TABLES

FIGURES

SECTION 4.6

Geology, Soils, and Seismicity

This section of the EIR presents a description of the existing geology, soils, and seismic conditions in the project area and analyzes potential physical environmental effects of the proposed project related to seismic hazards, underlying soil characteristics, slope stability, erosion, and excavation of soils.

Public comments received in response to the Notice of Preparation included concerns on the following topics:

- Soil compaction and erosion from increased traffic on the north campus loop road and increased trail use
- Erosion impacts from construction
- Potential impacts due to karst instability
- Potential for landslides and wash-outs of Empire Grade Road near Cave Gulch
- Increased runoff and erosion from increased impermeable surfaces (roofs, walkways, roadways)

All of these issues are addressed in this section, except potential for increased runoff and erosion, which is addressed in Section 4.8, *Hydrology and Water Quality* (Volume II).

4.6.1 Environmental Setting

A campus geology map and report were prepared by Nolan, Zinn, and Associates (2005) updating an earlier map and report prepared in 1993 by Weber & Associates. Much of the description and analysis of geologic conditions presented in this section is summarized from the updated campus geology report. Additional information was obtained from various EIRs prepared for previous projects on the campus.

4.6.1.1 Study Area

4.6.1.2 Geologic Overview

Regional Geology

The UC Santa Cruz campus is located in the central portion of the Coast Ranges Physiographic Province of California. This province, a sub-division of the Pacific Mountain System as defined by the U.S. Geological Survey, parallels the coastline and stretches from the California/Oregon border to Santa Barbara. It contains a series of northwest-southeast-trending coastal mountain ranges, the structures of which are primarily controlled by faulting along a complex of faults that forms the San Andreas Fault System (Nolan, Zinn and Associates 2005). The campus is located on the southwest end of Ben Lomond Mountain, one of the ranges that make up the Santa Cruz Mountains. The project site (main campus and

2300 Delaware Avenue) is shown on Figure 4.6-1, *Site Topographic Map*. Figure 4.6-2, *Regional Geologic Map*, presents regional geology and Figure 4.6-3, *Area Faults*, shows faults in the region.

Ben Lomond Mountain consists of a series of broad, gently sloping marine terraces stepping upward from the shoreline to a height of 2,600 feet at the summit in the northwest. At least five terraces stranded above the present sea level by episodic uplifting have been identified (Warrick 1982). The mountain is situated within the structurally complex granitic and metamorphic basement rock complex of the Salinian block, a large structural feature bounded on the east by the San Andreas fault zone and on the west by the Sur-Nacimiento and San Gregorio fault zones. The “basement complex” consists of plutonic igneous and metamorphic rocks. Metamorphic rocks (which include quartz-mica schist, limestone marble, and small amounts of quartzite and gneiss) underlie most of the campus. The metamorphic rocks are surrounded and have been invaded by a variety of intrusive igneous rocks. The dominant igneous rock is quartz diorite, but both dikes and irregularly shaped bodies of granodiorite, alaskite, and pegmatite are scattered throughout the campus.

Local Geology

The UC Santa Cruz campus slopes upward from an elevation of 300 feet at its southern boundary on High Street to an elevation of 1,200 feet at its northwestern corner, as shown on Figure 4.6-4, *Site Geologic Map*. The average north/south slope is slightly greater than 5 percent. This slope includes a series of marine terraces that defines its unique appearance, as described above. The terraces roughly correspond with lower, central, north, and upper campus areas. Along the flanks and margins of the numerous stream drainages crossing the campus, slope gradients generally range from approximately 25 to 70 percent.

Beneath the surface soils and sedimentary rocks on campus, the geologic basement complex consists of two major rock types: a marble/schist substrate and a granitic substrate (see Figure 4.6-4 and Figure 4.6-5, *Geologic Cross Sections*). The marble/schist substrate underlies most of the campus, including the central, lower, and north campus. Granitic rock underlies the upper campus area and the north campus west of Cave Gulch, and also forms intrusions into the marble in the central and lower campus.

In the north and upper campus (generally, all areas north of McLaughlin Drive) the schist and granitic rocks are overlain in some areas by thin (5- to 30-foot) eroded remnants of the Santa Margarita sandstone and marine terrace deposits. Groundwater occurs in portions of the Santa Margarita sandstone as well as within the weathered schist and granitic rock formations. In the north campus, depths to groundwater generally range from approximately 1 foot to more than 21 feet below ground surface (bgs) (Nolan Associates 2000).

The southern half of the UC Santa Cruz campus is underlain almost entirely by marble and schist. The marble underlying much of the central and lower campus contains an extensive system of solution cavities, formed by the dissolution of limestone and marble by groundwater. The solution cavities form underground channels that store groundwater and allow for its transport. The locations of these channels are predominantly determined by bedrock fractures that provide zones where water can penetrate, weather, and dissolve the rock, eventually widening the fracture. The extent of the marble on campus can be distinguished on the surface by the development of “karst topography,” a landscape unique to limestone and few other highly soluble rocks. Karst topography is characterized by the absence of an integrated surface drainage system and the presence of sinkholes, which form closed depressions (see Section 4.6.1.7, *Karst Hazard and Subsidence*, for further detail). Most surface drainage on the central and lower campus is captured by the karst system and is discharged in springs at lower elevations. Depth to groundwater in the fractured marble aquifer system is highly variable; at some locations it was encountered at approximately 100 feet bgs while at other locations, groundwater was not encountered even at 300 feet bgs.

The geologic structure of the UC Santa Cruz campus is dominated by two major orthogonal, mutually independent, fracture systems that trend approximately north-south and east-west. A secondary set of fractures is orientated northwest-southeast. A significant proportion of the fractures deviate from the predominant pattern. East of campus, almost along the campus boundary, the basement complex is bounded by a large vertical fault, the Ben Lomond fault (Nolan, Zinn and Associates 2005). This fault is important in that it probably provides a barrier to eastward movement of groundwater and controls the locations of spring-fed ponds in the West Lake area, as shown in Figure 4.8-4, in Section 4.8, *Hydrology and Water Quality* (Volume II).

Marble Bedrock. The marble bedrock underlying the campus is a limestone marble composed primarily of calcite. The marble is dense and solid in some areas and highly fractured in others. Karst features (including ravines, sinkholes, closed depressions, swallow holes, underground streams, and caverns) develop in areas of fracture, joints, and faults where groundwater flow dissolves the marble. Sinkholes form from the collapse of caverns or from the gradual settling of the ground surface over an area of dissolving marble. Karst features are readily apparent in the lower campus and are also present in parts of the middle or central campus. At least 30 sinkholes, ranging from a few feet to hundreds of feet in diameter, small caves, and a number of creeks that disappear into swallow holes are found on campus. The karst terrain is also deeply incised by the three major campus drainages that extend through the southern two-thirds of campus in a north/south direction. These include Cave Gulch, Moore Creek, and Jordan Gulch.

Schists. Schists, which are metamorphic rocks composed of layers of mostly micaceous minerals, are found throughout the central and upper campus, interbedded with the marble bedrock. The schist found on campus is a gray to medium-brown quartz mica schist, although where it is deeply weathered and oxidized it becomes red or red-brown.

Granitic Bedrock. The granitic bedrock on campus was formed when granitic magmas rose through the earth's crust, forming intrusions (i.e., plutons) that were trapped beneath overlying rock. These intrusions cooled to form quartz diorite and other granitic rocks. The largest body of granitic rock on campus is composed mostly of quartz diorite and is located in a portion of campus north of Cave Gulch (Rogers Johnson and Associates 1987). Seismic refraction surveys of the upper campus indicate the presence of a surficial weathered zone in the granite up to 100 feet thick. Other granitic intrusions occur in several campus locations, including the area behind the Cook House in the main entrance area, the area south of Stevenson College, and the area southwest of the intersection of Red Hill Road and North Fuel Break Road (Rogers Johnson and Associates 1987).

Sedimentary Deposits. Upper Miocene Santa Margarita sandstone is one of the sedimentary rocks overlying the basement rock complex in scattered patches on the north campus. These are the eroded remnants of a much larger blanket that once covered most of central Santa Cruz County. Quaternary marine deposits also overlie other rock units on campus as a veneer that ranges from a few feet to about 30 feet in thickness (Rogers Johnson and Associates 1985).

Mima Mounds. An unusual geologic feature on the campus is the "mima mounds" topography in the southwestern corner of the campus and in Marshall Field. These low flattened, natural mounds are 30 to 60 feet in diameter, and are sometimes separated from each other by moist depressions called vernal pools or "hogwallows." The mounds generally occur in flat to gently sloping grassland areas with clay pan or hardpan soils that are waterlogged during the rainy season. During this period the vernal pools fill with water, while the mima mounds remain relatively dry. The process by which the mima mounds were formed is not understood.

Geologic Structure. The geologic structure of the campus, as mentioned above, is dominated by two major orthogonal fracture systems and one secondary set. High-angle reverse and normal faulting has occurred parallel to the two major fracture orientations. The east-west faults are offset by the north-south faults indicating the relative ages of the two faulting events. The dip-slip separation along these faults is probably on the order of 50 to 100 feet (Rogers Johnson and Associates 1987). The small amount of structural data available suggests that the schist and marble have been folded into a series of synclines and anticlines, whose axes trend roughly east-west.

4.6.1.3 Soils

Soil Types

On campus, the weathering of bedrock and the action of vegetation have resulted in a large variety of soils types, which vary in composition, texture, and thickness. The Soil Conservation Service (SCS 1980) identified 12 different soil types and complexes on the campus. As shown in Figure 4.6-6, *Soils on UC Santa Cruz Campus*, seven of the soil types are dominant in that they are of greatest areal extent on the campus. These major soil types are discussed below by the geographic areas of the campus. Additional soil types are present but they are of relatively minor aerial extent. Most of the soil on campus is loam, a mixture of clay, silt, sand, and organic matter.

Upper/North Campus Soils. Soil types in the north and upper campus are predominantly the Watsonville loam, Lompico-Felton complex, and the Aptos loam. Watsonville loam is found on coastal terraces and formed in alluvium. The thickness of this unit is about 4 to 5 feet. Watsonville loam has very low permeability and the erosion hazard is slight to moderate. The Lompico-Felton complex is found on foot slopes and near ridge tops. It is composed of material weathered from sandstone, shale, siltstone, mudstone or schist. It is typically 3 feet thick. Permeability of the Lompico-Felton complex soil is moderate and the erosion hazard is very high. Aptos loam is found on hills and mountains and is composed of material weathered from sandstone, siltstone, or shale. It is typically about 3 feet thick and overlies a weathered fractured shale. Aptos loam has moderate permeability and moderate erosion potential.

