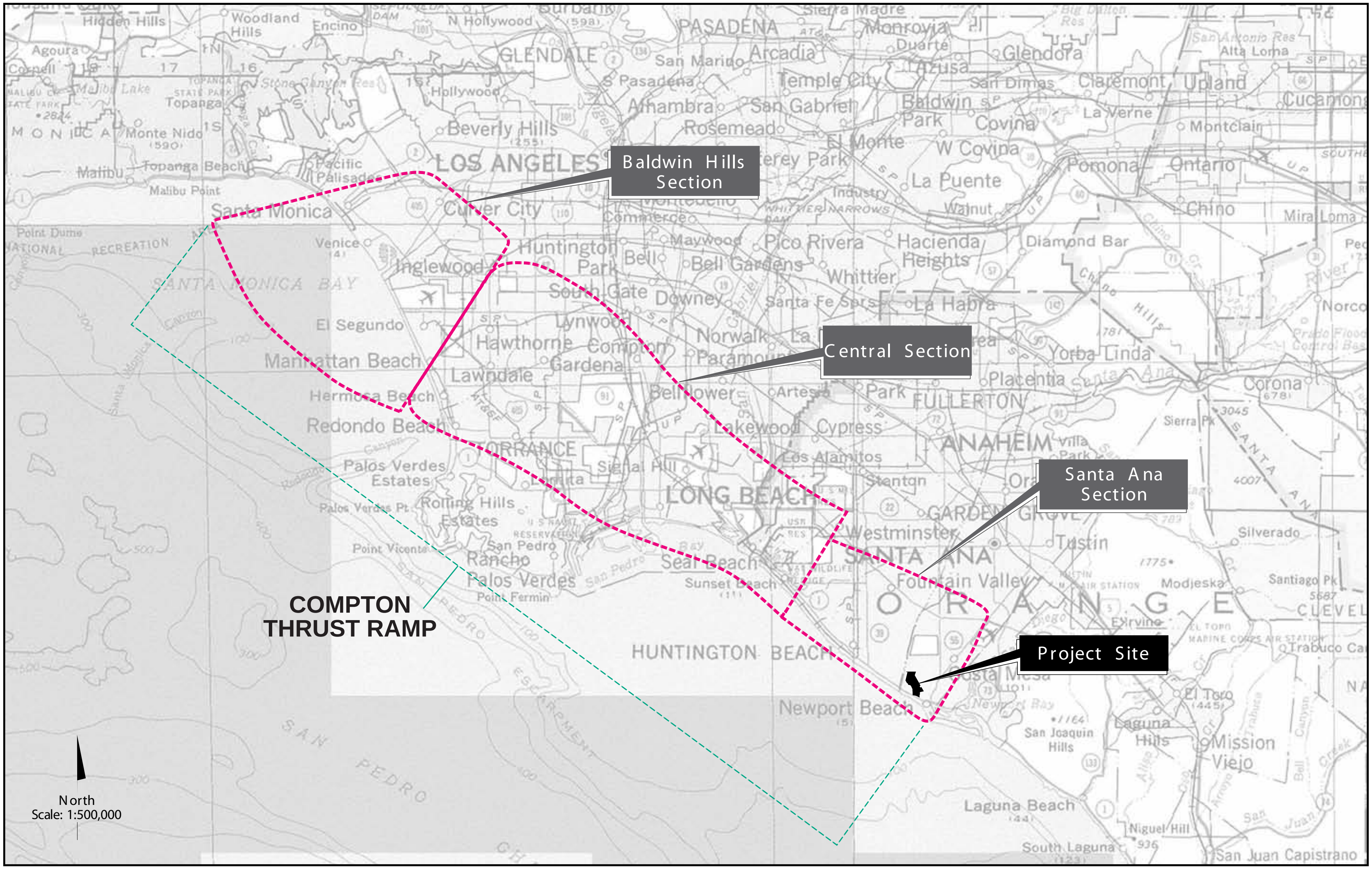
S:\clients\brooks_street_1729\1729001\05_project_documents\excel\gis_tables\pcdp_mdp_tables\gis_tables_20110706.xlsx - msp_ch3 7/6/2011

GMU GEOTECHNICAL, INC.

LAND USE TABLE

Plate **2.2**

Project Name: **Newport Banning Ranch** | **06-163-00** | **Date:** **July 2011**

