Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

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EMI Project No. 06-125

RBF Consulting
14725 Alton Parkway
Irvine, California 92618

Attention: Mr. Bruce R. Grove, Jr., REA

Subject: ***Geotechnical Study for Preliminary Engineering/Environmental Document***
Foothill Parkway Westerly Extension
City of Corona, Riverside County California

Dear Mr. Grove:

In accordance with your request, Earth Mechanics, Inc. (EMI) conducted a preliminary geologic and geotechnical study for the proposed westerly extension of Foothill Parkway in the City of Corona. The proposed roadway extends from the existing westerly terminus of Foothill Parkway to the Green River Road/Paseo Grande intersection, which is approximately 2 miles in length. The project location is shown on Figure 1. Below are discussions regarding geologic units, geologic structure, geotechnical conditions, and geologic and seismic hazards present along the proposed roadway alignment.

TOPOGRAPHY

The site is located at the northeast corner of the Santa Ana Mountains, at the transition where the foothills are uplifted above the Corona Plain. Topographic relief along the proposed roadway alignment is highly variable with the central portion of the alignment traversing rugged terrain where ridgelines are dissected by interfingering alluvial canyons that extend out to the Corona Plain. Topographic relief is less severe at the northern end where the proposed alignment generally follows the bottom of Wardlow Canyon and also at the southern end where it enters the generally flat Corona Plain.

Elevations range from 1,320 feet above mean sea level (msl) along the ridgeline just northwest of Mabey Canyon to 800 feet above msl at the bottom of Wardlow Canyon near the intersection of Paseo Grande and Green River Road.

SITE CONDITIONS

Portions of the proposed alignment are within areas that have been previously developed. The northern end of the alignment, within Wardlow Canyon, is the site of an equestrian center with associated horse corrals, barns and trails. Residential trailers and abandoned cars and other heavy-duty equipment are scattered about the canyon bottom. Portions of the canyon have been graded and filled to create level building areas. The grading is presumed to not conform to current City or County standards and should not be considered suitable for support of structural fill; consequently, the existing fill most likely needs to be removed and replaced as properly engineered fill.

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The central portion of the alignment is generally in undeveloped natural terrain with the exception of Mabey Canyon where the alignment crosses the embankment of an existing flood control basin.

The southern end of the alignment is within existing residential development with portions of the alignment already graded and paved. A bridge that will support the roadway over Hagador Canyon has been partially constructed.

REGIONAL GEOLOGIC SETTING

The proposed roadway alignment trends across the northeast corner of the Santa Ana Mountains. These mountains lie within the Peninsular Ranges Geomorphic Province of California, which is characterized by its generally northwest trending mountains and geologic structure. The Peninsular Ranges Province is bounded on the north by the Transverse Ranges Province, which is characterized by its east-west geologic structure and topographic grain, and on the east by the Colorado and Mojave Desert Provinces.

The Corona Plain lies adjacent to this portion of the Santa Ana Mountains and represents a down faulted, alluvial filled linear trough at the base of the uplifted foothills.

The northeastern part of the Santa Ana Mountains is a sharply folded anticline, plunging northwest (Schoellhamer et al, 1981). The northeast limb of the anticline exposes sedimentary bedrock units of late Cretaceous to Tertiary age. This limb of the anticline is narrow due to downfaulting along the Whittier-Elsinore Fault Zone. Below the sedimentary bedrock units are the basement rocks of the Jurassic-age Bedford Canyon Formation. Unconformably overlying and intruding the Bedford Canyon Formation is the Santiago Peak Volcanics of Cretaceous-age.

The Elsinore Fault Zone lies at the base of the Santa Ana Mountains and is a major active right-lateral, strike-slip fault zone of the San Andreas Fault System. The fault separates two major structural blocks of the northern Peninsular Ranges. East of the fault zone is the Perris Block and west of it the Santa Ana Mountains Block. A physiography and fault map is provided on Figure 2.

GENERAL SITE GEOLOGY

The proposed alignment of the Foothill Parkway extension is underlain by Cretaceous and Tertiary sedimentary bedrock units within the foothills of the Santa Ana Mountains and by alluvial fan and channel deposits in the Corona Plain. Where the alignment crosses previously developed areas in Wardlow Canyon, Mabey Canyon and at the southern terminus, man-made fill has been placed.

Bedding within the bedrock units, although locally variable, generally follows the predominant structural trend of the major faults in the area with a northwest strike and moderate dips to the northeast.

The most significant geologic feature within close proximity to the proposed Foothill Parkway extension is the confluence of three major fault zones: (a) the Elsinore Fault Zone, (b) the Whittier Fault Zone, and (c) the Chino Fault Zone. The Elsinore Fault Zone trends northwest along the base of the Santa Ana Mountains. Where it begins to take a more westerly strike into the foothills of the Santa Ana Mountains, the fault is termed the Whittier Fault Zone. Between Hagador and Mabey Canyons, the fault zone generally parallels the proposed alignment with fault strands crossing the alignment at multiple locations and displacing the sedimentary bedrock units of the Santa Ana Mountains. At the southern terminus of the Foothill Parkway extension, the Chino Fault Zone maintains the northwest strike of the Elsinore fault and crosses the alignment at a single location where the fault is buried under alluvial fan deposits.

The geologic units which underlie the alignment of the proposed Foothill Parkway extension are described below. Geologic units relative to the proposed roadway are shown on Figure 3.

Man-Made Fill

Deposits of man-made fill exist locally in areas of Wardlow and Mabey Canyons and the southern terminus of the proposed alignment where previous and on-going development has occurred. In most cases, these fills were likely derived from nearby geologic units and thus would be similar in lithology. However, wide variability in material type can occur in man-made fills, because of differences in the source materials (i.e. varied bedrock and alluvial units), and also because of variations in the way the fills are placed. Important factors associated with man-made fills include: (1) the degree to which the area beneath the fill was prepared before fill placement and (2) the degree to which the fill material was compacted. Man-made fill is considered "engineered" if records of compaction tests and remedial removals procedures used during fill placement are available. If no records are available the fill is considered "non-engineered." Depending on site-specific conditions, "non-engineered" fill may need to be removed as part of the Foothill Parkway extension grading.