Central/Lower Campus Soils. The dominant soil type in the central campus is the Nicene-Aptos complex and the soil types in the lower campus are predominantly Elkhorn sandy loam, Los Osos loam, Ben Lomond-Felton complex, and Watsonville loam. The Nisene-Aptos complex is mainly found on foot slopes of the Santa Cruz Mountains and is composed of material eroded from sandstone, siltstone, or shale. It is typically about 5 to 9 feet thick. Permeability of Nisene-Aptos soil is moderate and the erosion hazard is high. Elkhorn sandy loam is found on old alluvial fans and marine terraces and is typically about 2 to 5 feet thick. Elkhorn sandy loam has moderately low permeability and slight to moderate erosion hazard. Los Osos loam is found on wide ridges on hills and mountains and is composed of material weathered from sandstone or shale. Typically, about 8 to 17 inches thick. Los Osos loam generally has low permeability and moderate erosion potential. The Ben Lomond-Felton complex is usually found in valleys and low areas near drainage ways and is composed of material eroded from sandstone, shale, siltstone, schist, or granite. It is typically about 4 feet thick. The permeability of the Ben Lomond-Felton complex is moderately low and the erosion potential varies from slight to very high.

Erosion Potential

Campus soils have been classified by the U.S. Soil Conservation Service for susceptibility to erosion, based on soil characteristics and site slope (SCS 1980). Campus soils fall into four erosion susceptibility categories, ranging from slightly to very highly erodible. Of the campus soils, Aptos loam, Los Osos loam, Watsonville loam, Danville loam, and Elkhorn sandy loam and the Nisene-Aptos complex are soils with a slight to moderate potential for erosion. The Tierra-Watsonville complex, Lompico-Felton complex, Ben Lomond-Felton complex, Bonnydoon Rock Outcrop complex, and Bon Lomond-Catelli-Sur complex soils have a high to very high erosion potential. The erosion potential of the Ben Lomond sandy loam is very high.

The erosion potential for the majority of soil types on the campus ranges from slight to moderate, as indicated in Table 4.6-1. Cross-referencing this table with Figure 4.6-6 indicates that large portions of the north campus contain soils with a slight to moderate erosion potential, and significant pockets of soils with a high to very high erosion potential are present in the upper, central, and lower areas of the campus.

Table 4.6-1
Erosion Potential for Soils on the UC Santa Cruz Campus

Soil Type	Erosion Potential
Nisene-Aptos Complex	Moderate
Lompico-Felton Complex	Very High
Watsonville Loam	Slight to Moderate
Danville Loam	Slight to Moderate
Elkhorn Sandy Loam	Slight to Moderate
Tierra-Watsonville Complex	High
Los Osos Loam	Moderate
Ben Lomond Sandy Loam	Very High
Ben Lomond-Felton Complex	Slight to Very High
Aptos Loam	Slight to Moderate

Source: SCS 1980

In areas where sinkholes have been filled by infiltration of fine-grained sediments or by wall collapse, as in the middle and lower Moore Creek watershed, erosion problems are particularly pronounced. These problems are discussed in more detail in Section 4.8, *Hydrology and Water Quality* (Volume II), along with descriptions of the effects of alterations of predevelopment storm water runoff patterns. Flooding and drainage are also discussed in that section.

As described in Section 4.8.1.1, *Surface Water Resources* (Volume II), storm water runoff on campus generally drains to the natural subsurface drainage system. The existing campus drainage system mainly involves: (1) conveyance of storm runoff from impervious surfaces to main trunk channels through culverts or lined ditches; (2) construction of detention facilities (since 1989) to detain excess runoff and slowly release downstream in order to avoid increasing peak flows; and (3) the detention of excess runoff in the Moore Creek drainage behind earthen dams near the base of campus. These drainage control measures have helped minimize slope erosion and the release of peak runoff to off-campus areas, however, unprotected trunk channels have been adversely affected by erosion and sedimentation and gullying has occurred on off-campus lands adjacent to the eastern campus boundary.

The Campus has developed a set of erosion control standards that are based substantially on Chapter 16.22 of the County Code (Erosion Control Ordinance). These standards are included in the Campus Standards Handbook and incorporated by reference in the specifications for campus development projects (see UCSC Campus Standards Handbook in Section 4.6.1.8, *Regulatory Setting*, for more detail).

4.6.1.4 Landslides

The few landslide deposits identified on the campus are a small landslide deposit that was mapped along Cave Gulch near the western boundary of the campus, and small-scale surficial slumps and some block topples in the old quarries. The lack of landslides is likely due to the presence of hard, stable granitic and metamorphic rocks that underlie much of the campus. Potential hazards from landslides are present only in limited areas where steep slopes are overlain by substantial thicknesses of colluvium and soil, generally only along the larger stream drainages and in the old marble quarries.

4.6.1.5 Expansive Soils

Expansive soils (soils that shrink and swell depending on moisture level) are present on parts of the campus. The distribution of expansive soils is highly variable across the campus on a smaller scale and even across building sites. Such soils can damage building foundations if they are inadequately designed for expansive soil conditions. Table 4.6-2 below presents the shrink-swell potential of the soils on the campus.

Table 4.6-2
Shrink-Swell Potential for Soils on the UC Santa Cruz Campus

Soil Type	Depth (inches)	Shrink-Swell Potential
Aptos	0-23 >23	Low Moderate
Ben Lomond	All depths	Low
Bonnydoon	All depths	Moderate
Catelli	All depths	Low
Danville	0-17 17-29 >29	Moderate High Moderate
Elkhorn	0-21 >21	Low Moderate
Felton	0-11 11-43 >43	Low Moderate Low
Lompico	0-5 >5	Low Moderate
Los Osos	0-19 19-36	Moderate High
Nisene	0-10 10-58	Low Moderate
Sur	All depths	Low
Tierra	0-14 >14	Low High
Watsonville	0-18 18-39 >39	Low High Moderate

Source: SCS 1980

4.6.1.6 Seismicity

Faults

On-Campus Faults. A series of north-south and east-west trending faults has been mapped on the campus. Many are identifiable only due to secondary development of erosional valleys, depressions and sinkholes or because the faults juxtapose dissimilar rock types across narrow zones. The two major north-south trending faults follow the two major north-south drainages (Jordan Gulch and Moore Creek) on the campus and define the three structural blocks that underlie central and lower campus. These faults are not apparent on the north and upper campus and do not appear to have affected the Santa Margarita sandstone formation in the north campus. This indicates that these faults are older than late Tertiary which is greater than 1.8 million years ago (mya). Accordingly, these faults are not Holocene or active. The smaller east-west trending faults appear to be offset or truncated by the north-south faults indicating that they are even older than the north-south faults and are therefore not active (Nolan, Zinn and Associates 2005).

Regional Faults. The following sections present information on the active and potentially active faults in the region. The descriptions are taken primarily from Nolan, Zinn and Associates (2005). The faults are shown on Figure 4.6-3, Area Faults.

Ben Lomond Fault. The Ben Lomond fault is the nearest mapped large fault. In the immediate vicinity of the campus, this fault is inferred to trend approximately north/south along the eastern boundary of the campus. It is a bedrock fault, which had significant vertical movement in the Tertiary Period more than 1.8 mya. Twelve miles of the fault trace have been mapped along the San Lorenzo River valley. The Ben Lomond fault is not known to be active, however, it appears to join the active Zayante fault at its northwest end (Nolan, Zinn and Associates 2005).

San Andreas Fault System. The San Andreas fault, located approximately 20 miles north of the campus in the Santa Cruz mountains, is an active fault and is the major seismic hazard in northern California (WGONCEP[1] 1996). The main trace of the fault trends northwest-southeast, extending over 700 miles from the Gulf of California through the Coast Ranges to Point Arena, where the fault extends offshore. The fault and its branches, the Hayward, Calaveras, and San Gregorio faults, are all currently active.

The San Andreas fault is a right-lateral, strike-slip fault that has experienced hundreds of miles of movement throughout the latter portion of the Cenozoic Era (beginning approximately 23 mya). The two largest historical earthquakes on the San Andreas fault that affected the area were the moment magnitude[2] (Mw) 7.9 San Francisco earthquake on April 18, 1906 (centered near Olema, north of San Francisco Bay) and the Mw 6.9 Loma Prieta earthquake, centered near Santa Cruz, on October 17, 1989.

The 1906 San Francisco earthquake caused severe seismic shaking and structural damage to many buildings in the Monterey Bay area. The 1989 Loma Prieta earthquake appears to have caused more intense seismic shaking than the 1906 event in localized areas of the Santa Cruz Mountains, even though its regional effects were not as extensive. There were also other significant earthquakes in northern California along or near the San Andreas fault in 1838, 1865, and possibly 1890 (WGONCEP 1996).

Zayante-Vergeles Fault. The Zayante-Vergeles fault is west of the San Andreas fault. It runs approximately 50 miles northwest from the Watsonville lowlands into the Santa Cruz Mountains. The northern portion is the Zayante fault and the southern portion, which merges with the San Andreas fault south of San Juan Bautista, is the Vergeles fault.

The Zayante fault has undergone late Pleistocene and Holocene movement (1.8 mya to present) and is potentially active. Movement has been vertical and probably accompanied by right-lateral, strike-slip movement (Nolan, Zinn and Associates 2005).

[1] The Working Group on Northern California Earthquake Potential is part of the USGS National Earthquake Hazards Reduction Program. It is a collaboration of regional tectonics experts in industry, academia and government, who work to identify potential sources of large earthquakes in northern California. It creates maps and databases of active faults and assist in the preparation of National Seismic Hazard Maps, which present probabilistic seismic hazards for various areas.

[2] The moment of an earthquake is a physical quantity proportional to the slip on a fault multiplied by the area of the fault surface that slips; therefore it is related to the total energy released during an earthquake. The moment is then converted into a number similar to other earthquake magnitudes by a standard formula. The result is called the moment magnitude.