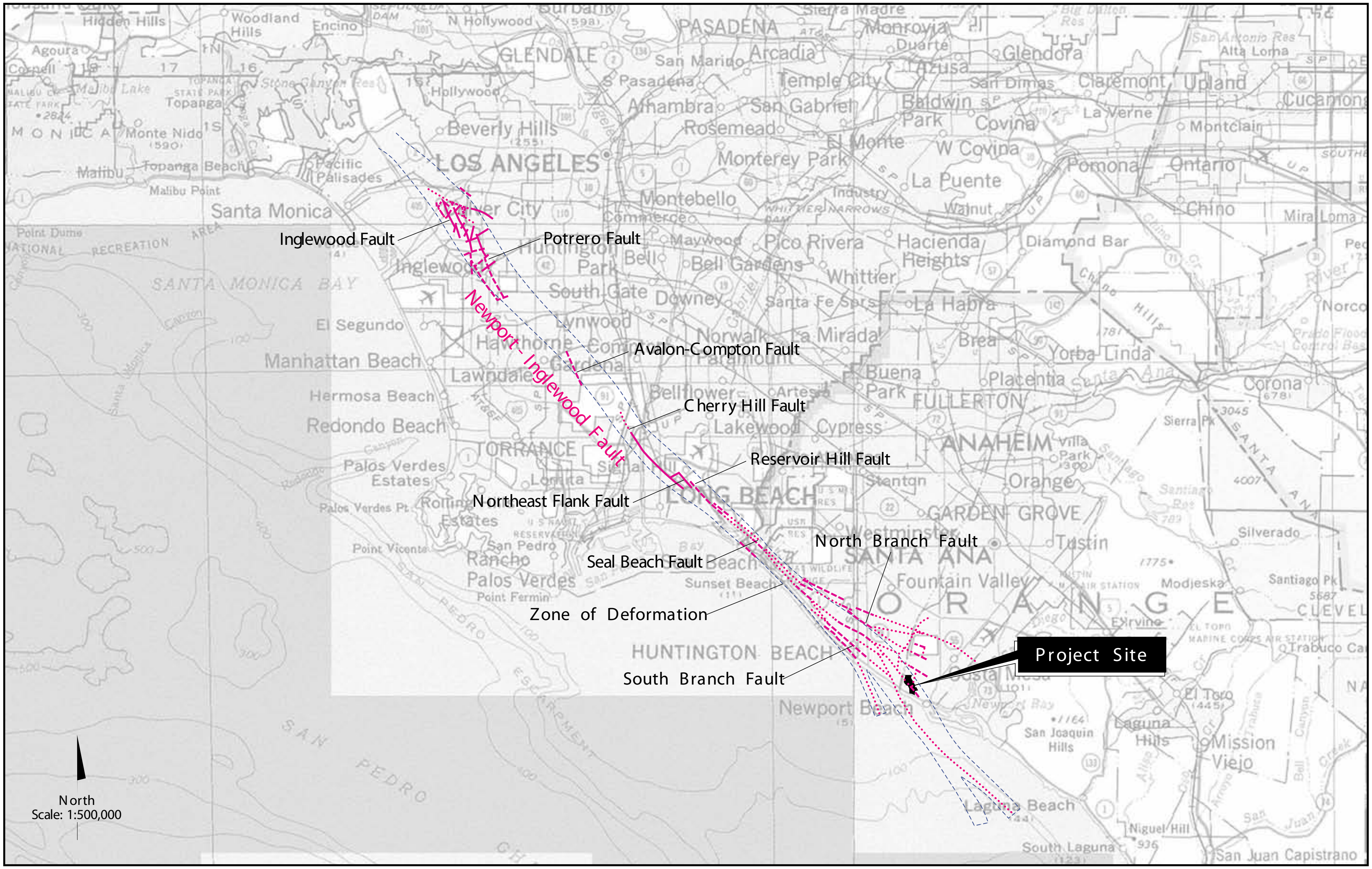


Reference:
USGS/SCEC Fault Activity Database
for Southern California

GMU GEOTECHNICAL, INC.

**REGIONAL FAULTING:
COMPTON THRUST RAMP**

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	3.1

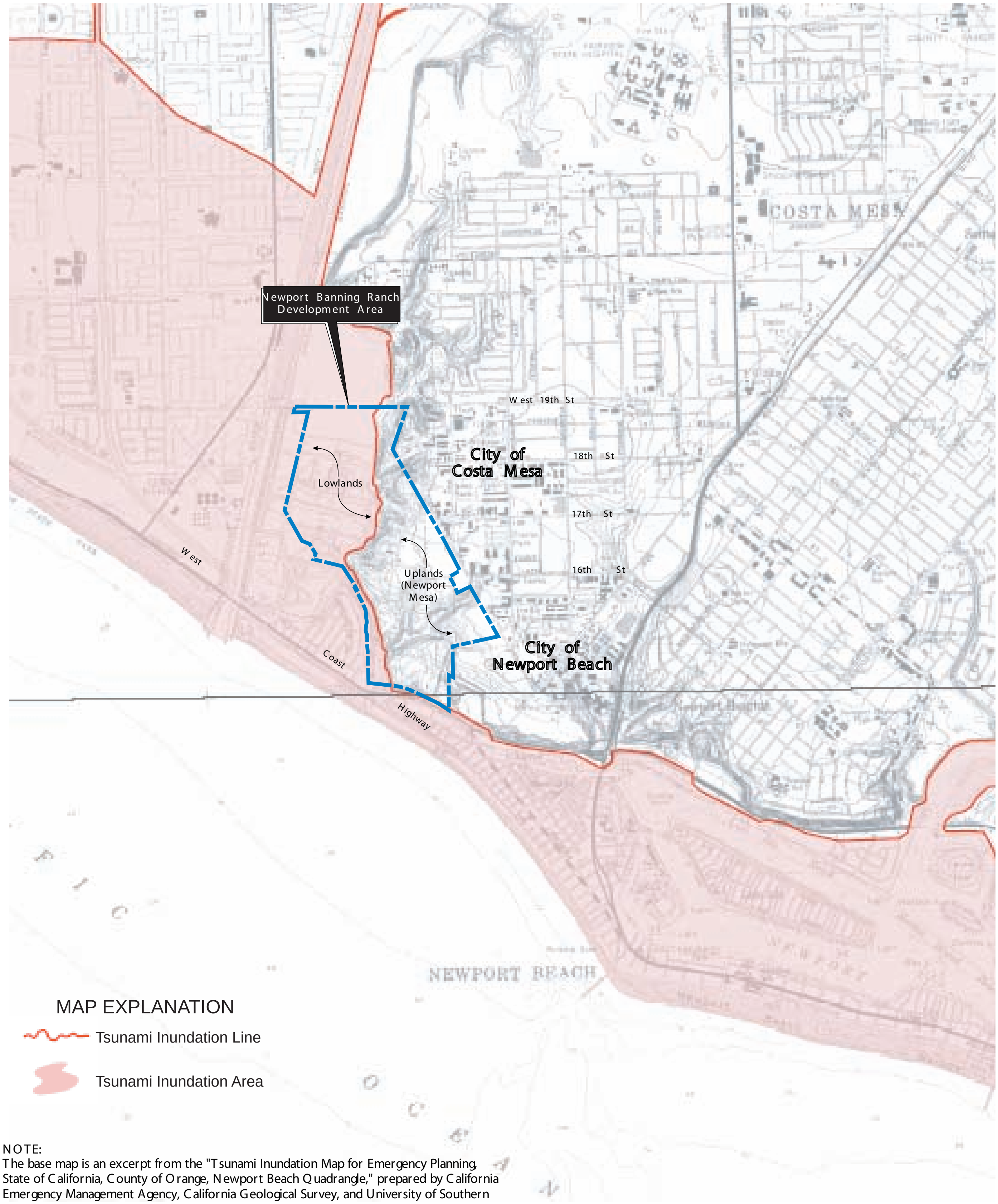


Reference:
Compiled from, Geologic Map of California, California Division of Mines and Geology (CDMG), Long Beach (1962), Los Angeles (1969), and Santa Ana (1965) Sheets: as contained in CDMG Special Report 114 (1974).

GMU GEOTECHNICAL, INC.

