3.7 Geological and Seismic Hazards

This section describes geologic and seismic conditions in the Hillcrest Station Area Specific Plan Planning Area (referred to throughout this section as "Planning Area") to provide relevant background information of the physical characteristics of the Planning Area with respect to geologic hazards, soils, and seismic conditions. The following information is compiled from geologic maps and reports available from Contra Costa County, City of Antioch, the California Geological Survey (CGS; formerly California Divisions of Mines and Geology), the U.S. Geographical Survey (USGS), the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), and the Association of Bay Area Governments (ABAG).

ENVIRONMENTAL SETTING

PHYSICAL SETTING

Topography

The Planning Area is located in northeastern Contra Costa County, on the northern flank of Mount Diablo at the southern edge of the Pittsburg-Antioch Plain. The Pittsburg-Antioch Plain is an alluvial plain that slopes gently north away from the base of the foothills of Mount Diablo to the tidal marshes of the Sacramento-San Joaquin Delta. The northern half of the alluvial plain is dominated by salt water marshes; the southern half is underlain by alluvial materials eroded from the Diablo Range to the south.

With the exception of two hills adjacent to Highway 4 (SR 4), the Planning Area is a shallow valley bisected by East Antioch Creek, which meanders in a northwest direction across the site and empties into the San Joaquin River approximately 1.5 miles northwest of the site. The topography of the Planning Area varies from gentle slopes of 2-3 percent on the valley floor to 15-30 percent slopes on the hilly areas in the southeast. Ground elevations within the Planning Area range from approximately 20 feet above mean sea level (msl) at the western edge of the site, to approximately 200 feet above msl in the southeast (see Figure 3.7-1).

Geology

The Planning Area is within the Coast Range Geomorphic Province of California. This province is characterized by a series of northwest-trending mountain ranges, ridges, and intervening valleys that run generally parallel to the San Andreas Fault System. The San Andreas Fault System includes several major fault zones, or areas with numerous fractures, including the San Andreas, Hayward, and Calaveras fault zones. These mountain ridges and valleys have been formed by the shearing action of the San Andreas Fault and other associated faults along the margin of the Pacific and North American tectonic plates over the course of millions of years.

The underlying geologic materials of the region are defined by the location of the San Andreas Fault, which separates two bedrock complexes or distinct groups of rocks: the Salinian Block and the Franciscan Formation. Contra Costa County is located to the east of the fault and is underlain by the Franciscan Formation. The rocks of the Franciscan Formation represent pieces of former oceanic crust that have been accreted to North America by subduction and collision. In this region of California, the Franciscan Formation bedrock complex is composed primarily of deep marine sandstone and shale (ancient seafloor sediments), basalt, chert (ancient silica-rich ocean deposits), and greenstone (altered volcanic deposits).

The surficial geology of the Pittsburg-Antioch Plain is characterized by unconsolidated alluvium, terrace deposits, and bay mud. In the immediate vicinity of the Planning Area, the area northeast of East Antioch Creek is underlain by fine-grained beach and dune sands. The area southwest of the creek is underlain by alluvial fan deposits (Graymer, et al, 2006a). At the southeastern edge of the Planning Area and at the toe of the foothills to Mount Diablo, the bedrock geology is comprised of sedimentary deposits of the Tulare formation. Materials of this formation consist of poorly consolidated non-marine siltstone, sandstone, and conglomerate, with some tuff (volcanic ash deposits) (Graymer, et al, 1994).

Soils

Surface soils exhibit various characteristics dependent on location, slope, parent rock, climate, and drainage. According to soil survey information obtained from the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), surface soils in the Planning Area range from clay and silty clay loam to fine-grained sand (see Table 3.7-1). At the northeast corner of the site and northeast of East Antioch Creek, site soils consist primarily of Delhi sand (DaC), which is characterized by sands formed from granitic rock sources on flood plains, alluvial fans, and terraces. With the exception of the hilly areas in the southeast portion of the site, site soils southwest of the creek are of the Zamora (ZaA) series, which consist of silty clay loam, clay loam, silt loam, and gravelly clay loam formed in sedimentary alluvium on nearly level flood plains. In the south-central portion of the Planning Area, soils are mapped as Capay clay (CaC). The hilly portions of the area in the southeastern portion of the area, are mapped as Los Oso clay loam (LhE), and Diablo clay (DdE), which are characterized as clays and silty clays. Soils along the northern reach of East Antioch Creek channel are mapped as Sycamore Silty clay loam (So) and are characterized as silty clay loam, silt loam, and stratified loamy fine sand to silty clay formed on nearly level floodplains (USDA SCS, 1977). Soils in the Planning Area are mapped on Figure 3.7-2.