The Zayante fault may have undergone sympathetic fault movement during the 1906 earthquake centered on the San Andreas fault, although this evidence is equivocal. Seismic records strongly suggest that a section of the Zayante fault approximately 3 miles long underwent sympathetic movement in the 1989 earthquake. The earthquakes tentatively correlated to the Zayante fault were centered at a depth of 5 miles; no instances of surface rupture on the fault have been reported. The fault, which is considered potentially active, is capable of generating an Mw 6.8 earthquake with an effective recurrence interval of 10,000 years or a Mw earthquake of 7.0 with no stated recurrence (Nolan, Zinn and Associates 2005).

Sargent Fault. The Sargent fault zone is a series of northwest-trending, moderate to steeply southwest dipping, thrust and right-lateral oblique-slip faults. These faults lie to the northeast of the San Andreas fault and roughly parallel to it for approximately 36 miles between San Juan Bautista and Lexington Reservoir. The Sargent fault zone appears to die out or merge with the San Andreas fault to the north. Southward, the Sargent fault extends under young alluvium and may connect with the Calaveras fault (Nolan, Zinn and Associates 2005).

The Sargent fault system has potentially been active since the Miocene and sections may have as much as 30 miles of cumulative displacement (Nolan, Zinn and Associates 2005). There is evidence for activity in the Holocene (Nolan et al. 1995). Although there is not enough available information to reliably estimate recurrence intervals or expected earthquake magnitudes, the Sargent fault is considered capable of an earthquake of Mw 6.8; an effective recurrence interval of 330 years has been cited.

San Gregorio Fault. The San Gregorio fault runs along the coastline of Santa Cruz County from Monterey northward. It trends onshore at Point Año Nuevo. Northward from Año Nuevo, it passes offshore again, to connect with the San Andreas fault near Bolinas. Along the section of the fault on land at Point Año Nuevo, there is evidence of predominantly right-lateral strike slip in the late Pleistocene and Holocene displacement. The portion of the fault nearest the project site (approximately 8 miles away) is considered to be capable of a Mw 7.2 to 7.3 earthquake, with a recurrence interval of 400 years (Nolan, Zinn and Associates 2005).

Monterey Bay-Tularcitos Fault Zone. The northwest-southeast-trending Monterey Bay-Tularcitos fault zone, located approximately 5 miles south of the campus, is approximately 25 miles long and 6 to 9 miles wide. It consists of numerous small offset (*en echelon)* faults identified during shipboard seismic reflection surveys (Rogers Johnson and Associates 1987).

The fault zone intersects the coast in the vicinity of Seaside and Ford Ord, where several onshore fault traces have been tentatively correlated with offshore traces. Movement in the fault zone appears to be predominantly right-lateral, and strike-slip. Fault traces show evidence of Quaternary (less than 1.8 mya) movement both onshore and offshore and, therefore, they are considered potentially active (Nolan, Zinn and Associates 2005).

Historical earthquakes have been tentatively located in the Monterey Bay-Tularcitos fault zone including two events, estimated at 6.2 on the Richter Scale in October 1926. Because of possible inaccuracies in locating the epicenters of these earthquakes, it is possible that they actually occurred on the nearby San Gregorio fault zone. Another earthquake in April 1890 might be attributed to the Monterey Bay-

Tularcitos fault zone. The Monterey Bay-Tularcitos fault zone is considered capable of an earthquake of Mw 7.1 with an effective recurrence interval of 2,600 to 2,841 years (Nolan, Zinn and Associates 2005).

Ground Shaking

On the basis of numerous active faults in the region, the UC Santa Cruz campus could experience significant seismically induced ground shaking, with more intense shaking on thick soil sequences than on bedrock. The magnitude of ground shaking due to an earthquake is typically presented as a percentage of the acceleration due to gravity (g). There are two approaches to evaluate seismic shaking hazard that may be applicable to any site: (1) the deterministic method, and (2) the probabilistic method. The deterministic model predicts a single result for a pre-determined earthquake scenario, usually representing the most severe ground shaking expected (i.e., the quake that would cause the greatest intensity of shaking at the site regardless of how often that particular event is likely to occur). The probabilistic model, on the other hand, uses the likelihood of earthquake occurrences, for all faults with potential to cause ground shaking on the site and estimates the probability that shaking of a particular intensity would be experienced.[3] For instance in 1999, a seismic shaking analysis was performed for the Core West Parking Garage site using both approaches (Rogers Johnson and Associates 1999). Based on the deterministic method, the analysis showed that a Mw 7.9 event on the San Andreas would produce a maximum ground acceleration of 0.48 g to 0.54 g. Based on the probabilistic method, the peak ground acceleration with a 10 percent probability of being exceeded in 100 years is 0.49 g to 0.50 g, (Nolan, Zinn and Associates 2005). Ground shaking that would be experienced at other locations on the campus is expected to be comparable to that estimated above for the Core West Parking Garage site.

Fault Rupture

Because ground fault rupture occurs during seismic events along active faults and there are no known active faults on the campus, the potential for ground rupture on the campus is low.

Liquefaction

Liquefaction of soils occurs when fine-grained saturated loose soils experience seismic shaking. Based on the nature of the subsurface soils on the campus, the ground accelerations presented above, and the depth to groundwater, the potential for liquefaction and liquefaction-induced lateral spreading are low (Nolan, Zinn and Associates 2005).

4.6.1.7 Karst Hazard and Subsidence

In areas that are underlain by limestone, marble, gypsum, or other soluble rocks, dissolution from water at the surface or water that has percolated down through cracks often produces karst topography. Such topography is characterized by irregular surfaces resulting from subsidence or collapse of surface strata and sediments into subterranean cavities. Karst topography is common in parts of the southeastern United States, but rare in California. Dissolution by groundwater often creates complex underground channels and caverns that form groundwater conduits. This process is generally slow (hundreds of thousands to

[3] Generally calculates the intensity of ground shaking that would have a certain chance of being exceeded over a specified number of years.

millions of years). There are often few or no surface streams in such areas since surface water has been captured in these underground networks.

Depressions in the land surface resulting either from intersection with a zone of solution or collapse of overlying sediments into a void, are called “sinkholes” or “dolines.” There are three types of dolines, as illustrated in Figure 4.6-7, *Sinkhole Formation Processes*. Solution dolines are formed by gradual settling of surficial sediments into a solution cavity while solution is occurring. These dolines are characterized by gently sloping sides and an absence of rock outcrops along the walls. Such dolines do not have extensive caverns or experience rapid large-scale collapse. Collapse dolines are formed by the sudden collapse of the roof of an underground void. They have steep sides and rocky, irregular walls. Subsidence dolines are similar to solution dolines, but are formed when surface sediments are washed into existing subsurface cavities. The overlying soils subside since some of their volume has been washed into the adjacent void.

At UC Santa Cruz, such dissolution of the marble areas has created an extensive system of solution cavities, creating local areas of karst topography (Nolan, Zinn and Associates 2005). Construction in karst terrain is potentially hazardous because many karst features are not visible at the surface. Underground cavities may be completely roofed or loosely filled with sediment. Settling and/or collapse can occur beneath a structure. These cavities are generally small, 10 to 50 feet or less in diameter and can often only be identified by detailed site-specific subsurface investigations (Nolan, Zinn and Associates 2005). Based on previous mapping and aerial photographs analysis, dolines are most likely to develop along faults or other major fracture systems on campus, but the inferred locations of these lineaments are not always a reliable indicator of all solution channels or cavities. A number of doline features that have affected building designs in the past, were not located on previously mapped faults or fractures, or on readily visible lineaments (Nolan, Zinn and Associates 2005).

Nolan, Zinn and Associates (2005) prepared a karst hazards zone map, which is included as Figure 4.6-8, *Geologic Hazards Map*. The map separates the campus into four hazard level zones based on the character of bedrock and the results of previous geotechnical investigations. The zones are defined by Nolan, Zinn and Associates (2005) as:

- **Zone 1** – Areas underlain by granitic rocks with no karst-related hazards. No special precautions or recommendations specific to karst processes are necessary. This zone encompasses areas underlain by granitic rocks.
- **Zone 2** – Areas with low potential for karst-related hazards. These are underlain by schist, where no marble or evidence for sinkhole activity has been observed, either in boreholes or at the surface. This zone was created by applying a 50-foot buffer beyond the contacts for the applicable earth material units as shown on the current campus geologic map. The buffers were included to account for the inherent uncertainty in locating borings and earth materials contacts portrayed by consultants in the many previous reports on which the compilation map is based. Zone 2 represents areas with a higher hazard level than Zone 1, because marble can occur as isolated lenses or pods, or may occur at depth.
- **Zone 3** – Zone 3 includes areas underlain directly or at shallow depth by marble, but that lack any direct indication of doline formation or other solution collapse of site soils in either surface or surface

data. Site investigations in this zone should include subsurface investigations appropriate for this geologic setting. A 50-foot buffer has been applied to the margins of the zone as described above.

- **Zone 4** – Areas with a high potential for hazards due to karst conditions. This includes areas underlain by marble with evidence of doline formation. A 100-foot buffer has been applied to the margins of the zone as described above. Note that the buffer for this zone is larger than for other zones because of the higher hazard level.
- Most of the existing campus core buildings are located in Karst Hazard Zones 3 and 4. To address the karst hazard, most existing construction on the UC Santa Cruz campus includes conventional spread footing foundations, which are adequate where building pressures are light and low-density zones or solution cavities are relatively deep. Other foundation construction techniques that have been used in karst areas include spread footings with grade beams to span low-density zones, structural mats and post-tensioned slabs, pier and grade beam foundations with either end-bearing or side-wall friction for support, driven piles, geotextile-reinforced compacted fill, pressure or compaction grouting[4] of underlying sediments combined with the aforementioned footings, and deep dynamic compaction (Nolan, Zinn and Associates 2005).

4.6.1.8 Regulatory Setting

The following laws, ordinances, regulations, and standards would apply to campus development and would minimize the potential for impacts related to geology and soils.

Federal

Clean Water Act. The Clean Water Act empowers the U.S. EPA with regulation of wastewater and stormwater discharges into surface waters by using National Pollutant Discharge Elimination System permits and pretreatment standards. At the state level, these permits are issued by the Regional Water Quality Control Boards, but the U.S. EPA may retain jurisdiction at its discretion. The Clean Water Act's primary application for geology and soils is with respect to the control of soil erosion during construction.

State

California Building Code. The California Building Code (CBC) contains the minimum standards for grading, building siting, development, seismic design, and construction in California. Local standards other than the CBC may be adopted if those standards are stricter. The CBC includes the standards associated with seismic engineering detailed in the Uniform Building Code of 1997.