REGIONAL FAULTING:
NEWPORT INGLEWOOD FAULT ZONE

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	3.2

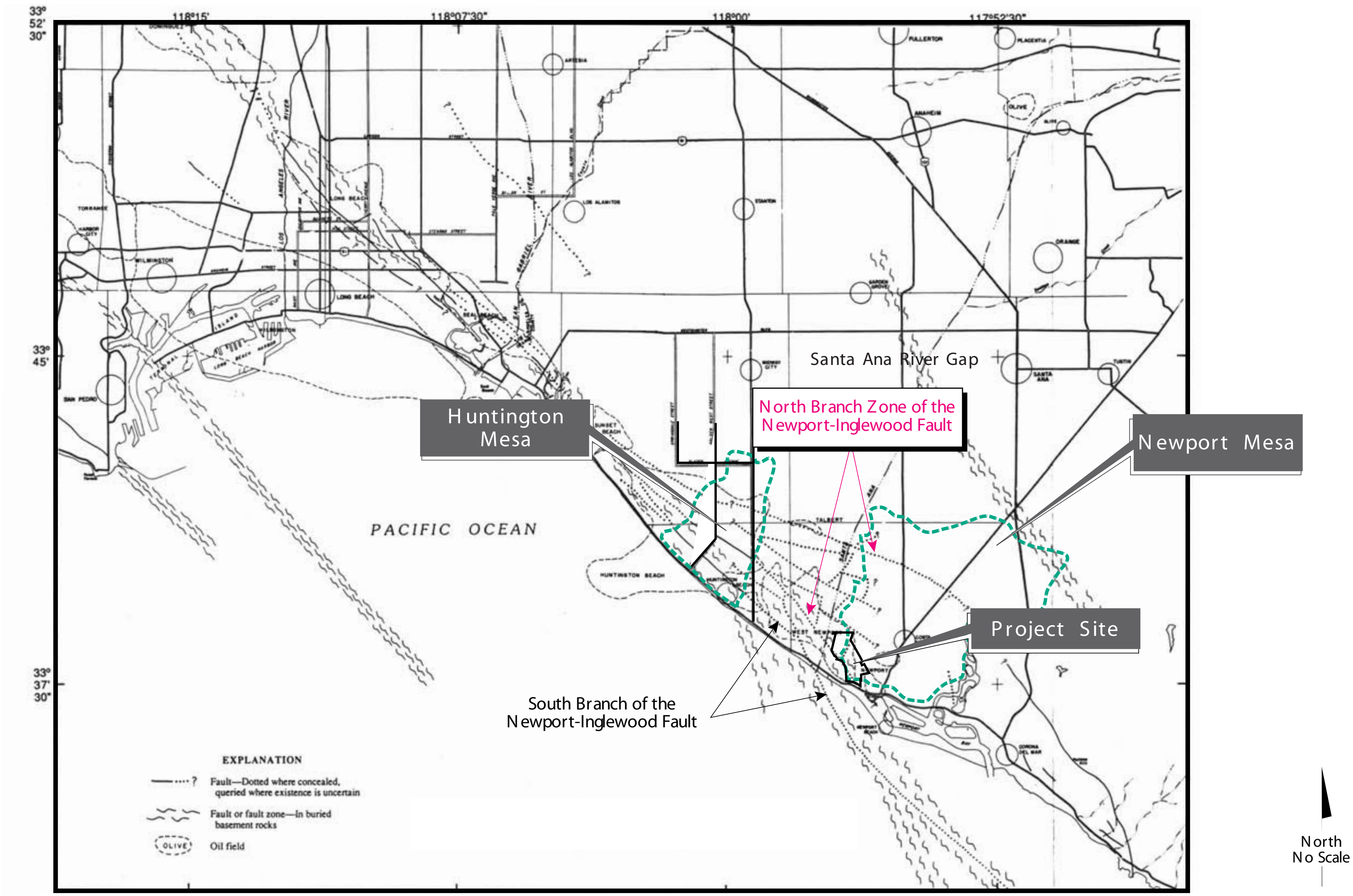


NOTE:
The base map is an excerpt from the "Tsunami Inundation Map for Emergency Planning, State of California, County of Orange, Newport Beach Quadrangle," prepared by California Emergency Management Agency, California Geological Survey, and University of Southern California, dated March 15, 2009

GMU GEOTECHNICAL, INC.

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	4

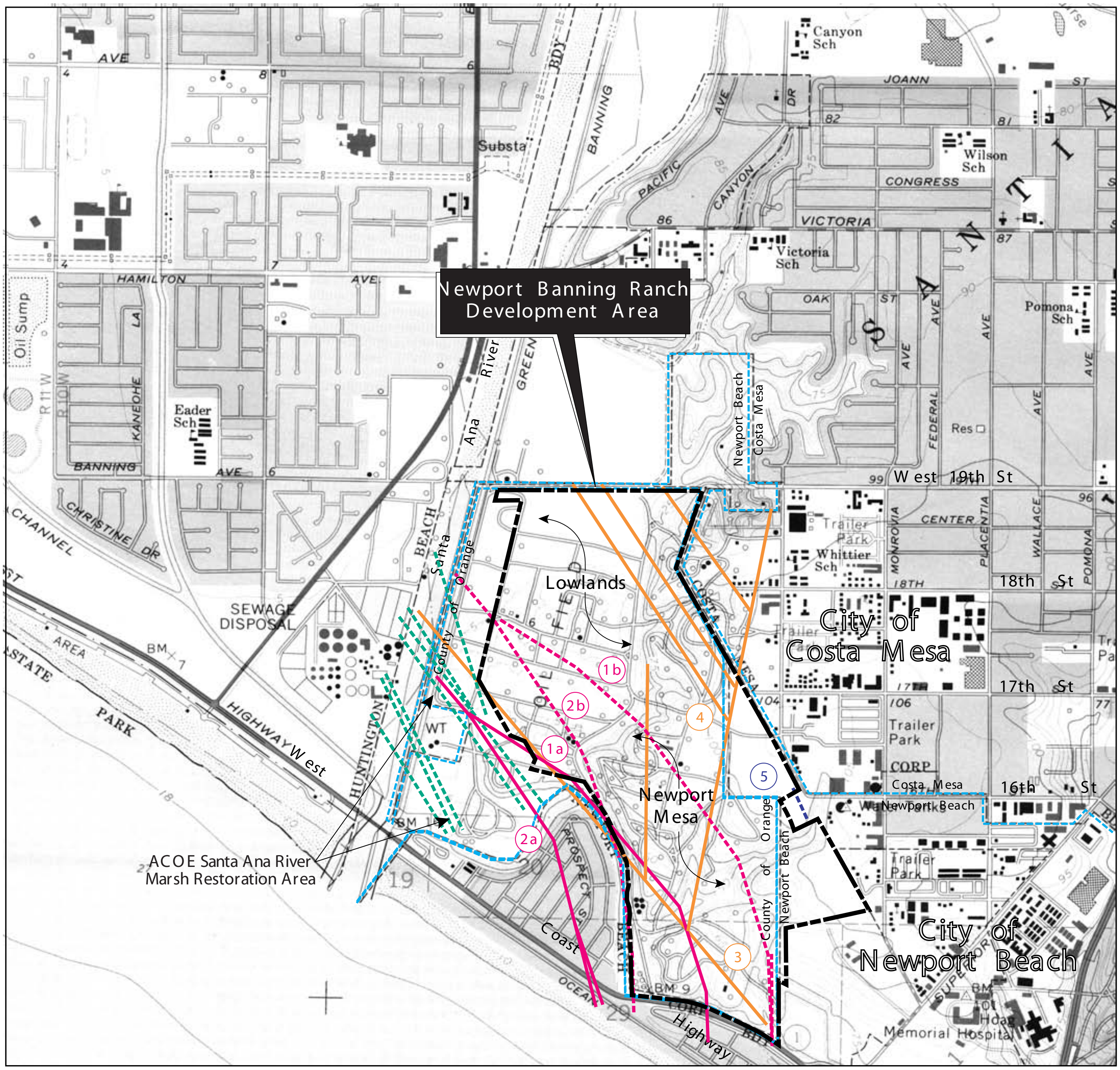


Reference:
Faults and Fault Zones from Yerkes and Others (1965, p.A4), Castle (1966, fig.4), and Poland and Others (1956, pl.3), Oil-Field Boundaries from California Division of Oil and Gas (1961): As Contained in "Vertical Surface Displacements Along a Part of the Newport Inglewood Zone of Faults and Folds..." Castle, Buchanan-Banks 1989.