In Wardlow Canyon, man-made fills exist that are associated with the construction and backfilling of the Metropolitan Water District Main Feeder and construction of the equestrian center bridal corals, trails, roadways, and trailer pads. It is assumed that much of this fill is non-engineered.

Another sequence of man-made fill exists in Mabey Canyon associated with construction of the existing flood control basin. It is assumed that this fill was placed under controlled engineered conditions during construction of the basin.

Man-made fill also exists near the southern terminus of the proposed roadway alignment. This fill was placed as part of the local residential development and construction of the initial phase of the extension of Foothill Parkway. It is assumed that the fill was placed under controlled conditions.

Young Alluvial Channel Deposits

In the bottom of Wardlow Canyon, young alluvial channel deposits exist. These deposits consist of unconsolidated, medium- to fine-grained sands, gravels, cobbles and boulders. Alluvial deposits typically exhibit poor sorting, moderately to poorly developed lenticular bedding and local cross bedding. Due to the low density and compressible nature of these units remedial removals will be required prior to placement of engineered fills.

Young Alluvial Fan Deposits

Young alluvial fan deposits are concentrated in the bottom of Mabey and Hagador Canyons. The fan deposits consist of sand, gravel and boulder deposits derived from volcanic and sedimentary units of the Santa Ana Mountains.

Old and Very Old Alluvial Fan Deposits

Old and very old alluvial fan deposits consist of moderately to well consolidated gravel and cobble deposits within a dirty sand matrix. The alluvial clasts correspond closely to the sedimentary and basement-complex types found nearby in the Santa Ana Mountains, indicating local derivation. The very old deposits are present along the east side of Wardlow Canyon and the southeast side of Mabey Canyon by the flood control basin. Old and very old alluvium is also present near the southern terminus of the proposed alignment.

Silverado Formation

The central portion of the proposed Foothill Parkway extension, between Mabey and Hagador Canyon, is underlain by the Paleocene Silverado Formation. This non-marine and marine unit consists of reddish-brown to buff clayey sandstone, siltstone, and conglomerate. The contact between the Silverado Formation and the underlying Cretaceous rocks is an unconformity which represents an episode of deformation and deep erosion. In the vicinity of the proposed roadway alignment the Silverado Formation lies in fault contact with the Ladd Formation. The Silverado Formation sandstones are generally massive and poorly to moderately indurated. Slope stability is generally moderate to good for natural and cut slopes in the Silverado Formation.

Williams and Ladd Formations (undifferentiated)

Cretaceous units of the undifferentiated Williams and Ladd Formations underlie the northern portion of the Foothill Parkway extension from the northwest side of Mabey Canyon, through Wardlow Canyon, to the northern roadway terminus. This sedimentary unit consists of buff to gray colored sandstone, cobble and small boulder conglomerate, siltstone and shale. The sandstone is massively bedded and locally is hard and cliff-forming. This formation underlies the steepest terrain along the alignment and the lack of landslides in the area suggests good natural slope stability. Along strands of the Whittier fault, the undifferentiated Williams and Ladd Formation is juxtaposed with the Silverado Formation.

Ladd Formation

Bedrock units of the Ladd Formation are present in the central portion of the alignment. These Cretaceous marine units consist of conglomerate, sandstone, siltstone and shale. The sandstone and conglomerate are thickly bedded.

FAULTING AND SEISMICITY

Being in the geologically complex area of southern California, the proposed roadway alignment is within a seismically active region and will be subject to seismically related geologic hazards. Any specific area of southern California is subject to seismic hazards of varying degrees, depending on the proximity and earthquake potential of nearby active faults, and the local geological and topographic conditions, which can either amplify or attenuate the seismic waves. The principal seismic hazards that are generally investigated for most development projects in southern California should also be considered during the design of the proposed roadway alignment. The principal seismic hazards to properties are surface rupturing of earth materials along fault traces and damage to structures and foundations due to strong ground motions generated during earthquakes. These hazards are related to the principal active faults in the region, which include the Whittier-Elsinore, Chino, San Andreas, San Jacinto and Newport-Inglewood faults. The Whittier-Elsinore and Chino faults cross the proposed Foothill Parkway extension alignment.

The fault classification criteria adopted by the California Geological Survey defines Earthquake Fault Zones along active or potentially active faults. The classification system of the Alquist-Priolo Earthquake Fault Zoning Act of 1972 is used here. Thus, an active fault is one that has ruptured in Holocene time (the last 11,000 years). A fault that has ruptured during the last 1.8 million years (Quaternary time), but is not proven by direct evidence to have moved or not moved with the Holocene is considered to be potentially active. Any fault older than Pleistocene (1.8 million years) is considered inactive.

The Alquist-Priolo Earthquake Fault Zoning Act was signed into state law in 1972, and was most recently revised in 1997. The primary purpose of the Act is to mitigate the hazard of fault rupture by prohibiting the location of structures for human occupancy across the trace of an active fault. The Act requires the State Geologist to delineate "Earthquake Fault Zones" along faults that are "sufficiently active" and "well defined." The Act also requires that cities and counties withhold development permits for sites within an Earthquake Fault Zone until geologic investigations demonstrate that the sites are not threatened by surface displacements from future faulting. Pursuant to this Act, structures for human occupancy are not allowed within 50 feet of the trace of an active fault. Review of the State of California Alquist-Priolo Earthquake Fault Zones Map for the Corona South Quadrangle indicates that the proposed Foothill Parkway extension is located within a defined earthquake fault zone boundary.

The seismic characteristics of the major seismic sources close to the site are discussed below.

Whittier-Elsinore Fault Zone

The northwest-trending Whittier-Elsinore Fault Zone extends nearly 150 miles from the Mexican border to the northern edge of the Santa Ana Mountains where it crosses the proposed Foothill Parkway extension alignment. The predominant sense of displacement across this fault zone is thought to be right-lateral. From geomorphic evidence, the Whittier-Elsinore fault is considered capable of seismic offsets of up to about 20 feet. Rockwell et al. (1985) suggest offset sediments exposed in trenches to indicate a 200- to 300-year recurrence interval for ground rupturing earthquakes. The fault is generally considered capable of generating earthquakes in the magnitude 7.0 to 7.5 range. The Whittier-Elsinore Fault Zone is considered active by the State of California and an Alquist-Priolo Earthquake Fault Zone has been established around the fault. The fault crosses the central portion of the proposed Foothill Parkway extension alignment.