Alquist-Priolo Earthquake Fault Zoning Act. The Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code Section 25523(a); 20 CCR 1752(b) and (c); 1972 (amended 1994)) was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. The Alquist-Priolo Earthquake Fault Zoning Act's main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that a proposed building will not be

[4] See Section 4.8.1.6 and LRDP Impact HYD-5 in Section 4.8 (Volume II), which describe the campus grouting program.

constructed across active faults. An evaluation and written report of a specific site must be prepared by a licensed geologist. If an active fault is found, a structure for human occupancy cannot be placed over the trace of the fault and must be set back from the fault, generally 50 feet.

Seismic Hazards Mapping Act. The California Public Resources Code Chapter 7.8, 1990 Seismic Hazards Mapping Act allows the lead agency to withhold permits until geologic investigations are conducted and mitigation measures are incorporated into plans. The Seismic Hazards Mapping Act addresses not only seismically induced hazards but also expansive soils, settlement, and slope stability. The Seismic Hazards Mapping Act will be relevant to soil conditions at some future facility sites.

Local

University of California Policy. The University of California Policy on Seismic Safety (revised 1995) requires that new structures be designed to comply with the current seismic provisions CBC or local seismic requirements, whichever are more stringent. The policy also requires that nonstructural elements be anchored for seismic resistance, and that independent review of the structural seismic design of all capital improvement projects designed for human occupancy or that affect human safety must be completed.

UC Santa Cruz Campus Standards Handbook. The Campus Standards Handbook (UC Santa Cruz 2001) contains a set of standards that are provided to UC Santa Cruz consultants for guidance in the preparation of construction documents. The Handbook includes building and site requirements, as well as standards for soil treatment, earthwork and erosion control.

City of Santa Cruz. The City of Santa Cruz seismic hazard policy requires a site-specific geologic investigation be performed by qualified professionals for developments in known potential liquefaction and other seismic hazard areas, and requires developments to incorporate the mitigations recommended by the investigations. The policy also requires that all new construction conform to the latest edition of the CBC (Note that according to the University's policy described above, local seismic requirements are applicable only if they are more stringent than the CBC).

The City of Santa Cruz Seismic Hazards Ordinance (Municipal Code Chapter 24.14, Section 70) applies to projects in areas with potential for liquefaction, as designated in the Safety Element of the General Plan (Map S-6). UC Santa Cruz is not identified on the map as having liquefaction potential.

4.6.2 Impacts and Mitigation Measures

The impact assessment below focuses on the main campus where new development and redevelopment under the 2005 LRDP would occur. No changes other than interior remodel are envisioned for the 2300 Delaware Avenue property under the LRDP. Therefore there would be no impact related to geology, soils and seismicity at the 2300 Delaware Avenue site.

4.6.2.1 Standards of Significance

The following standards of significance are based on Appendix G of the CEQA Guidelines. For the purposes of this EIR, the project would have a significant impact with regard to geology, soils, or seismicity if it would:

- Expose people or structures to potential substantial adverse effects involving strong seismic ground shaking
- Expose people or structures to potential substantial adverse effects involving seismic-related ground failure, including liquefaction
- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving landslides
- Result in substantial soil erosion or the loss of topsoil
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslides, lateral spreading, subsidence, liquefaction, or collapse
- Be located on expansive soil, creating substantial risks to life or property

The impacts from soil erosion and loss of topsoil on water quality are addressed in Section 4.8, *Hydrology and Water Quality* (Volume II).

4.6.2.2 CEQA Checklist Items Adequately Addressed in the Initial Study

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault

  The UC Santa Cruz campus and the surrounding area are not located within an Alquist-Priolo Earthquake Fault Zone.

- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater

  The main campus and 2300 Delaware Avenue property do not have septic tanks or alternative wastewater systems and none would be developed under the 2005 LRDP.

4.6.2.3 Analytical Method

The potential for impacts associated with site geologic conditions were evaluated through review of the existing information and the proposed land use plan under the 2005 LRDP.

4.6.2.4 2005 LRDP Impacts and Mitigation Measures

LRDP Impact GEO-1:	Development under the 2005 LRDP could occur on a geologic unit or soil that would become unstable as a result of the project and could result in on- or off-site landslides, lateral spreading, or liquefaction, creating potential risks to life or property.
Significance:	Potentially significant
LRDP Mitigation GEO-1:	Where existing information is not adequate, detailed geotechnical studies shall be performed for areas that will support buildings or foundations. Recommendations of the geotechnical investigations will be incorporated into project design.
Residual Significance:	Less than significant

Construction on unstable geologic or soil units can pose risk to life and property. Unstable geologic or soil units include landslides and areas with soils that are susceptible to liquefaction or lateral spreading. Landslide potential is limited to a few areas of the campus, which generally are located along the larger stream drainages and in old quarries. Development under the 2005 LRDP would not be located in such areas. Liquefaction and lateral spreading of soils occurs when fine-grained saturated loose soils experience seismic shaking. Based on the nature of the subsurface soils on site, the estimated ground acceleration for the campus (see *Ground Shaking* in Section 4.6.1.6, *Seismicity* for more detail), and the depth to groundwater, the potential for liquefaction and liquefaction-induced lateral spreading on campus are very low. Because there are only a few areas on the campus that are underlain by unstable geologic or soil units, new development on the campus under the 2005 LRDP would, for the most part, not be located on such units and the risk to life and property would not be significant. However, some of the proposed bridges could cross areas with landslide potential and there are some limited areas within the north campus development areas where soils may be susceptible to liquefaction. New construction in these areas could expose people and property to the risk from unstable ground conditions, and thereby result in a potentially significant impact.

To address this concern, the Campus routinely performs geotechnical investigations that evaluate the potential for liquefaction, lateral spreading, and other types of ground failure at each building project site and provide site-specific recommendations for the treatment of site conditions. To ensure that such investigations would continue to be performed as the campus develops under the 2005 LRDP, and that the recommendations of the geotechnical investigation are implemented to help avoid impacts associated with construction in areas with landslides, lateral spreading, liquefaction or any other hazard related to unstable geologic or soil units, the Campus would implement LRDP Mitigation GEO-1 in addition to the CBC and the University of California Seismic Safety Policy and therefore would ensure that the impacts would be less than significant.

LRDP Impact GEO-2:	Development under the 2005 LRDP could result in construction of campus facilities on expansive soil, but this would not create potential risks to life and property.
Significance:	Potentially significant
LRDP Mitigation GEO-2:	The Campus shall implement LRDP Mitigation GEO-1.
Residual Significance:	Less than significant

Expansive soils are present on parts of the campus, with a highly variable distribution across potential building sites. These soils shrink and swell as a result of moisture changes. This can cause heaving and cracking of slabs-on-grade, pavements, and structures founded on shallow foundations if they are inadequately designed for these conditions. Potential risk to life and property would result if buildings and other structures were constructed on expansive soils without appropriate design, and the impact would be potentially significant. Engineering solutions available to address expansive soils include replacement of expansive soils with fill, treatment of soils, or deepening of foundations.

UC policy requires compliance with the CBC, which includes requirements for construction on expansive soils. The campus Office of Physical Planning and Construction currently requires geotechnical investigations for every applicable project managed by that office unless adequate information is available from previous investigations, and the UC Santa Cruz Campus Standards Handbook incorporates guidelines for geotechnical investigations, including estimated settlement. To ensure that the current practice of conducting detailed geotechnical investigations of each project site is continued and that the recommendations of the study are implemented, the Campus would implement LRDP Mitigation GEO-2. This would reduce the impact to a less-than-significant level.

LRDP Impact GEO-3:	Development under the 2005 LRDP would not result in substantial erosion of soils as a result of construction, including tree removal, and increased traffic.
Significance:	Less than significant
LRDP Mitigation:	Mitigation not required
Residual Significance:	Not applicable

Soils at UC Santa Cruz range from slightly to very highly erodible, based on U.S. Soil Conservation Service classification. Highly to very highly erodible soils are present in some areas of central and north campus and in small portions of the lower campus. These problems and the effects of alterations to predevelopment storm water runoff patterns are discussed in more detail in Section 4.8, *Hydrology and Water Quality* (Volume II).

Construction of facilities would result in short-term soil-disturbing activities that could lead to increased erosion including cut and fill, grading, trenching, boring, and removal of trees and other vegetation. The Campus has developed a set of erosion control standards that are based substantially on Chapter 16.22 of the Santa Cruz County Code (Erosion Control Ordinance). These standards are included in the Campus

Standards Handbook and incorporated by reference in the specifications for campus development projects (see *UC Santa Cruz Campus Standards Handbook* in Section 4.6.1.8, *Regulatory Setting*, for more detail). In addition, to comply with National Pollutant Discharge Elimination System (NPDES) requirements for construction site storm water discharges, projects involving construction sites that are 1 acre or more are required to prepare and implement a storm water pollution prevention plan (SWPPP). Appropriate erosion-control measures will be incorporated into each SWPPP and implemented during site preparation, grading, and construction. These measures will include but are not limited to the following: design and construction of cut and fill slopes in a manner that will minimize erosion, protection of exposed slope areas, control of surface flows over exposed soils, use of wetting or sealing agents or sedimentation ponds, limiting soil excavation in high winds, construction of beams and runoff diversion ditches, and use of sediment traps, such as hay bales.

Erosion associated with the development and use of the north campus loop road would be minimized by roadway design. Techniques such as over-excavation will be implemented as necessary to create benches to address the potential adverse effects of soil creep on slope areas that are adjacent to the north campus loop road. Any graded slopes or localized sections of disturbed or unstable natural slopes will include erosion control protection. Typical requirements for slope design are outlined in the CBC. Furthermore, the 2005 LRDP development areas generally would be outside of steep slopes and drainages, and campus standards require that substantial development on slopes greater than 20 percent shall be avoided. Therefore, tree removal and other construction activities would not occur on steep slopes, with the exception of footings for the proposed bridge across Cave Gulch and several pedestrian bridges in the central and north campus. Therefore, the impact related to erosion and sedimentation would be less than significant.