GMU GEOTECHNICAL, INC.

LOCAL GEOMORPHOLOGY AND NORTH BRANCH OF THE NEWPORT INGLEWOOD FAULT ZONE

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	5



EXPLANATION

- Approximate Location of Surface Trace (Converse, 1994).
- Surface Trace of Active Strands Projected as Straight Lines from Site North of the Santa Ana River (Law/Crandall, 1994).
- Solid Line is Trace in Subsurface (Top of A Zone), Dashed Line is Inferred Surface Trace as Projected from the Subsurface (Earth Tech, 1986).
- Solid Line is Trace in Subsurface (Top of B Zone), (Corwin, 1947).

1a 2a North Branch Fault.

1b 2b North Branch Splay Fault.

3 Newport Inglewood Fault (Corwin, 1947).

4 Banning Fault, (Corwin, 1947)

5 West Mesa Fault.

0 1000 2000 3000

Approximate Graphic Scale in Feet

North

NOTES:
1) The Base Map is a Computer Scanned Image from USGS 7.5 Minute Newport Beach, California Topographic Quadrangle, 1965, Photorevised 1972.
2) All Locations and Dimensions are Approximate.

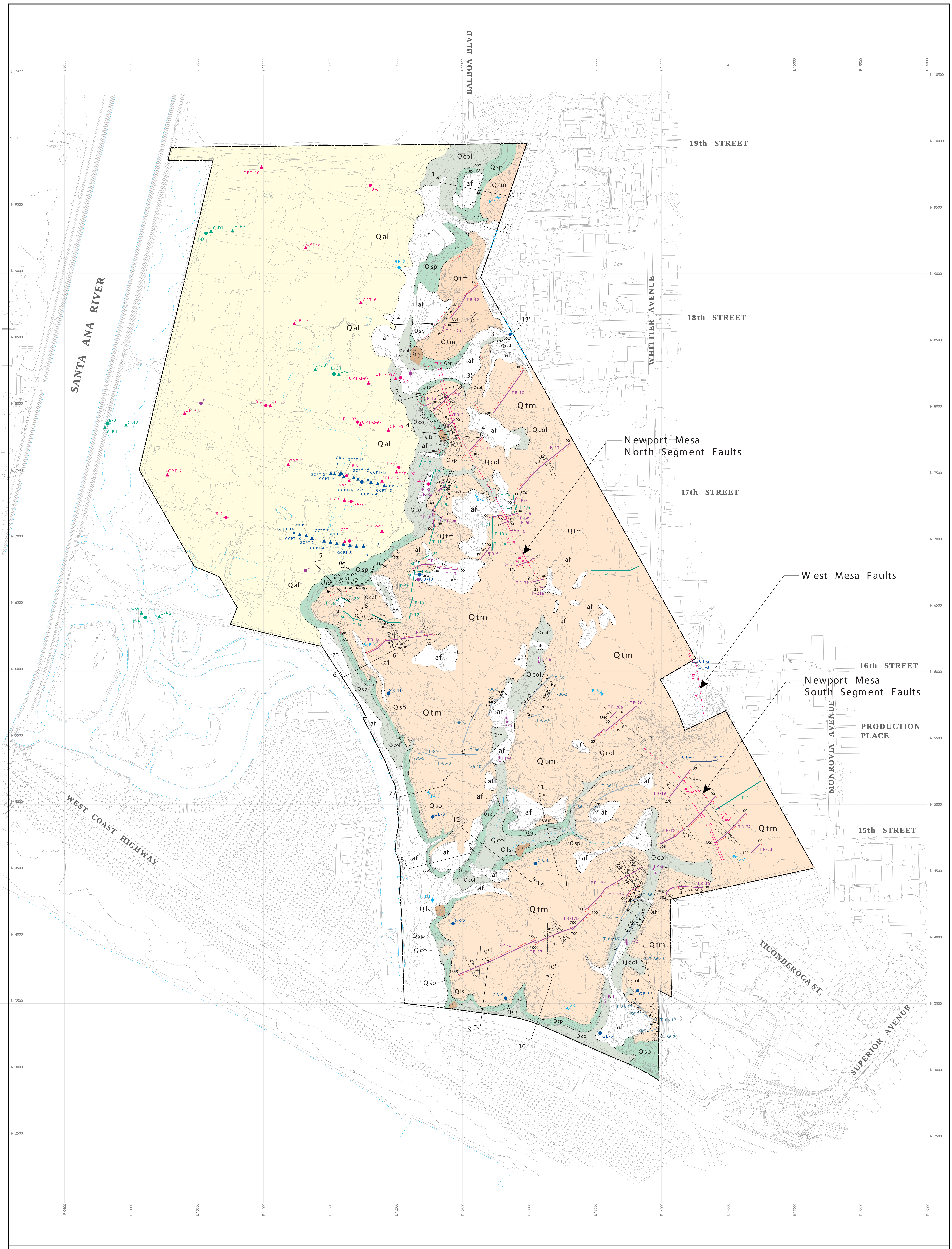
REFERENCE:
"Fault Trenching Investigation, Newport Bay Property, Orange County, California, by Earth Consultants International, dated November 25, 1997.

GMU GEOTECHNICAL, INC.