Chino Fault Zone

The Chino Fault Zone diverges from the Whittier-Elsinore Fault Zone south of Corona and extends northward through the Chino Hills, dying out in the Los Serranos suburb of the city of Chino Hills. The tectonic geomorphology of the Chino Fault Zone indicates predominately right-lateral strike-slip motion with a component of reverse-oblique movement, based on offset ridgeline, deflected drainages and beheaded drainages in the Chino Hills. The Chino Fault Zone is considered active by the State of California and an Alquist-Priolo Earthquake Fault Zone has been established around the fault. The Chino Fault Zone has a long-term slip rate ranging from 0.7 to

2.2 millimeters per year and a magnitude in the 6.5 to 7.0 range. The fault crosses the proposed Foothill Parkway extension near the southern terminus of the alignment, where the fault is buried by quaternary alluvial deposits.

San Andreas Fault

The San Andreas fault is the dominant active fault in California, and is located about 28.3 miles northeast of the proposed Foothill Parkway alignment (at its nearest point to the site). As the main element of the boundary between the Pacific and the North American tectonic plates, the fault extends from Cape Mendocino to the Salton Sea, a distance of about 625 miles (Ziony and Yerkes, 1985). In southern California, the Carrizo, Mojave and Coachella Valley segments of the fault are potential sources of future earthquakes that could result in strong ground shaking along the proposed Foothill Parkway extension. The fault has generated the largest known earthquakes in California and is considered capable of generating earthquakes in the magnitude 7.5 to 8.0 range.

San Jacinto Fault Zone

The San Jacinto Fault Zone is historically the most seismically active fault zone in California and is located about 22.8 miles northeast of the proposed Foothill Parkway extension. Segments of the San Jacinto Fault Zone extend from near San Bernardino southeast more than 190 miles through the Imperial Valley and into northern Baja California, Mexico (Ziony and Yerkes, 1985). At its northern end, this right-lateral strike-slip fault appears to merge with the San Andreas fault. Over the past century, the San Jacinto Fault Zone has produced at least 10 earthquakes of about magnitude 6.0 or greater. Geologic, geodetic and seismologic observations generally point to an average slip rate of 8 to 12 millimeters per year during Quaternary time. This fault zone is generally considered capable of generating earthquakes in the magnitude 7.0 to 7.5 range.

Newport-Inglewood Fault Zone

The Newport-Inglewood Fault Zone is a broad zone of discontinuous faults and folds striking southeastward from near Santa Monica across the Los Angeles basin to Newport Beach. The fault, at its nearest point to the project site, is located about 22.3 miles southwest of the proposed Foothill Parkway extension. The surface trace of the fault zone is discontinuous in the Los Angeles Basin, but the fault zone can easily be noted there by the existence of a chain of low hills extending from Culver City to Signal Hill. South of Signal Hill, the fault roughly parallels the coastline until just south of Newport Bay, where it heads offshore, and becomes the Newport-Inglewood/Rose Canyon Fault Zone. These various faults constitute a system more than 150 miles long. The Newport-Inglewood fault was the source of the destructive 1933 Long Beach earthquake. This right-lateral fault zone represents a major hazard to the densely populated Los Angeles basin, including Orange County. Generally this fault is considered capable of earthquakes up to about magnitude 7.0.

San Joaquin Hills Blind Thrust Fault

The uplift of the folded sedimentary rocks of the San Joaquin Hills is produced by a southwest dipping blind thrust fault that extends at least 23.6 miles from northwestern Huntington Mesa to Dana Point and comes within 1.2 miles of the ground surface (Grant et at., 1997; Mueller et al., 1998). The fault is about 20 miles from the Foothill Parkway extension. Work by Grant et al.

(1997 and 1999) suggest that uplift of the hills began in the Late Quaternary and has continued during the Holocene. Uplift rates have been estimated between 0.25 and 0.5 millimeters per year. The California Geologic Survey estimates that fault rupture on the San Joaquin Hills Blind Thrust could generate an earthquake with a magnitude of 6.6.

GROUNDWATER CONDITIONS

Groundwater levels recorded during a previous investigation (Group Delta, 2001) for the Metropolitan Water District main feeder crossing the proposed Foothill Parkway extension indicated that groundwater levels in the alluvial deposits in Wardlow Canyon range from 18 to 21 feet below the ground surface. There is also the potential for perched groundwater within the area.

Present groundwater depth along the proposed roadway alignment is unknown since geotechnical borings were not performed for this study.

POTENTIAL GEOLOGIC AND SEISMIC HAZARDS

Geologic and seismic hazards are those that could impact a site due to the surrounding geologic and seismic conditions. Potential geologic hazards include: landsliding, erosion, collapsible and expansive soils, subsidence, and volcanic eruptions. Potential seismic hazards include phenomena that occur during an earthquake such as ground shaking, ground rupture, and liquefaction. The geology and seismic hazards have been evaluated in terms of their impact on the proposed project. The following sections provide the results of the geologic hazards evaluation. Assessment of these hazards was based on guidelines established by the California Geologic Survey and outlined in Note 46 (California Division of Mines and Geology, 1975).

Geologic Hazards

Landslides

Slope instability is a condition that can be pre-existing and can pose a negative condition for a proposed project. Landslides often occur along pre-existing zones of weakness within bedrock (i.e. previous failure surfaces). They may also occur on over-steepened slopes, especially where weak layers (i.e. thin clay layers) are present and dip out-of-slope. Landslides can also occur on antidip slopes, along other planes of weakness such as faults or joints. Local folding of bedrock or fracturing due to faulting can add to the potential for slope failure. Groundwater is very important in contributing to slope instability and landsliding. Other factors that contribute to slope failure include undercutting by stream action and subsequent erosion and mass movement of slopes caused by seepage or cyclical wetting and drying.

The geologic map of the Corona South Quadrangle prepared by Gray et al. (2002) showed no landslides mapped within the grading limits of the proposed Foothill Parkway extension. Two landslides, however, have been mapped within ½-mile south of the proposed roadway centerline in bedrock units of the Silverado, Williams and Ladd Formations. These landslides are located within the Whittier Fault Zone and suggest that bedrock units within the fault zone may be more susceptible to sliding due to severe shearing and fracturing associated with tectonic stresses.