LRDP Impact GEO-4:	Development under the 2005 LRDP could result in construction of facilities on sites underlain by karst features, which could lead to settling or collapse beneath the structures.
Significance:	Potentially significant
LRDP Mitigation GEO-4:	The Campus shall implement LRDP Mitigation GEO-1.
Residual Significance:	Less than significant

Construction in karst terrain is potentially hazardous because many karst features are not visible at the surface. Based on boring data from prior investigations on campus, the surface of the marble bedrock is highly irregular, varying in elevation by more than 100 feet over a horizontal distance of 10 feet or less (Nolan, Zinn and Associates 2005). Underground cavities may be completely roofed or loosely filled with sediment such that they are not visible on the surface. In addition to the potential structural failure of the roof of a cavern, dissolution of the marble surface below the overlying soils creates regions of soft weak soils that may have inadequate bearing capacity for construction. Such soils may also contain marble rubble, overlain by more consolidated soils supported by soil arching. Settling and/or collapse can occur beneath a structure above an undetected cavity. These cavities can often only be identified by detailed site-specific subsurface investigations (Nolan, Zinn and Associates 2005).

There are no documented instances of catastrophic collapse on the UC Santa Cruz campus, nor is there any geologic evidence of historical collapse (Nolan, Zinn and Associates 2005). However, the unpredictability of subsurface conditions still poses risks in development.

Nolan, Zinn and Associates (2005) identify the following issues related to development on karst:

- The lack of evidence of collapse at the surface does not preclude the existence of older filled dolines in the subsurface. In addition, caverns and voids may be present below areas where schist or other nonmarble rock is exposed at the surface.
- Doline fill can be difficult to differentiate from weathered schist or granitic bedrock.
- In addition to low-density zones at depth, there is the possibility of sliding of apparently intact schist, granite, or marble into a doline cavity.
- The marble bedrock on the campus is cut by many pegmatite dikes. Therefore, a boring encountering pegmatitic material may be a few feet away from marble, either laterally or vertically.

Figure 4.6-8, *Karst Hazards Map*, presents the karst hazards zones on the campus. The campus is divided into four hazard level zones based on the character of bedrock and the results of previous geotechnical investigations. The zones are described in *Karst Hazard and Subsidence* in Section 4.6.1.6, *Seismicity*. All of the north campus development would be located in Zone 2 where the hazard level is low. The Colleges and Student Housing area would be located predominantly in Zone 2, though the easternmost portion may be in Zone 3. Infill development within the central campus is primarily of concern in this regard because this development would be in Zones 3 and 4. The proposed extensions of Chinquapin Road and Heller Drive, as well as the bridge across Cave Gulch would be located in Karst Hazard Zone 2. The proposed road between Meyer Drive and Hagar Drive includes two vehicle bridges in Zone 3. The proposed cross-campus road to connect Hagar Drive to Glenn Coolidge Drive would be mostly in Zone 3, but its eastern end would be in Zone 4. Three additional pedestrian bridges are envisioned in the northern part of the campus to link existing development to the envisioned north campus. These likely would be in Zone 2.

Construction in karst terrain is potentially hazardous because many karst features are not visible at the surface, and settling or collapse can occur beneath a structure. However, campus practices have been successful in preventing settlement or collapse of building structures. Therefore, implementation of LRPD Mitigation GEO-1, which requires characterization of project site conditions and implementation of the recommendations of the geotechnical investigation, would reduce this impact to a less-than-significant level.

LRDP Impact GEO-5:	Development under the 2005 LRDP would not expose people and structures on campus to potentially adverse effects associated with seismic ground shaking or seismic-related ground failure.
Significance:	Less than significant
LRDP Mitigation:	Mitigation not required
Residual Significance:	Not applicable

Despite the fact that the UC Santa Cruz campus is located in a seismically active region, no active or potentially active faults have been identified on campus. The Ben Lomond fault, which is the nearest mapped large fault, lies to the east of the campus. The Ben Lomond fault is not known to be active, but, it appears to join the active Zayante fault at its northwest end (Nolan, Zinn and Associates 2005). The campus could experience significant ground shaking associated with a seismic event on nearby active regional faults, including the Zayante and San Andreas faults. As discussed in *Ground Shaking* in Section 4.6.1.6, *Seismicity*, a previous seismic shaking analysis performed for the Core West Garage site showed that a Mw 7.9 event on the San Andreas would produce a peak ground acceleration of up to 0.54 g.

These levels of ground shaking from seismic activity in the region could lead to structural damage, and people in the area would be exposed to these hazards. Pursuant to the University of California Policy on Seismic Safety, all project construction is required to comply with the requirements of Title 24 CCR, CBC or local seismic requirements, whichever are more stringent. In addition, the Campus has an on-going program to upgrade or replace existing buildings not adequately prepared to withstand seismic hazards.

The University of California Policy on Seismic Safety, to which the Campus adheres, requires anchorage for seismic resistance of nonstructural building elements such as furnishings, fixtures, material storage facilities, and utilities that could create a hazard if dislodged during an earthquake. Campus Environmental Health and Safety provides guidance for preparing department-level Illness and Injury Prevention Plans that emphasizes methods for minimizing seismic hazards in laboratories, for example, by properly securing chemical containers and gas cylinders. Each department has a Safety Coordinator who develops and maintains a departmental emergency response plan. The departmental emergency response plans must be submitted to the Emergency Preparedness Policy Group for annual review to ensure consistency with the campus Emergency Operations Plan, which includes seismic safety and building evacuation procedures. The emergency procedures incorporated into the departmental emergency response plans further reduce the hazards from seismic shaking by preparing faculty, staff, and students for emergencies. All of these procedures would continue to be implemented as new facilities are developed on campus under the 2005 LRDP. Therefore, this impact would be less than significant.

4.6.2.5 Cumulative Impacts and Mitigation Measures

Most geologic impacts of campus development would be site specific and would not cumulate. The hazards associated with construction on karst areas are generally confined to the campus. The hazards associated with construction on expansive soils or on unstable geologic units also tend to be localized to the areas where such soils or unstable conditions occur and can be mitigated using standard engineering practices. Cumulative geologic and seismic impacts associated with campus development under the 2005 LRDP and other planned or foreseeable future development in the campus vicinity would involve the exposure of an increased number of people and/or structures to risk of earthquakes and their associated geologic hazards. That impact is discussed below. Cumulative impact from erosion and sedimentation on study area drainages and receiving waters is discussed in Section 4.8, *Hydrology and Water Quality* (Volume II).

LRDP Impact GEO-6:	Cumulative development, including the development on campus under the 2005 LRDP, could expose people or structures to potential adverse effects involving seismic ground shaking.
Significance:	Less than significant
LRDP Mitigation:	Mitigation not required
Residual Significance:	Not applicable

The broader geographic area for the analysis of cumulative impacts involving risks associated with earthquakes and geologic hazards is all of Santa Cruz County. New commercial and residential development throughout the county would comply with the current seismic provisions of the CBC and local building codes. These state and local requirements are designed to ensure that structures developed in regions prone to significant ground shaking can withstand the likely stress that would result. Compliance with the CBC by the development community, including the campus, would ensure that cumulative effects involving seismic ground shaking are less than significant. It is reasonable to assume that all jurisdictions would enforce the seismic provisions of the CBC on new development and significant adverse impacts would be avoided.

4.6.3 References

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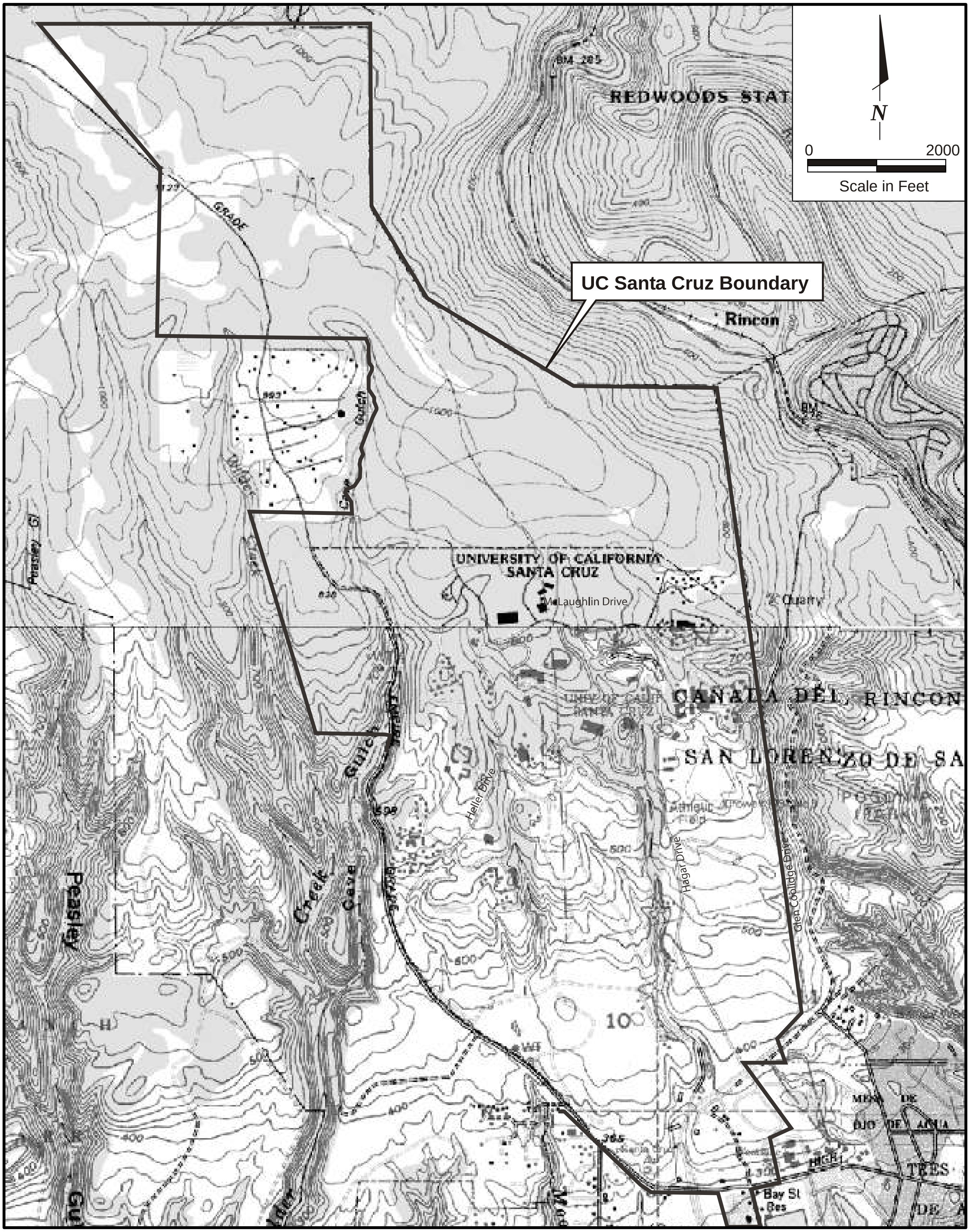

BASE MAP:
USGS Topographic 7.5 minute series, 1"=2,000' (1:24,000);
Felton, California Quadrangle (Santa Cruz County), 1980;
and Santa Cruz, California Quadrangle (Santa Cruz County), 1981.