Soils are generally characterized by their properties of: shrink-swell potential, erosion potential, and runoff potential. The degree to which a soil will undergo changes in volume depends on the moisture and clay content of the soil. With the exception of the Delhi sands northeast of East Antioch Creek, site soils have relatively high clay content. Soils with relatively high clay content swell or expand when wetted and shrink or contract as they dry (shrink-swell potential), are more susceptible to soil expansion, and can threaten the stability of structures without adequately engineered foundations. Also, these clayey soils do not absorb water readily and generate moderately high to high rates of runoff. The hazard of erosion by running water of these soils varies from slight where gently sloping, to moderate in the hilly areas at the southeast portion of the Planning Area (USDA SCS, 1977).

Seismologists have observed that soft soils can amplify seismic ground shaking. Generally, water-saturated mud and artificial fill are expected to have the strongest amplification of shaking; sands and silts are expected to have significant amplification of shaking; while clays are expected to have slightly less significant amplification. A soil type and shaking hazard map prepared by the National Earthquake Hazards Reduction Program (NEHRP) that evaluates the velocity at which certain soils transmits shear waves (S-waves) indicates that soils at the northeast corner of the

Planning Area and northeast of East Antioch Creek can significantly amplify seismic ground shaking. Soils at the southwest corner of the site (and southwest of East Antioch Creek) can cause moderate to significant amplification of seismic ground shaking (USGS, 2008).