Slope areas within or adjacent to the proposed alignment that are also within the Whittier Fault Zone may be susceptible to slope instability. Assuming that during design and construction any existing landslides or potentially unstable slopes are identified and treated with the appropriate remedial grading to achieve stable slopes, the potential for landsliding affecting the Foothill Parkway extension is considered low.

Unstable Cut and Fill Slopes

Construction of a project can trigger slope instability, due to exposure of unsupported planes of weakness or removal of material that was previously resisting slope failure. The stability of cut and fill slopes is primarily a function of the steepness of the slope, the character of the material (including its discontinuities) that the slope is composed of and the groundwater conditions. In general, these conditions can be readily investigated and analyzed, and slopes with favorable stability can be designed and constructed.

Assuming all cut and fill slopes proposed along the Foothill Parkway extension will incorporate standard practices during design and construction to identify any unstable conditions, and remedial recommendations are adhered to, the potential for unstable slopes at completion of grading is low.

Collapsible and Expansive Soil

Bedrock underlying the Foothill Parkway extension is generally only slightly compressible and is expected to adequately support embankment fills and roadway loads. Man-made fill and alluvium along the alignment are typically compressible and may be collapsible; as a result, these materials may not be suitable for support of fill and structural loads in their natural state.

Expansive soils generally result from having high percentages of expansive clay minerals, such as montmorillonite. These fine-grained soils can undergo substantial increases and decreases in volume with an increase and decrease in water content, respectively. If not adequately addressed, expansive soils can cause extensive damage to structures and paving. Remedial earthwork or in-situ treatment of expansive soils can reduce potential adverse impacts to structures and paving. Also, structures can be designed to accommodate forces due to soil expansion.

Assuming that during final design and construction, soils with the potential to collapse or expand will be identified, evaluated and mitigated, the potential of damage related to these soils is low.

Trench-Wall Stability

The stability of trench walls depends largely on the character of the material to be excavated and the size and shape of the excavation. In most cases, intact bedrock will tend to be stable, requiring less support, whereas the softer materials, such as alluvium and man-made fill will tend to be more unstable and will require more support. The presence of groundwater is also an important factor and excavations below groundwater may require temporary dewatering to achieve stability.

Recommendations regarding trench-wall stability will be provided during design of the Foothill Parkway extension. Assuming that the recommendations together with standard construction safety requirements will be adhered to during construction of the roadway, the potential hazards associated with trench-wall stability can be avoided.

Land Subsidence

If a project involves extraction of fluids or gas, there is the potential for causing subsidence. For example, in the area of Wilmington, California, years of oil extraction with no mitigation resulted in many feet of subsidence. Similarly, in the San Joaquin Valley, many years of groundwater extraction have resulted in significant subsidence. Depending on whether the area is developed, subsidence can cause extensive problems, which can be very costly to mitigate.

There are no known ongoing or planned large-scale extractions of groundwater, gas, oil, or geothermal energy that could cause subsidence in the project area. Therefore, there is no known hazard related to land subsidence along the proposed Foothill Parkway extension.

Volcanic Hazard

If a project area were located in proximity to an active volcano, and located downhill and in a topographically unprotected location, there would be the potential for damage from lava flow.

There are no active or potentially active volcanoes in the region of the Foothill Parkway extension. Therefore, there are no volcanic hazards associated with the roadway extension.

Seismic Hazards

Seismic hazards are those hazards associated with earthquakes such as ground shaking, ground rupture, liquefaction, differential compaction or seismic settlement and other phenomenon. The proposed Foothill Parkway extension, like most of southern California is susceptible to ground shaking generated during earthquakes on nearby faults. Potential seismic hazards and how they may affect the Foothill Parkway extension are discussed in the following sections.

Surface Fault Rupture

Primary ground rupture is ground deformation that occurs along the surface trace of the causative fault during an earthquake. The proposed Foothill Parkway extension is crossed by active faults within the Whittier-Elsinore and Chino Fault Zones. Alquist-Priolo Earthquake Fault Zones have been established by the State of California around these faults and the southern two-thirds of the proposed roadway alignment lies within these zones.
Since no development for human occupancy is proposed as part of the Foothill Parkway extension, a detailed fault investigation to determine if any fault strands that cross the alignment are active is not required. However, if no trenching is performed to determine the degree of fault activity, then damage to the roadway and associated structures due to surface fault rupture should be considered possible.

Strong Ground Motion

The potential for strong ground motion affects most of California and like other similar facilities, the Foothill Parkway extension would be subject to strong ground motion. Strong ground motion occurs as energy is released during an earthquake. Ground motion intensity depends on: distance between faults and roadway alignment; the magnitude of the earthquake; and, the geologic conditions underlying and surrounding the alignment. Earthquakes occurring on the faults that cross the proposed Foothill Parkway extension will likely generate the largest ground motions.

The most significant faults relative to the project area are listed in the table below along with estimates of their maximum earthquake magnitude and the peak bedrock acceleration. The peak bedrock acceleration was determined using the Caltrans Seismic Hazard Map (Caltrans, 1996a) and the attenuation relationship of Mualchin (1996b).

Fault or Fault Zone	*Style of Faulting*	*Maximum Credible Earthquake (MCE) Magnitude (M)*	*Approximate Distance From Site (miles)*	*Peak Bedrock Acceleration (g)*
Whittier-Elsinore (WEE)	Strike-slip	7.5	< 1.0	0.71
Chino Fault (CNO)	Strike-slip	6.5	< 1.0	0.58
San Andreas Fault (SAC)	Strike-slip	8.0	28.3	0.22
San Jacinto Fault (SJO)	Strike-slip	7.5	22.8	0.17
Newport-Inglewood-Rose Canyon/E (NIE)	Strike-slip	7.0	22.3	0.13

Notes:
1. *Style of faulting as indicated in "A Technical Report to Accompany the Caltrans Seismic Hazard Map," by Mualchin (Caltrans, 1996b).*
2. *Distance from fault to the project site was obtained from the Caltrans Seismic Hazard Map (1996a).*
3. *Peak bedrock accelerations are based on attenuation relationship of Mualchin (1996b) and the Caltrans Seismic Hazard Map (1996a).*

The potential for strong ground motion cannot be reduced, but damage potential can be mitigated by incorporating appropriate design and construction techniques. Design and construction of the Foothill Parkway extension will incorporate geotechnical and structural recommendations and current codes and practices relative to ground motions. Therefore, the potential for damage due to seismic ground motion will not be precluded, but will be reduced to normal levels for this type of project.