FAULTS MAPPED IN THE
NEWPORT BANNING RANCH AREA
BY PREVIOUS INVESTIGATORS

PLATE 6

Project Name:	Project No:	Date:
Newport Banning Ranch	06-163-00	July 2011



EXPLANATION

- Qal — Alluvium
- af — Man-Made Fill (Artificial), Where Observed or Inferred to be Greater Than About 2 Feet Thick
- Qcol — Colluvium/Slopewash Deposits
- Qls — Landslide Deposits (Surficial Slump Debris)
- Qtm — Marine Terrace Deposits
- Qsp — San Pedro Formation
- 12 — Strike and Dip of Beds
- Horizontal Bedding
- Geologic Contact, Approximately Located, Dotted Where Concealed and Dashed Where Uncertain
- Continuous, Unbroken Pre-Holocene Age Deposits
- 65 — Inactive Fault (Black), Showing Strike and Dip
- 75 — Fault That Could Not Be Proved Inactive (Red), Showing Strike and Dip
- Paleo-Channel in Qsp Formation Deposits
- Landslide, Showing Movement Direction
- CPT-10, CPT-4-97 — Leighton & Associates CPT Sounding (1997)
- B-6, B-1-97 — Leighton & Associates Hollow Stem Auger Boring (1997)
- GCPT-1 — Goffman, McCormick & Urban, Inc., CPT Sounding (1998)
- GB-1 — Goffman, McCormick & Urban, Inc., Bucket Auger Boring (1998)
- B-7 — Pacific Soils Engineering Bucket Auger Boring (1993)
- HB-2 — Pacific Soils Engineering Hollow Stem Auger Boring (1993)
- C-B1 — Woodward Clyde Consultants CPT Sounding (1985)
- B-B1 — Woodward Clyde Consultants Hollow Stem Auger Boring (1985)
- TR-9, 00 — Fault Trench, by Goffman, McCormick & Urban, Inc., This Study, Showing Station "00"
- T-86-15 — Fault Trench by Earth Technology (1986)
- CT-3 — Fault Trench by Converse Consultants (1994)
- T-3a — Fault Trench By ECI, Inc., for Leighton & Associates, Inc. (1997)
- TP-6 — Test Pits by Goffman, McCormick & Urban, Inc. (1998)
- D — Groundwater Monitoring Well Installed by GeoSyntec (1994)
- Hilfiker Wall
- A' — Geologic Cross Section Line
- Fault Setback Zone

0 400 800 1200

Approximate Graphic Scale:
One Inch Equals 200 Feet
Countour Interval: 2 feet

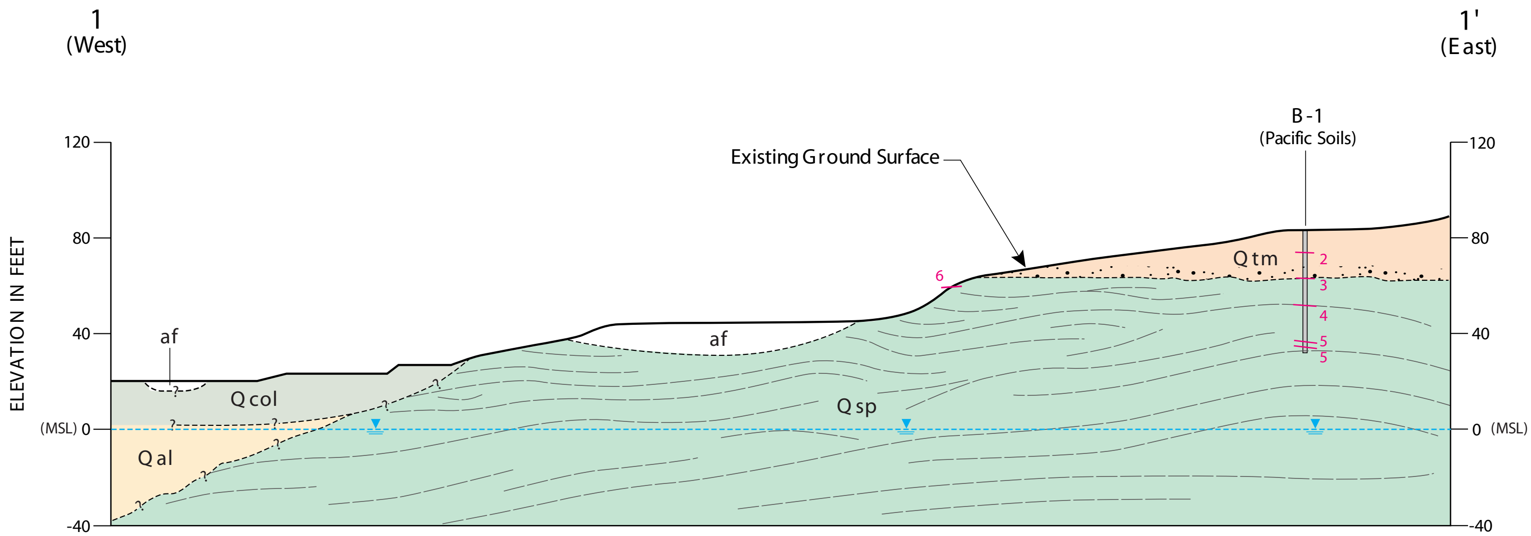
Notes:
1. All Locations are Approximate.
2. The Base Map was Obtained from Fuscoe Engineering.

North

GMU GEOTECHNICAL, INC.

GEOLOGIC MAP

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	7



EXPLANATION

Qal Alluvium

af Man Made Fill

Qcol Colluvium/Slopewash Deposits

Qtm Marine Terrace Deposits

Qsp San Pedro Formation

Geologic Contact, Queried Where Unknown

Strike and Dip of Bed

Groundwater Table

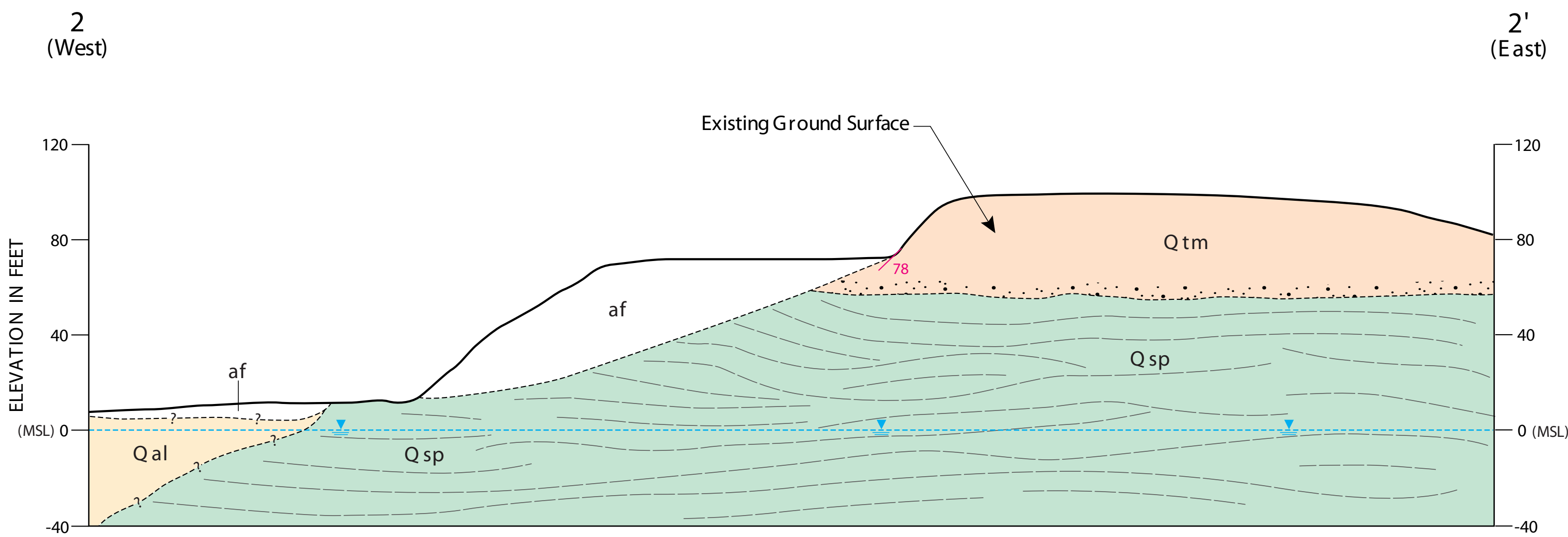
Notes:
1. All locations are approximate.
2. Bedding shown in Qsp is largely diagramatic and has been drawn to illustrate the formations general structural nature (i.e. gentle folds, warping, cross bedding and minor fault offsets.