Table 3.7-1 Planning Area Soils

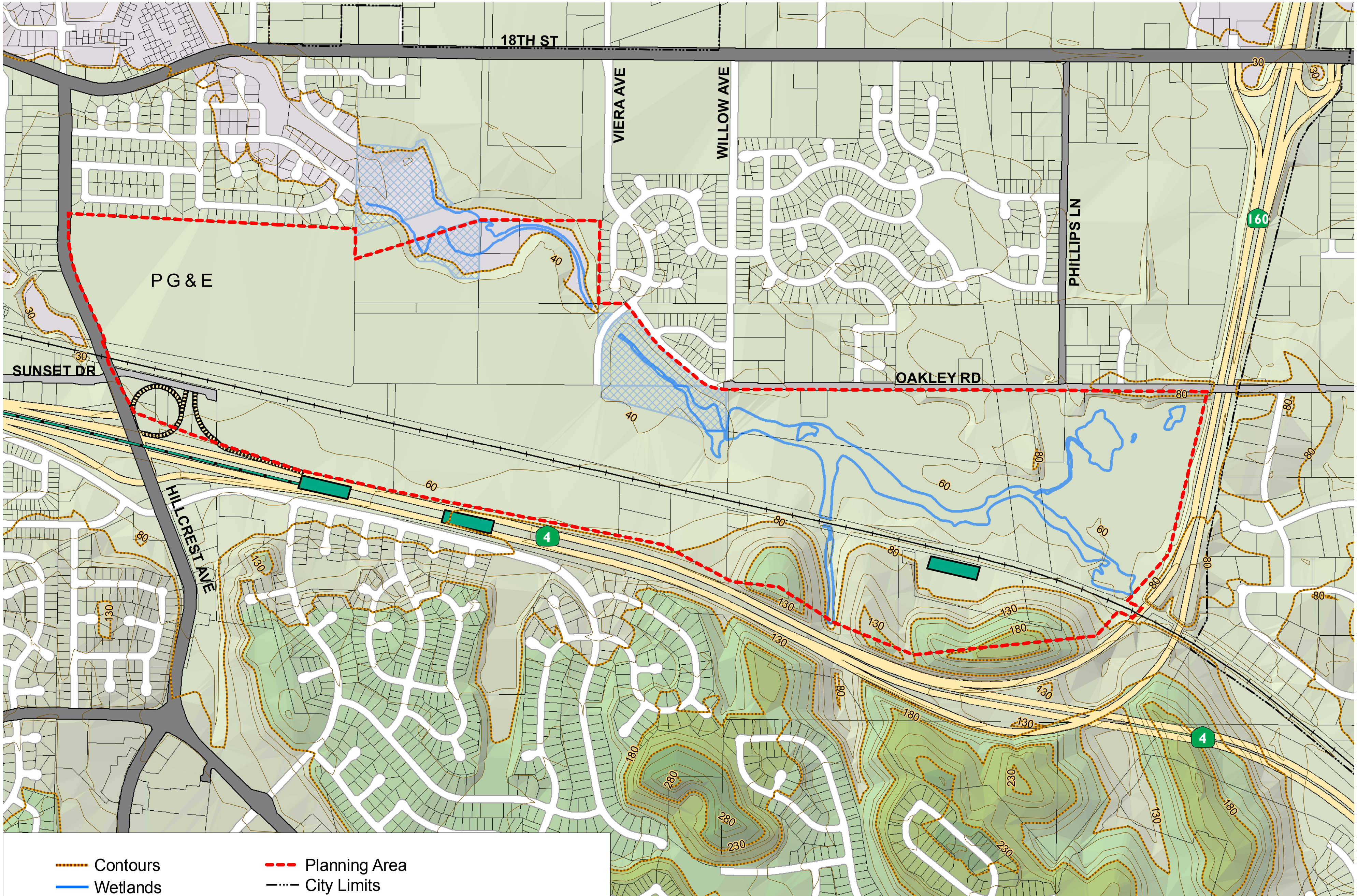
Map Symbol	*Soil Name/ Slope*	*Topsoil/Subsoil Texture*	*Shrink-Swell Potential*	*Erosion Potential*	*Hydrologic Soil Group* [1]	*% of Planning Area*
CaC	Capay Clay, 2 to 9% slopes	Clay, silty clay loam, and clay loam	High	Slight	D	6%
DaC	Delhi Sand, 2 to 9% slopes	Sand	Low	Slight	A	22%
DdE	Diablo Clay, 15 to 30% slopes	Clay and silty clay	High	Moderate	D	7%
LhE	Los Osos Clay Loam, 15% slopes	Clay loam and clay	High	Moderate	C	3%
RbD	Rincon Clay Loam, 9 to 15 percent slopes	Clay loam, sandy clay, clay, clay loam, and silty clay loam	Moderate to High	Slight	C	<1%
So	Sycamore Silty Clay Loam	Silty clay loam, silt loam, and stratified loamy fine sand to silty clay	Moderate	Slight	C	6%
ZaA	Zamora Silty Clay Loam, 0 to 2% slopes	Silty clay loam, clay loam, silt loam, and gravelly clay loam	Moderate	Low	B	56%

1. Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. Hydrologic soil group: A= high infiltration rate/low runoff potential; B= moderate infiltration rate/moderate runoff potential; C= slow infiltration rate/moderately high runoff potential; D= very slow infiltration rate/high runoff potential.

Source: USDA SCS, 1977.