SITE TOPOGRAPHIC MAP

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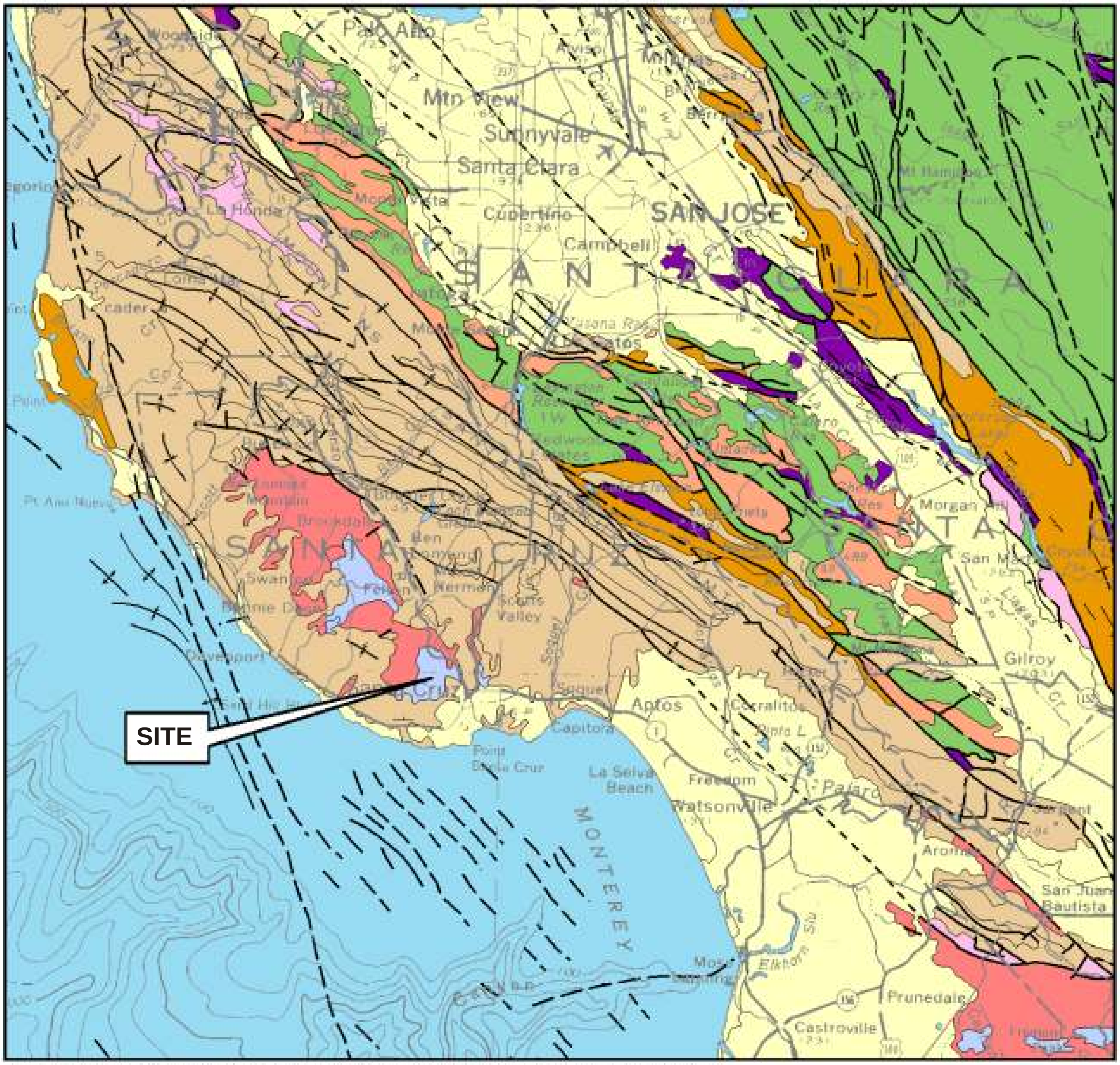
FIGURE 4.6-1



Reference: Jennings, C.W., 1977, Geologic Map of California: California Department of Conservation, Division of Mines and Geology, scale 1:750,000.
Digital Data: Saucedo, G.J., Bedford, D.R., Raines, G.L., Miller, R.J., and Wentworth, C.M., 2000, GIS Data for the Geologic Map of California: California Department of Conservation, Division of Mines and Geology, CD-ROM 2000-007, ver. 2.0.

Legend

Geologic Units
- Quaternary Deposits
- Quaternary Volcanics
- Tertiary Sedimentary Rocks
- Tertiary Volcanic Rocks
- Pre-Tertiary Sedimentary Rocks
- Pre-Tertiary Volcanic Rocks
- Granitic Intrusive Rocks
- Franciscan Complex
- Ultramafic Rocks
- Pre-Tertiary Metamorphic Rock
- Pre-Cambrian Metamorphic and Igneous Rocks

Symbols
- contact
- fault, certain
- fault, approx. located
- fault, concealed or inferred
- anticline
- monocline
- syncline

N

SCALE 1:500.000

10 0 10 20 Miles

REGIONAL GEOLOGIC MAP

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Santa Cruz, California

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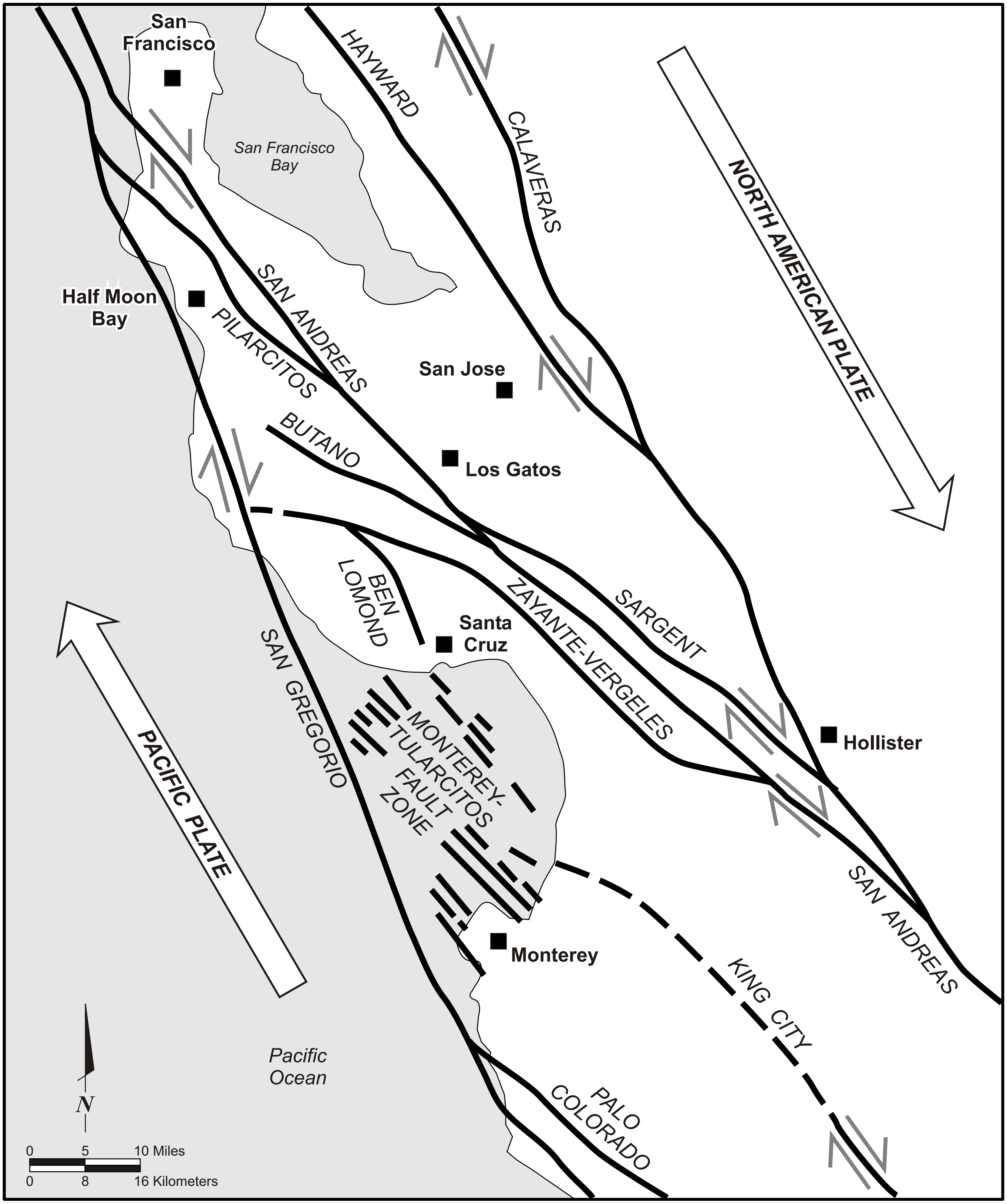
FIGURE 4.6-2

10/05/05 vsa ..\28649607 UC Santa Cruz\F4.6-2_reg geo.cdr



Source: Modified from Warrick, 1982.