Liquefaction

Liquefaction is the loss of soil strength or stiffness due to a buildup of pore-water pressure during a seismic event and is associated primarily with relatively loose, saturated fine- to medium-grained cohesionless soils. As the shaking action of an earthquake progresses, the soil grains are rearranged and soil densifies. Densification of the soil results in a buildup of pore-water pressure. When the pore-water pressure reaches the total overburden pressure, soil strength becomes near zero and liquefaction occurs. Surface manifestations of liquefaction include sand boils, settlement and, bearing capacity failures below structural foundations. In addition, slopes can suffer lateral movement due to liquefiable soils situated beneath the toe of slopes.

Liquefiable soil conditions are not uncommon in alluvial deposits in moderate to large canyons and may also be present in other areas of alluvial soils where the groundwater level is shallow. Bedrock units, due to their dense nature, are unlikely to present a liquefaction hazard.

The proposed alignment for the Foothill Parkway extension crosses a number of large, alluvial-filled canyons including Wardlow, Mabey and Hagador Canyons. Also, young and old alluvial fan deposits underlie the south portion of the alignment as it enters the Corona Plain. Since alluvial sediments commonly have an unconsolidated nature and can experience shallow groundwater conditions, liquefaction should be considered possible in these areas. During final design for the roadway, the liquefaction potential of unconsolidated alluvial deposits should be defined and, if needed, remedial recommendations provided to avoid liquefaction. Because the final design and construction of the proposed Foothill Parkway extension will incorporate these recommendations, the potential for liquefaction related damage along the alignment will be low.

Seismically-Induced Landsliding

If subjected to strong seismic shaking, existing landslide masses and slopes composed of weak materials can move downhill. No existing landslides have been mapped along the alignment of the proposed Foothill Parkway extension; however, the potential for heavily sheared and fractured material should be considered due to the proximity of the alignment to the Whittier-Elsinore Fault Zone. Left untreated, areas of weak materials could be subject to movement triggered by strong seismic shaking and thus, an adverse condition could exist.

The susceptibility of existing weak materials, on natural or manufactured slopes, to movement during strong seismic shaking can be estimated using information obtained from geologic field investigations and laboratory testing. During design of the project, areas of weak materials will be investigated in detail and remedial grading options will be developed to stabilize materials that are susceptible to seismic landslide movement. Consequently, the potential for earthquake-triggered movements is considered low.

Seismically-Induced Settlement and Differential Compaction

Seismically-induced settlement and differential compaction occurs when relatively soft or loose soils experience a reduction in volume (compaction) caused by strong ground motion. Soil conditions subject to these hazards include unconsolidated soils or areas where weak soils of variable thickness overlie firm soil or bedrock. The type of materials that would be more likely to experience seismically-induced settlement and differential compaction are deposits of alluvium and possibly poorly constructed man-made fills. If structures were built on such soils, settlement damage could result in the event of strong seismic shaking. Final design geotechnical studies will evaluate this potential and provide design and construction recommendations to mitigate this hazard. Thus, at completion of construction, the potential for damage related to seismically-induced settlement and differential compaction is considered low.

Earthquake-Induced Flooding

Earthquake-induced flooding may occur if strong seismic shaking causes the failure of a dam which retains water. The only dam-type facility in close proximity to the Foothill Parkway extension is the Mabey Canyon retention basin. This facility is used for flood control and typically does not retain water year round. The probability is very low that strong seismic shaking would occur during the limited time when the retention basin is holding water; therefore, the downstream hazard of seismically-induced flooding is very low.

Another form of earthquake-induced flooding can occur by the temporary damming of an active river channel due to landsliding and a subsequent sudden release of the impounded water. Since there are no significant active river channels above the proposed Foothill Parkway extension, the potential of flooding from this source is not considered a seismic hazard.

Other Seismic Hazards

Other potential seismic hazards include tsunamis and seiches. A tsunami is a great sea wave (commonly called a tidal wave) produced by a significant undersea disturbance such as tectonic displacement of the sea floor associated with large, shallow earthquakes. A seiche is an oscillation of a body of water in an enclosed or semi-enclosed basin (such as a reservoir, harbor, lake or storage tank resulting from earthquakes or other large environmental disturbances. The potential for tsunamis and seiches impacting the alignment is not considered a risk due to the site's distance from the Pacific Ocean and the absence of lakes or large bodies of water in the immediate area.

MINERAL RESOURCES

There is a continued need for natural resources, such as petroleum products for fuels and building materials for roads and structures. With time, existing resources are depleted and new sources must be identified and mined to support continued needs. As more and more land is developed, additional pressure is placed on assuring an adequate supply of natural resources. Therefore, it is important that each new project be evaluated to determine whether it might preclude access to an important resource, change the land use so that a resource can no longer be removed or create zoning restrictions so that access to the resource is no longer allowed.

In the vicinity of the proposed Foothill Parkway extension, mining operations have occurred in the past. The majority of the activity involved mining of clay minerals in Wardlow Canyon within the Silverado and Ladd Formations for brick and clay pipe during the 1920's through the 1950's. South and west of the proposed alignment there was also clay mining in Mabey Canyon and gypsum mining in Hagador Canyon.

Grading for the proposed Foothill Parkway extension would result in placement of embankment fills that would limit access to the abandoned clay mines within Wardlow Canyon. Since these mines have been closed since the 1950's and production from them was small, the impact on mineral resources due to the construction of the Foothill Parkway extension would be low.

If you have any questions regarding the above information or require additional information please call our office. We appreciate the opportunity to be of assistance.

Sincerely,
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Attachments: 1. References.
2. Figure 1. Site Location Map.
3. Figure 2. Physiography and Fault Map.
4. Figure 3. Geologic Map.