0 40 80 120
Approximate Graphic Scale
Horizontal: 1 Inch Equals 80 Feet

GMU GEOTECHNICAL, INC.

GEOLOGIC CROSS SECTION 1-1'

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	8.1



EXPLANATION

Qal	Alluvium
af	Man Made Fill
Qcol	Colluvium/Slopewash Deposits
Qtm	Marine Terrace Deposits
Qsp	San Pedro Formation
	Geologic Contact, Queried Where Unknown
6	Strike and Dip of Bed
	Groundwater Table

Notes:
1. All locations are approximate.
2. Bedding shown in Qsp is largely diagramatic and has been drawn to illustrate the formations general structural nature (i.e. gentle folds, warping, cross bedding and minor fault offsets.

0 40 80 120
Approximate Graphic Scale
Horizontal: 1 Inch Equals 80 Feet

GMU GEOTECHNICAL, INC.

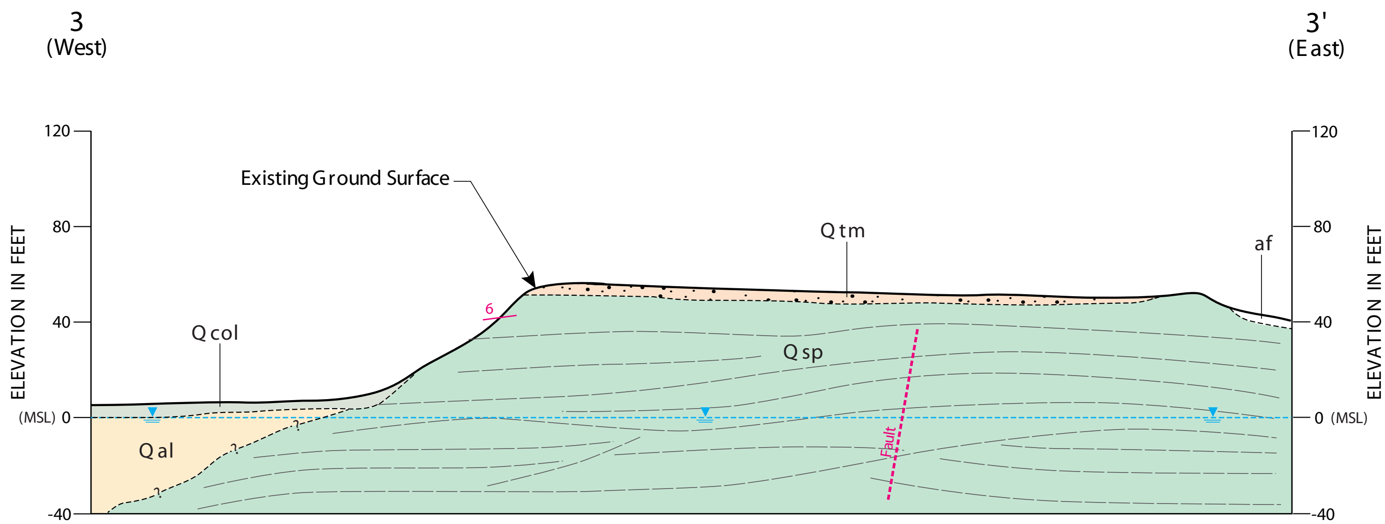
GEOLOGIC CROSS SECTION 2-2'

Project Name: Newport Banning Ranch

Project No: 06-163-00

Date: July 2011

PLATE 8.2



EXPLANATION

Qal Alluvium

af Man Made Fill

Qcol Colluvium/Slopewash Deposits

Qtm Marine Terrace Deposits

Qsp San Pedro Formation

Geologic Contact, Queried Where Unknown

6 Strike and Dip of Bed

Groundwater Table

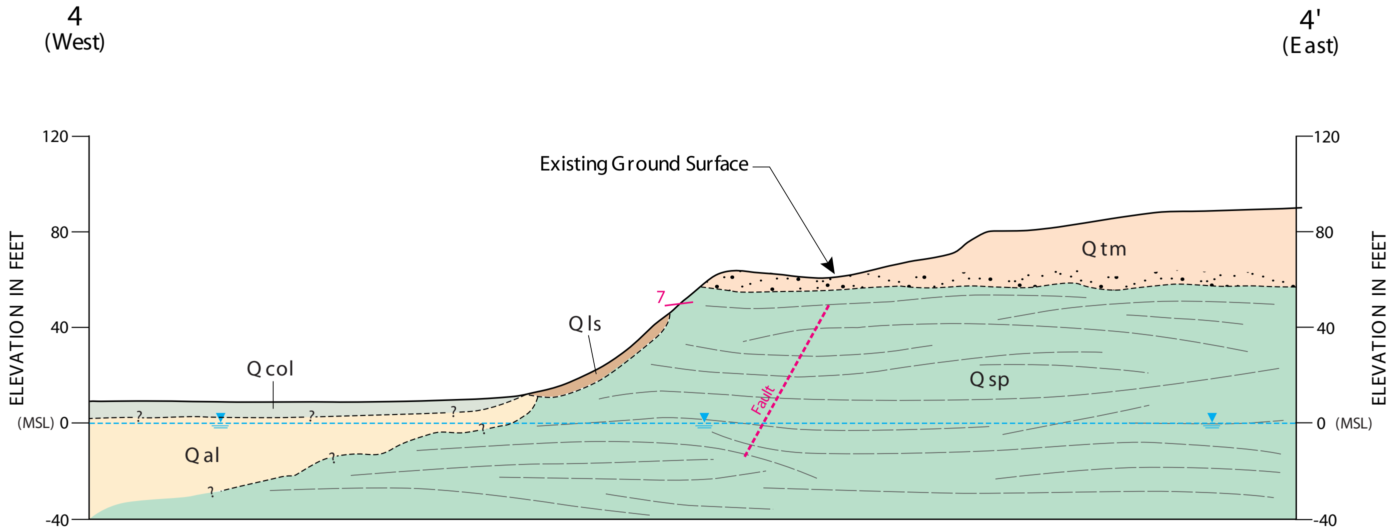
Notes:
1. All locations are approximate.
2. Bedding shown in Qsp is largely diagramatic and has been drawn to illustrate the formations general structural nature (i.e. gentle folds, warping, cross bedding and minor fault offsets.