LEGEND

Fault, Certain

Fault, Concealed or Inferred

Right Lateral Fault Movement

AREA FAULTS

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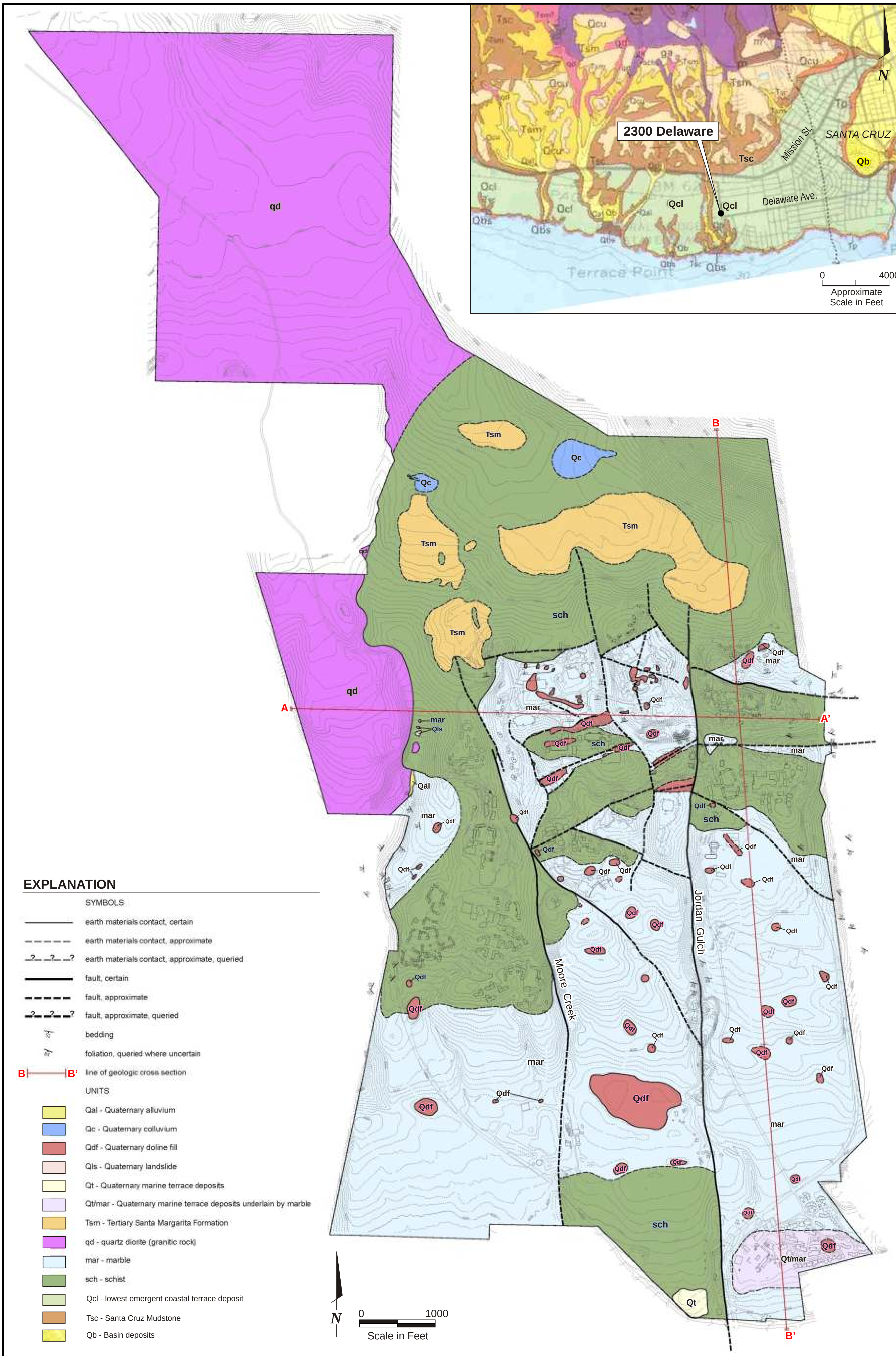
Santa Cruz, California

URS

FIGURE 4.6-3

10/05/05 vsa ..\28649607 UC Santa Cruz\F4.6-3_faults.cdr



Source:
Nolan, Zinn, and Associates, 2005

SITE GEOLOGIC MAP

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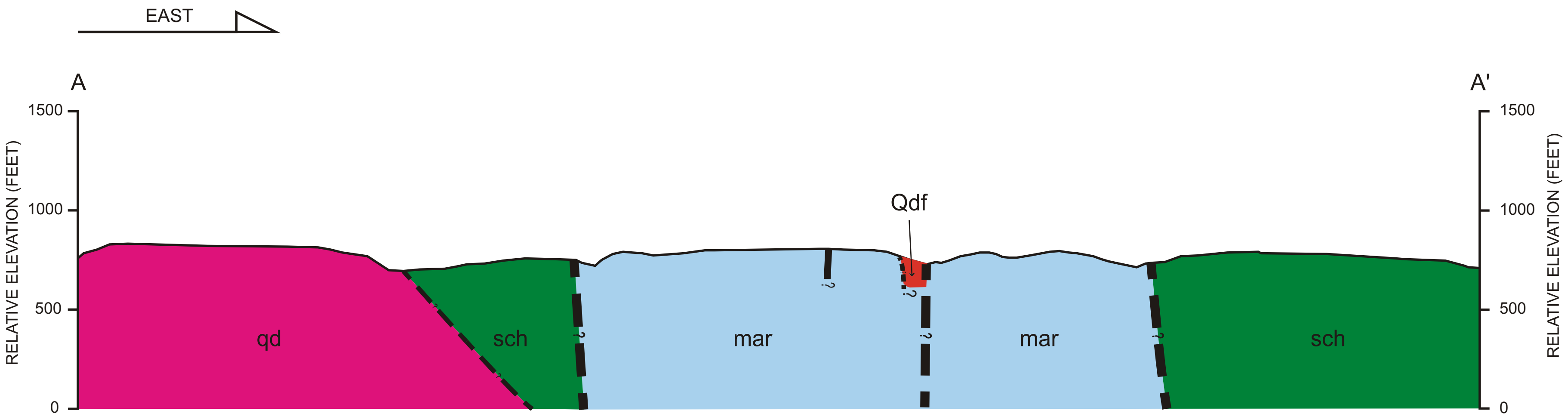
UC Santa Cruz LRDP EIR
Santa Cruz, California

URS

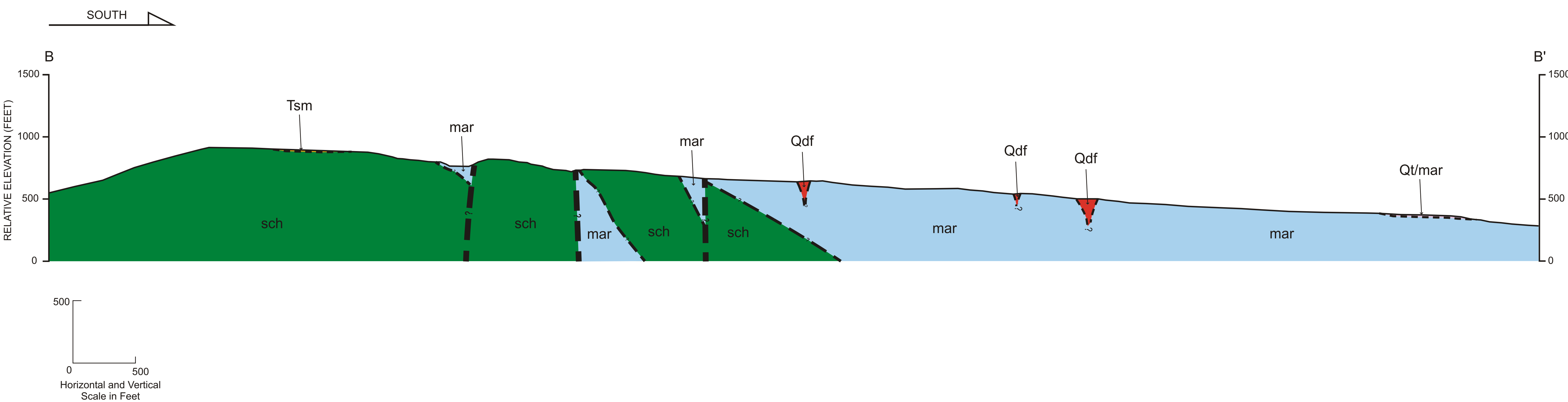
FIGURE 4.6-4

10/05/05 vsa ..\28649607 UC Santa Cruz\F4.6-4_site geo map.cdr

CROSS SECTION A-A’



CROSS SECTION B-B'



Source:
Nolan, Zinn, and Associates, 2005

Note:
See figure 4.6-4 for an explanation of symbols and units.

GEOLOGIC CROSS SECTIONS

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UC Santa Cruz LRDP EIR
Santa Cruz, California

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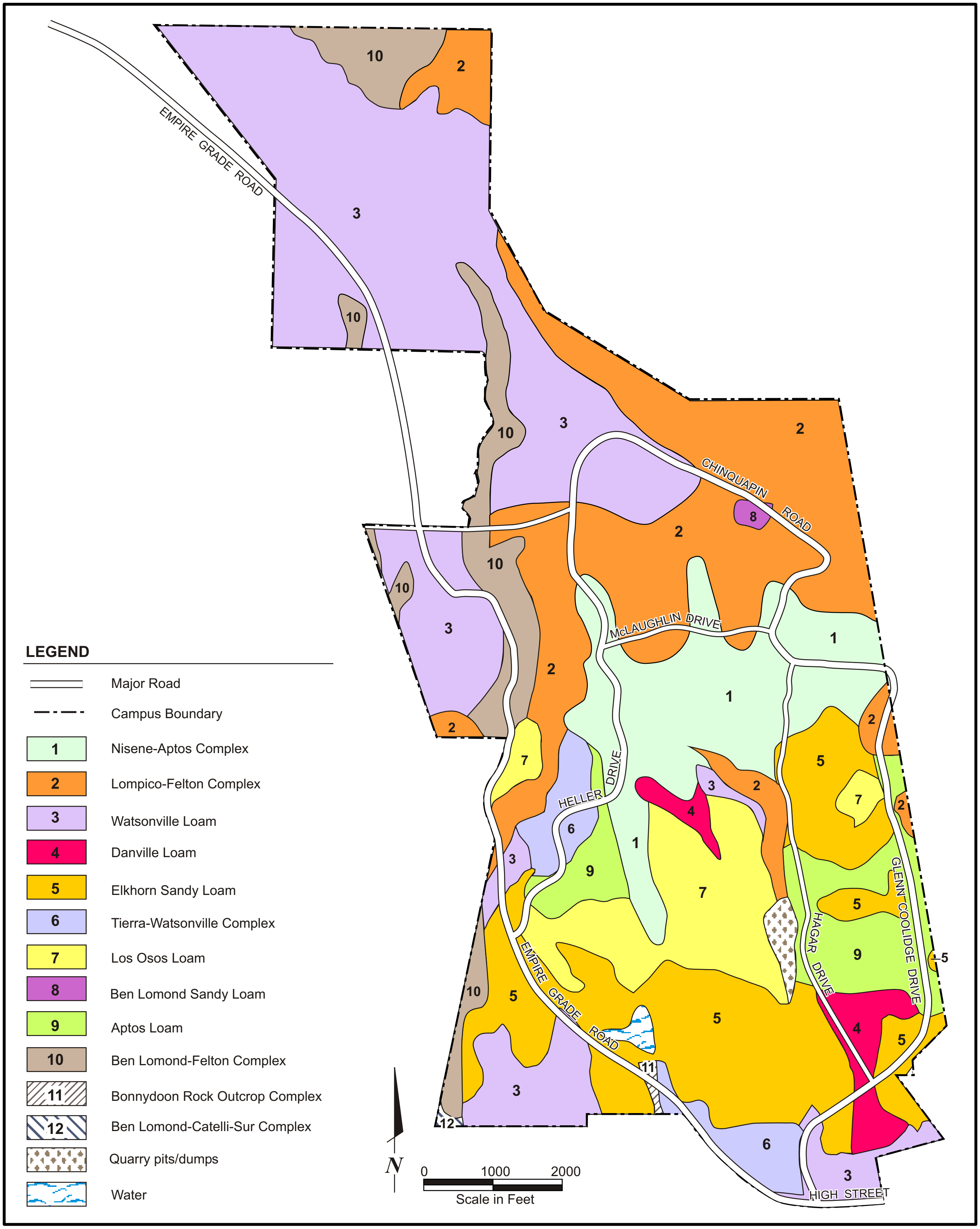
FIGURE 4.6-5