ATTACHMENTS

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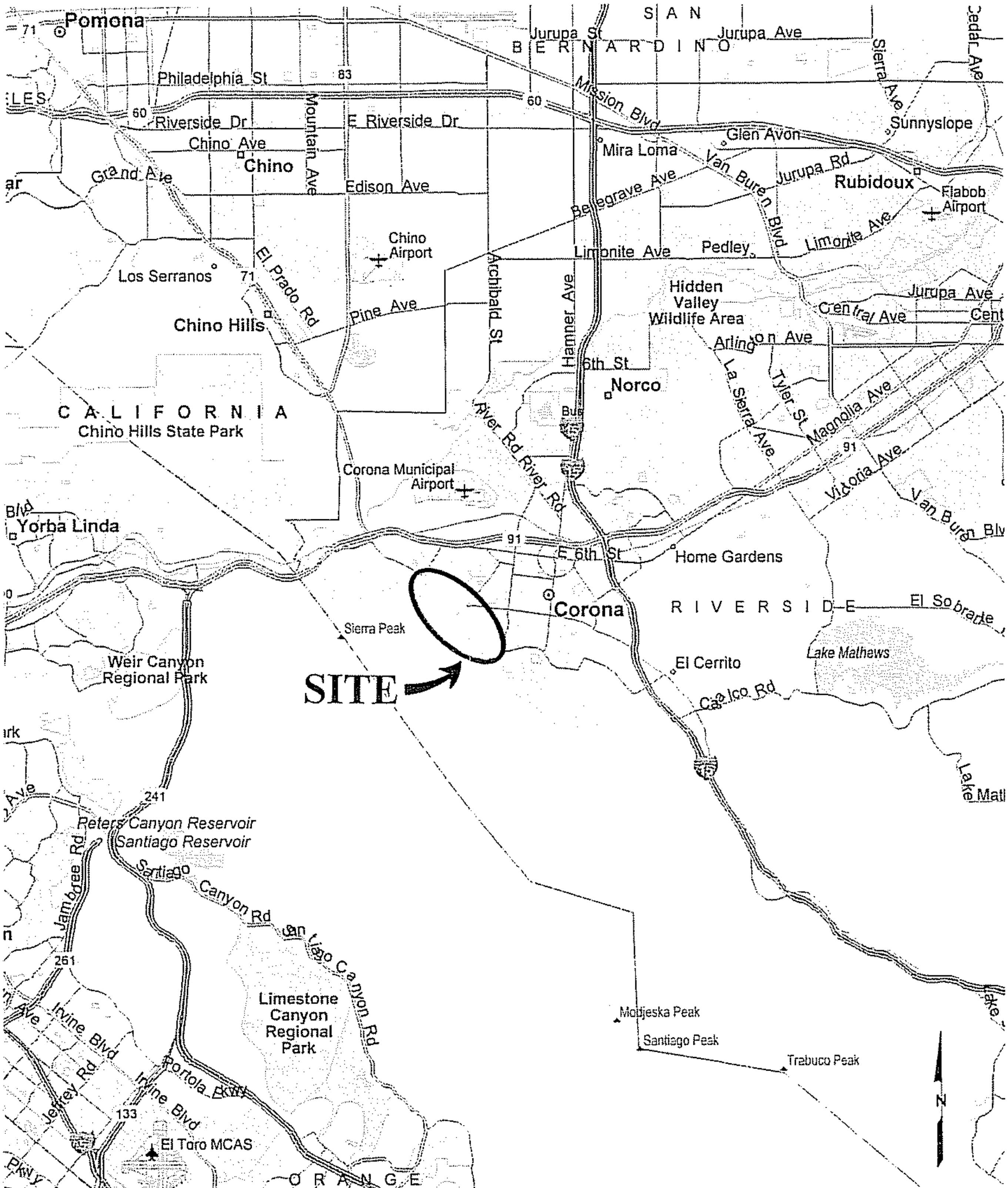

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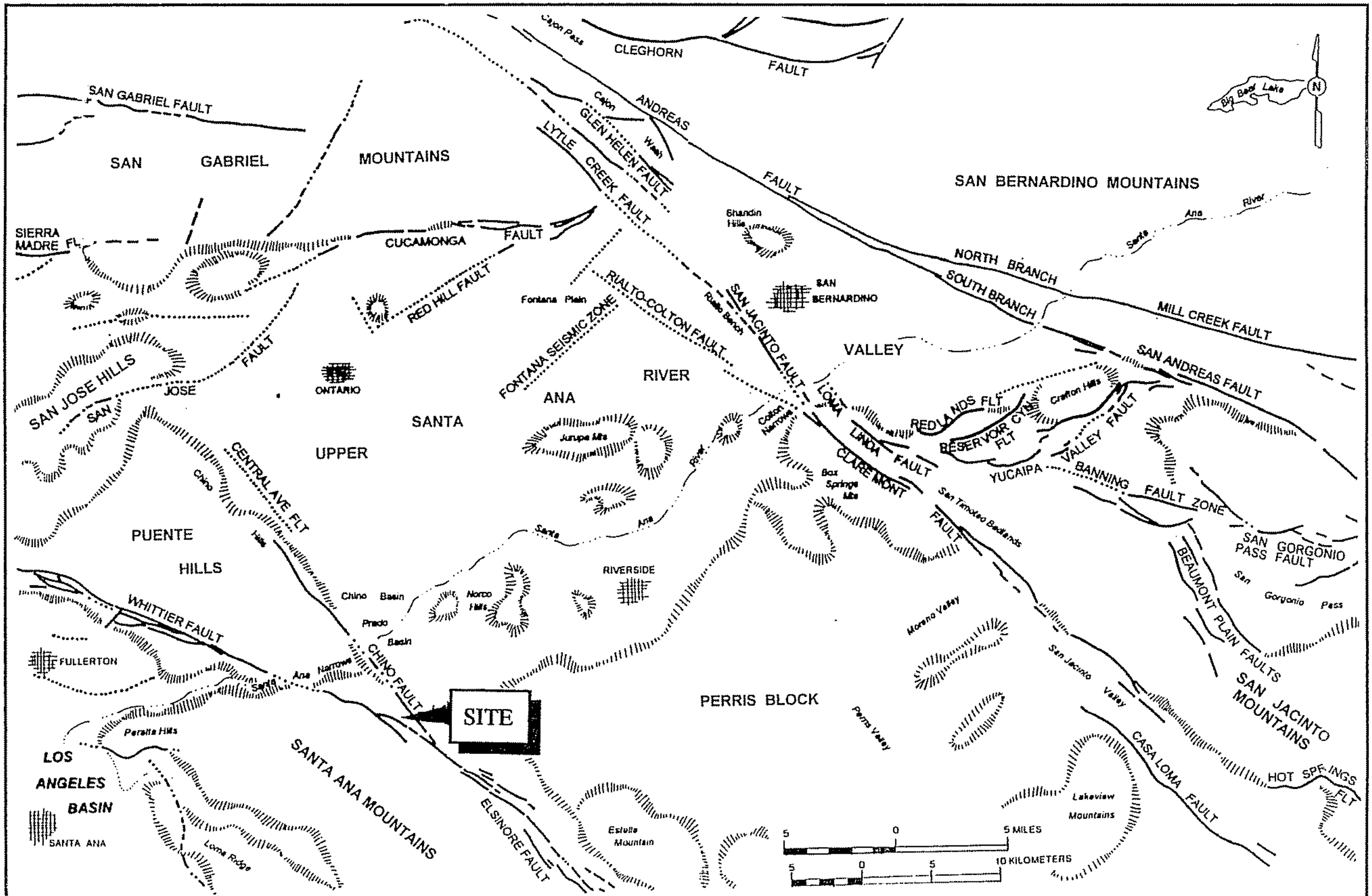
SITE LOCATION MAP