Mineral Resources

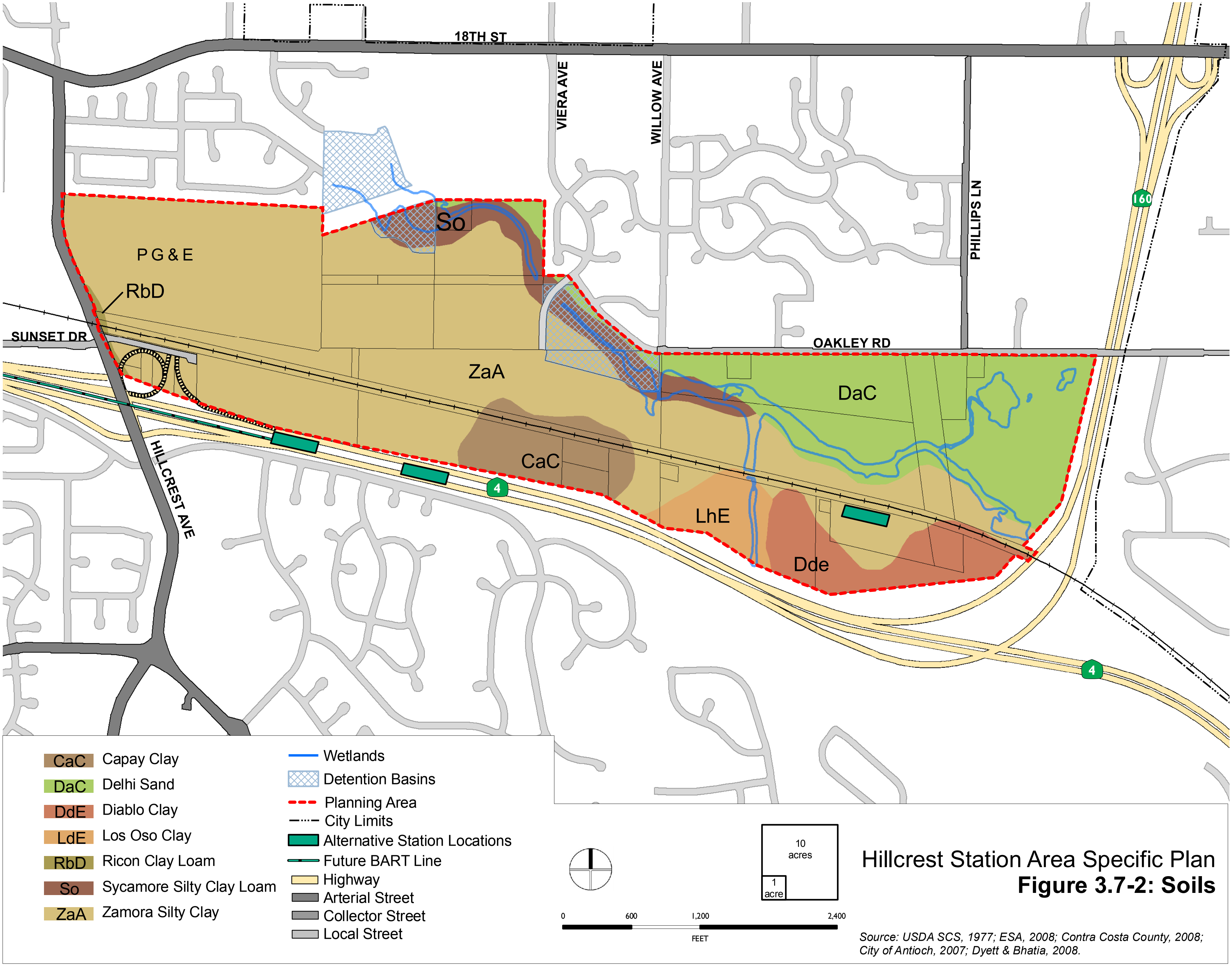
Mineral extraction is important in Contra Costa County, as in other counties, because minerals such as crushed rock, sand, among others, supply the necessary components for local home building as well as for a diverse array of other industries. According to a map of mineral resource areas in the Contra Costa County General Plan, no significant mineral resource areas exist within or in the vicinity of the Planning Area (Contra Costa County, 2005).



Hillcrest Station Area Specific Plan

Figure 3.7-1: Topography

Source: Contra Costa County, 2004; City of Antioch, 2007; USGS, 2007.