0 40 80 120
Approximate Graphic Scale
Horizontal: 1 Inch Equals 80 Feet

GMU GEOTECHNICAL, INC.

GEOLOGIC CROSS SECTION 3-3'

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	8.3



EXPLANATION

Qal	Alluvium
af	Man Made Fill
Qcol	Colluvium/Slopewash Deposits
Qtm	Marine Terrace Deposits
Qsp	San Pedro Formation
Qls	Landslide Deposits
	Geologic Contact, Queried Where Unknown
6	Strike and Dip of Bed
	Groundwater Table

Notes:
1. All locations are approximate.
2. Bedding shown in Qsp is largely diagramatic and has been drawn to illustrate the formations general structural nature (i.e. gentle folds, warping, cross bedding and minor fault offsets.

0 40 80 120
Approximate Graphic Scale
Horizontal: 1 Inch Equals 80 Feet

GMU GEOTECHNICAL, INC.

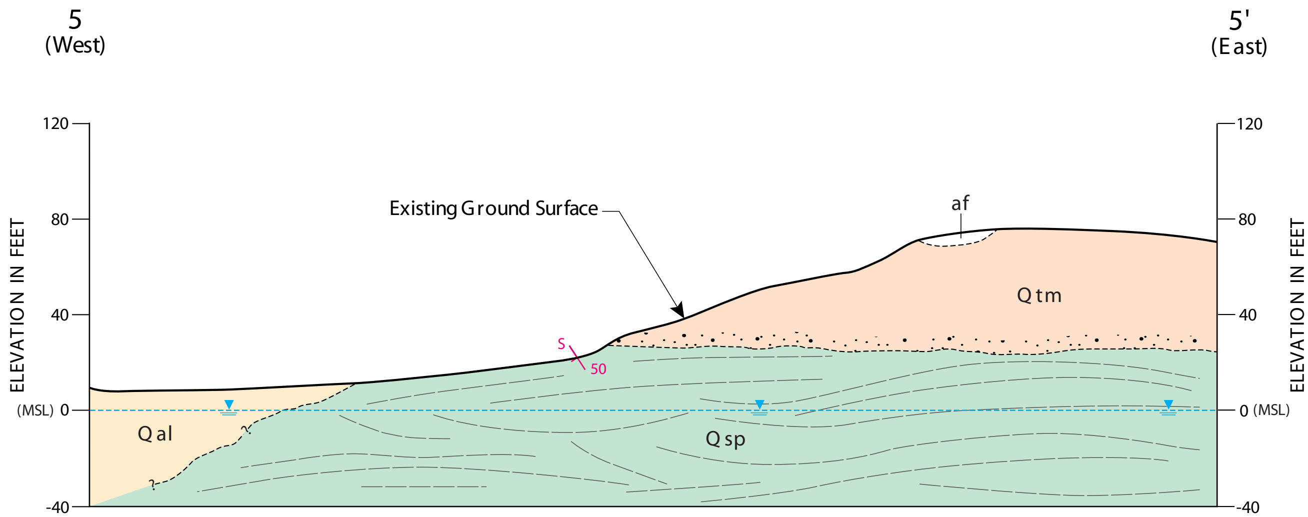
GEOLOGIC CROSS SECTION 4-4'

Project Name: Newport Banning Ranch

Project No: 06-163-00

Date: July 2011

PLATE 8.4



EXPLANATION

Qal	Alluvium		Geologic Contact, Queried Where Unknown
af	Man Made Fill	6	Strike and Dip of Bed
Qcol	Colluvium/Slopewash Deposits		Groundwater Table
Qtm	Marine Terrace Deposits		
Qsp	San Pedro Formation		

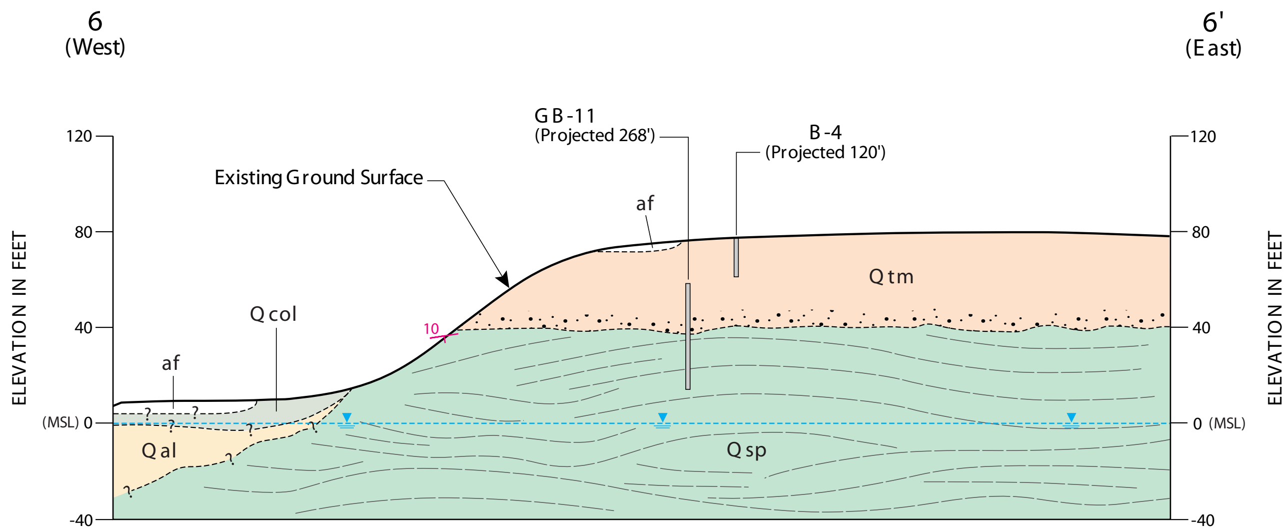
Notes:
1. All locations are approximate.
2. Bedding shown in Qsp is largely diagramatic and has been drawn to illustrate the formations general structural nature (i.e. gentle folds, warping, cross bedding and minor fault offsets.

0 40 80 120
Approximate Graphic Scale
Horizontal: 1 Inch Equals 80 Feet

GMU GEOTECHNICAL, INC.