Figure 1

FOOTHILL PARKWAY WESTERLY EXTENSION	Project No. 06-125	Date: 7-7-06



Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	FOOTHILL PARKWAY WESTERLY EXTENSION	PHYSIOGRAPHY AND FAULT MAP
	Project No. 06-125 / Date: 7-7-06	Figure 2

Source: Gray et al., 2002, Geologic Map of the Corona South 7.5" Quadrangle, USGS OFR 02-21

N

No Scale

Geologic Map
Foothill Parkway Extension

Figure 3

DESCRIPTION OF MAP UNITS

MODERN SURFICIAL DEPOSITS—Sediment recently transported and deposited in channels and washes, on surfaces of alluvial fans and alluvial plains, and on hillslopes. Soil-profile development is non-existent. Includes:

Qaf — **Artificial fill (late Holocene)**—Deposits of fill resulting from human construction or mining activities; includes numerous noncontiguous areas related to sand and gravel operations and flood control in and adjacent to Temescal Wash and to road grade and ramps along Corona Freeway segment of Interstate 15

YOUNG SURFICIAL DEPOSITS—Sedimentary units that are slightly consolidated to cemented and slightly to moderately dissected. Alluvial fan deposits (Qyf series) typically have high coarse:fine clast ratios. Younger surficial units have upper surfaces that are capped by slight to moderately developed pedogenic-soil profiles (A/C to A/AC/B/C_{ox} profiles). Includes:

Qyw — **Young wash deposits (Holocene and late Pleistocene)**—Sand, gravel and boulder deposits. Restricted to Silverado Canyon in southern part of quadrangle

Qyf — **Young alluvial fan deposits (Holocene and late Pleistocene)**—Gray-hued gravel and boulder deposits derived largely from volcanic and sedimentary units of Santa Ana Mountains. Fans consisting mainly of gravel emanate and coalesce from Tin Mine, Hagador, Main Street, and Eagle Canyons. Fan emanating from Bedford Canyon is coarser grained, containing a large component of boulders. All fans coarsen toward mountains. Locally, young alluvial fan deposits are divided into subunits based on sequential terrace development and other factors; one such unit is found in quadrangle:

Qyf_1 — **Young alluvial fan deposits, Unit 1 (Holocene and late Pleistocene)**—Consists of pale-gray, unconsolidated, cobble- to granule- sized gravel. Restricted to single fan bisected by younger Qyf fan emanating from Main Street and Eagle Canyons. Forms older part of Qyf unit. Precise distance this unit may have been displaced from its source area by young faults terminating upper part of fan is unknown, but estimated to be small

Qya — **Young alluvial channel deposits (Holocene and late Pleistocene)**—Gray, unconsolidated alluvium. Found chiefly in Temescal Wash and its tributaries, where it consists of medium- to fine-grained sand in lower reaches and coarsens to gravel and cobbles up stream. Also found in Wardlaw Canyon and its tributaries, and in Ladd Canyon in southwestern part of quadrangle

Qyls — **Young landslide deposits (Holocene and late Pleistocene)**—Rock debris and rubble, unsorted. All or parts of many Qyls landslides subject to renewed movement; primary landslide morphology typically preserved. Found mainly on lower part of northeastern slope of Santa Ana Mountains

OLD SURFICIAL DEPOSITS—Sedimentary units that are moderately consolidated and slightly to moderately dissected. Older surficial deposits have upper surfaces that are capped by moderately to well-developed pedogenic soils (A/AB/B/Cox profiles and Bt horizons as much as 1 to 2 m thick and maximum hues in the range of 10YR 5/4 and 6/4 through 7.5YR 6/4 to 4/4 and mature Bt horizons reaching 5YR 5/6). Includes:

Qof — **Old alluvial fan deposits (late to middle Pleistocene)**—Moderately indurated, gravel and cobble alluvial fan deposits. Flanks Qyf unit emanating from Bedford Canyon and Qyf_1 unit emanating from main Street and Eagle Canyons. Most of unit is slightly to moderately dissected and reddish-brown. Some Qof includes thin, discontinuous surface layer of Holocene alluvial fan material. Includes:

Qof_1 — **Old alluvial fan deposits, Unit 1 (middle Pleistocene)**—Indurated, gravely alluvial fan deposits. Most are slightly to moderately dissected; reddish-brown. Some deposits include thin, discontinuous surface layer of Holocene alluvial fan material. In quadrangle, restricted to single occurrence flanking Qyf fan west of Corona

Qols — **Old landslide deposits (late to middle Pleistocene)**—Mostly fragmented rock debris. Landslide morphology moderately to greatly modified. Restricted to fault-bounded deposits at foot of Santa Ana Mountains between Eagle and Bedford Canyons

VERY OLD SURFICIAL DEPOSITS—Sediments that are slightly to well consolidated to indurated, and moderately to well dissected. Upper surfaces are capped by moderate to well developed pedogenic soils (A/AB/B/C_{ox} profiles having Bt horizons as much as 2 to 3 m thick and maximum hues in the range 7.5YR 6/4 and 4/4 to 2.5YR 5/6)