9/27/05 vsa ..\28649607 UC Santa Cruz\F4.6-5_geo xsecs.cdr



Source:
Adapted from SCS, 1980.

SOILS ON UC SANTA CRUZ CAMPUS

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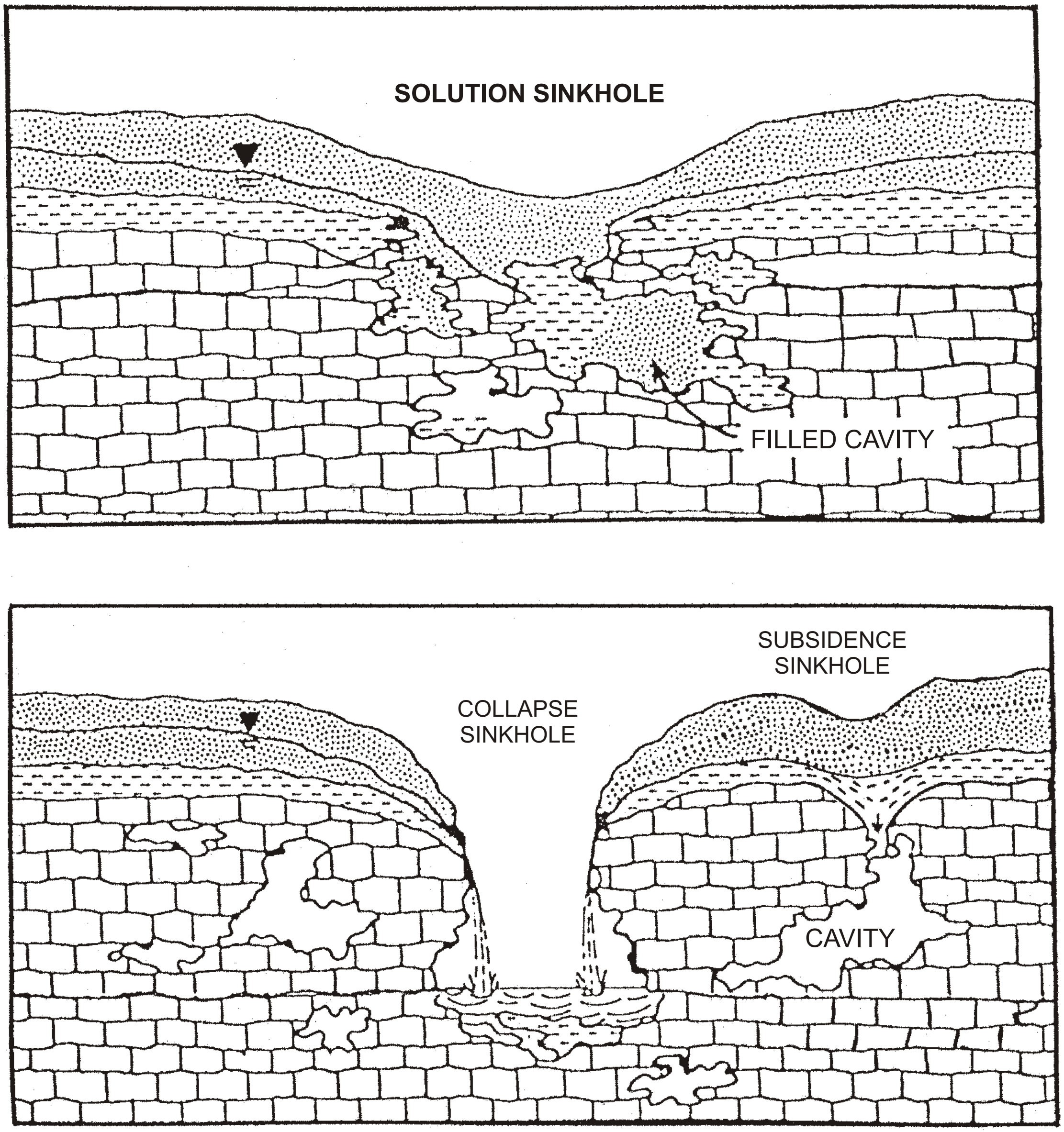
UC Santa Cruz LRDP EIR
Santa Cruz, California

URS

FIGURE 4.6-6

10/12/05 vsa ..\28649607 UC Santa Cruz\F4.6-6_soils ucsc.cdr



Modified after Destephen and Wargo, 1992

Source:
Nolan, Zinn, and Associates, 2005

SINKHOLE FORMATION PROCESSES

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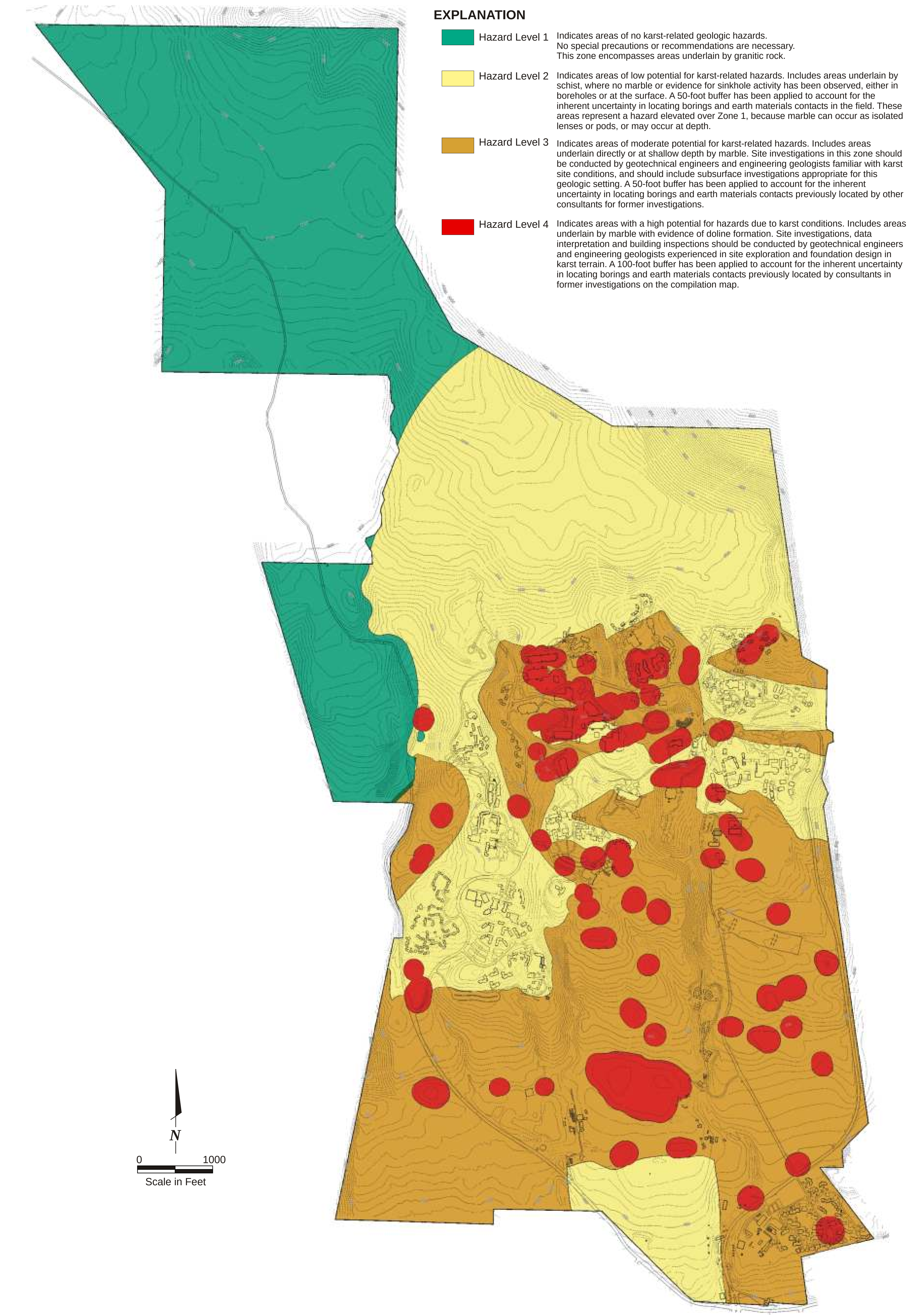
28649607

UC Santa Cruz LRDP EIR
Santa Cruz, California

URS

FIGURE 4.6-7

10/05/05 vsa ..\28649607 UC Santa Cruz\F4.6-7_sinkhole.cdr



Source:
Nolan, Zinn, and Associates, 2005

KARST HAZARDS MAP

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UC Santa Cruz LRDP EIR
Santa Cruz, California

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FIGURE 4.6-8