GEOLOGIC CROSS SECTION 5-5'

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	8.5



EXPLANATION

Qal	Alluvium
af	Man Made Fill
Qcol	Colluvium/Slopewash Deposits
Qtm	Marine Terrace Deposits
Qsp	San Pedro Formation
	Geologic Contact, Queried Where Unknown
6	Strike and Dip of Bed
	Groundwater Table

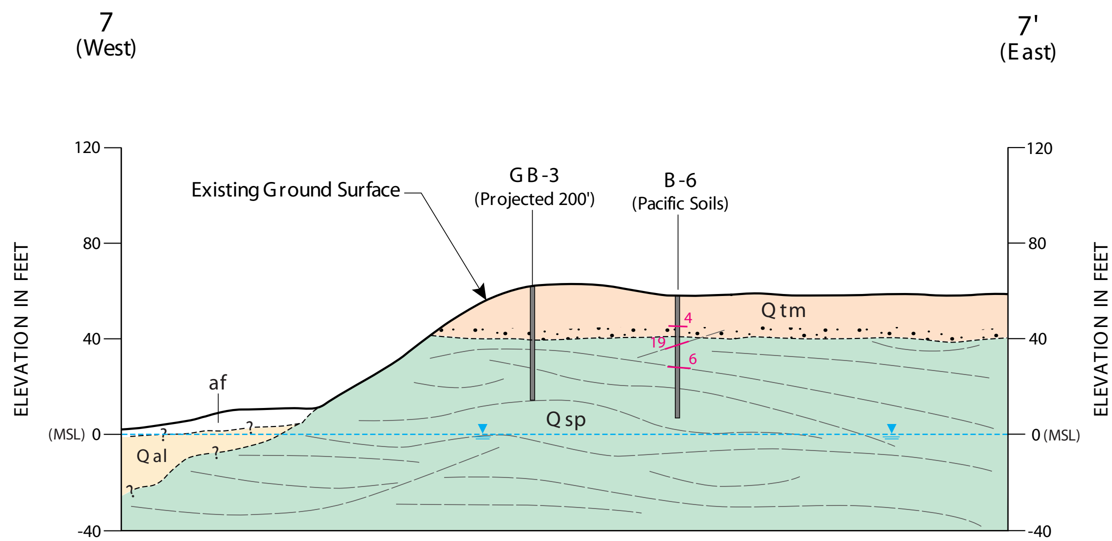
Notes:
1. All locations are approximate.
2. Bedding shown in Qsp is largely diagramatic and has been drawn to illustrate the formations general structural nature (i.e. gentle folds, warping, cross bedding and minor fault offsets.

0 40 80 120
Approximate Graphic Scale
Horizontal: 1 Inch Equals 80 Feet

GMU GEOTECHNICAL, INC.

GEOLOGIC CROSS SECTION 6-6'

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	8.6



EXPLANATION

Qal Alluvium

af Man Made Fill

Qcol Colluvium/Slopewash Deposits

Qtm Marine Terrace Deposits

Qsp San Pedro Formation

Geologic Contact, Queried Where Unknown

Strike and Dip of Bed

Groundwater Table

Notes:
1. All locations are approximate.
2. Bedding shown in Qsp is largely diagramatic and has been drawn to illustrate the formations general structural nature (i.e. gentle folds, warping, cross bedding and minor fault offsets.

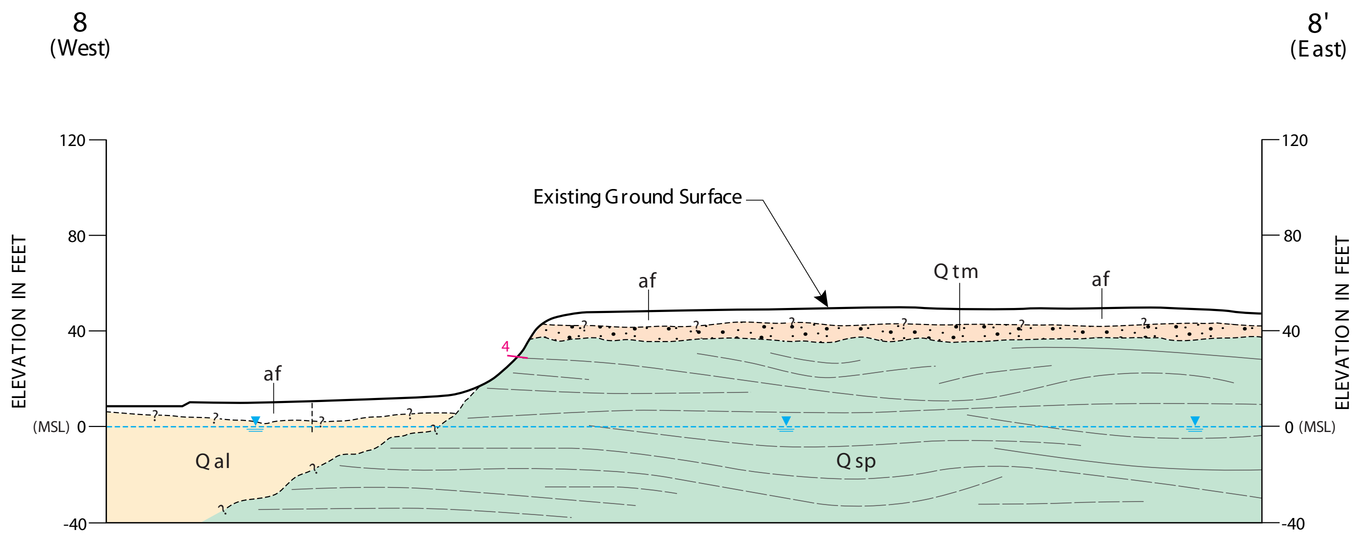
0 40 80 120

Approximate Graphic Scale
Horizontal: 1 Inch Equals 80 Feet

GMU GEOTECHNICAL, INC.

GEOLOGIC CROSS SECTION 7-7'

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	8.7



EXPLANATION

Qal Alluvium

af Man Made Fill

Qcol Colluvium/Slopewash Deposits

Qtm Marine Terrace Deposits

Qsp San Pedro Formation

Geologic Contact, Queried Where Unknown

6 Strike and Dip of Bed

Groundwater Table

Notes:
1. All locations are approximate.
2. Bedding shown in Qsp is largely diagramatic and has been drawn to illustrate the formations general structural nature (i.e. gentle folds, warping, cross bedding and minor fault offsets.

0 40 80 120
Approximate Graphic Scale
Horizontal: 1 Inch Equals 80 Feet

GMU GEOTECHNICAL, INC.

GEOLOGIC CROSS SECTION 8-8'

Project Name:	Project No:	Date:	PLATE
Newport Banning Ranch	06-163-00	July 2011	8.8