Qvof — **Very old alluvial fan deposits (early Pleistocene)**—Mostly well-dissected, well-indurated, reddish-brown cobble and gravel deposits. Commonly contains duripans and locally silcretes. Found scattered along foot of Santa Ana Mountains and extending out from foot for 3 km. Most are fault-bounded and probably displaced laterally, as they commonly do not head at major canyons. Includes:

$Qvof_1$ — **Very old alluvial fan deposits, Unit 1 (early Pleistocene)**—Mostly well-dissected, well indurated, reddish-brown alluvial fan deposits. Grain size chiefly cobbles and gravel. Represents old part of Qvof. Found as fault slices and noncontiguous deposits resting on Paleocene Silverado Formation and on Cretaceous heterogeneous granitic rock in Temescal Valley

Qvoa — **Very old alluvial channel deposits (early Pleistocene)**—Gravel, sand, and silt; reddish-brown, well-indurated, surfaces well-dissected. Underlies large area between Santa Ana River and Temescal Wash

Tvs — **Vaqueros and Sespe Formations, undifferentiated (early Miocene, Oligocene, and late Eocene)**—Interbedded marine and nonmarine sandstone and conglomerate assigned to the Sespe and Vaqueros Formations. Occurs in northwestern corner of quadrangle and as fault and alluvium bounded blocks south of El Cerrito. Locally, marine fossil-bearing strata of Vaqueros Formation are bed-by-bed interlayered with nonmarine rocks of Sespe Formation to degree that formations cannot be mapped as separate units. Undifferentiated unit locally includes boulder conglomerate (Woodford and others, 1973)

Tvss — **Vaqueros, Sespe, Santiago and Silverado Formations, undifferentiated (early Miocene, Oligocene, late Eocene, and Paleocene)**—Marine and nonmarine sandstone and conglomerate of Sespe, Vaqueros, and Silverado Formations. Found only on small hill between Home Gardens and El Cerrito.

Tsi — **Silverado Formation (Paleocene)**—Nonmarine and marine sandstone, siltstone, and conglomerate. Dickerson (1914) first recognized Paleocene rocks in Santa Ana Mountains, and based on faunal similarities, correlated strata with Martinez Formation of central California. Woodring and Popenoe (1945) described unit in detail and named it Silverado Formation. Formation was deposited on deeply weathered erosional surface. Rocks underlying Silverado are characteristically saprolitic. Silverado Formation consists of basal conglomerate, locally boulder-bearing, overlain by relatively thin sequence of sandstone and siltstone. Sandstone and siltstone sequence is overlain by thick sequence of sandstone, siltstone, and conglomerate which includes two distinctive clay beds of commercial importance. In addition to clay, upper part of section contains carbonaceous shale and lignite beds. Thicker lignite beds were locally mined for fuel. Upper part of unit also contains abundant marine mollusks. Some eastern exposures of formation contain distinctive and diagnostic Paleocene *Turritella pachecoensis*

Kwl — **Williams and Ladd Formations, undifferentiated (Upper Cretaceous)**—Sandstone, siltstone, conglomerate, and conglomeratic sandstone of Williams and Ladd Formations; all are feldspathic. Williams Formation typically conglomeratic throughout; Ladd Formation contains thick sequences of non-conglomeratic shale and siltstone. However, both formations contain rocks ranging from conglomerate to shale. Williams Formation typically resistant, cliff-forming, white to brownish-gray, massive-bedded, poorly sorted feldspathic sandstone, pebbly sandstone, and conglomeratic sandstone. Unconformity separates two formations

Kl — **Ladd Formation (Upper Cretaceous)**—Conglomerate, sandstone, siltstone, and shale. Named by Popenoe (1942) for exposures just west of mouth of Ladd Canyon, northern Santa Ana Mountains. Popenoe divided formation into older Baker Canyon Conglomerate Member and younger Holz Shale Member as follows:

Klhs — **Holz Shale Member**—Interbedded marine shale, siltstone, sandstone, and localized conglomerate beds. Sandstone beds are mostly massive, but locally crossbedded. Unit contains 5 cm- to 1 m-wide calcite cemented concretions. Foraminifera are widespread and megafossils abundant in places. Except for resistant conglomerate beds, Holz Shale weathers to form smooth rounded slopes. Unit includes prominent zone of concentrated sandstone and conglomerate beds

Klbc — **Baker Canyon Conglomerate Member**—Marine and locally nonmarine(?) conglomerate. Lower part is gray conglomerate containing clasts up to 2 m across, derived mainly from granitic and volcanic rocks. Granitic clasts appear to be from Cretaceous Peninsular Ranges batholith and volcanic clasts from Cretaceous Santiago Peak Volcanics. Upper part of conglomerate is brown conglomeratic sandstone and pebble conglomerate. Sparse sandstone beds contain abundant mollusk shells. Conglomerate is similar to the Cretaceous Trabuco Formation and locally interfingers within the Trabuco Formation west of the quadrangle. Pelecypods indicate deposition in primarily shallow-water environment

Kmp — **Micropegmatite granite (Cretaceous)**—Fine-grained, pink-tinted, leucocratic granite having distinctive micropegmatitic texture. In quadrangle, restricted to hill 1 km northwest of Home Gardens. Most of unit is in Corona North quadrangle where it forms elongate band of outcrops between Corona and Norco

Kcg — **Monzogranite of Cajalco pluton of Morton (1999) (Cretaceous)**—Mostly biotite and biotite-hornblende monzogranite ranging to granodiorite. Exposed north and east of El Cerrito; very extensive in Lake Mathews 7.5' quadrangle to east. Medium grained equigranular to subporphyritic. Informally named for exposures in Cajalco area, Lake Mathews 7.5' quadrangle (Morton, 1999). Rocks of Cajalco pluton were included within Cajalco quartz monzonite by Dudley (1935) and within Woodson Mountain granodiorite by Larsen (1948). Body is composite, shallow-level pluton emplaced by magmatic stoping within largely volcanic and volcaniclastic rocks. It was tilted eastward and eroded to progressively greater depths from west to east. East of quadrangle, upper part of pluton contains very prominent halo of highly tourmalinzed rock. Zircon ages are 109.5 Ma_{id} and 112.6 Ma_{ip}. Within quadrangle unit includes:

Kgu — **Granite, undifferentiated (Cretaceous)**—Equigranular, leucocratic fine-to coarse-grained massive granite and biotite monzogranite. Consists of