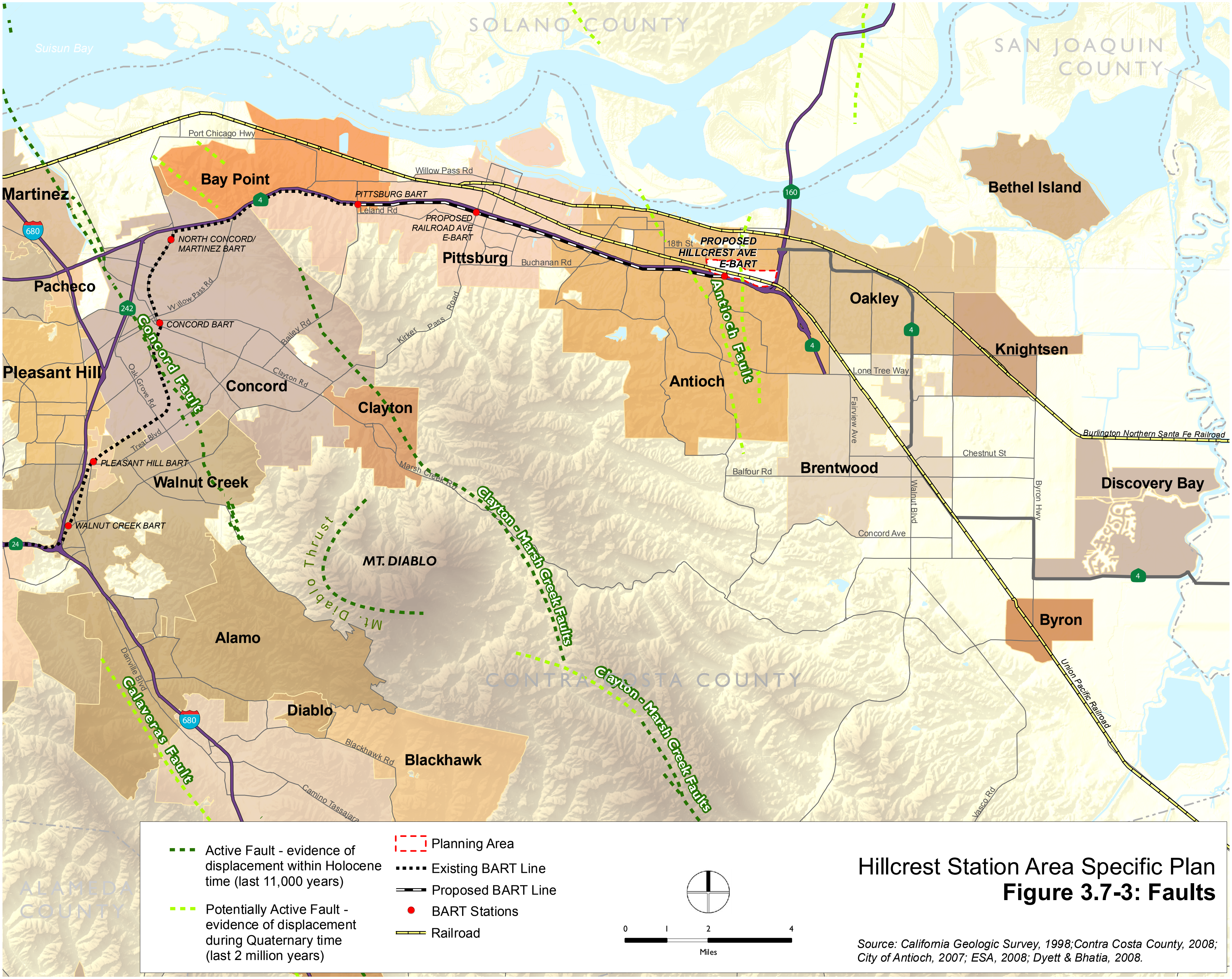


Hillcrest Station Area Specific Plan

Figure 3.7-2: Soils

Source: USDA SCS, 1977; ESA, 2008; Contra Costa County, 2008; City of Antioch, 2007; Dyett & Bhatia, 2008.

Hillcrest Station Area Specific Plan
Figure 3.7-3: Faults



- Active Fault - evidence of displacement within Holocene time (last 11,000 years)
- Potentially Active Fault - evidence of displacement during Quaternary time (last 2 million years)
- Planning Area
- Existing BART Line
- Proposed BART Line
- BART Stations
- Railroad

Source: California Geologic Survey, 1998; Contra Costa County, 2008; City of Antioch, 2007; ESA, 2008; Dyett & Bhatia, 2008.

Seismicity

The City of Antioch, as well as the San Francisco Bay Area as a whole, is located in one of the most seismically-active regions in the United States. The 1997 Uniform Building Code locates the entire Bay Area within Seismic Risk Zone 4, which represents the maximum seismic risk zone. The 2003 report by the Working Group on California Earthquake Probabilities estimated that there is a 62 percent probability of at least one magnitude 6.7 or greater earthquake to occur on one of the major faults within the San Francisco Bay region before 2032 (USGS, 2003). Major earthquakes have occurred in the vicinity of the City of Antioch in the past, and can be expected to occur again in the near future.

Regional Faults

The California Geological Survey (formerly California Division of Mines and Geology) classifies recognized faults in the State based on their potential seismicity. Faults are classified as active, potentially active, or inactive. A fault that shows evidence of movement within Holocene time (approximately the last 11,000 years) is defined as *active*. A fault segment is considered *potentially active* if there is evidence of displacement during Quaternary time (approximately the last 2 million years) (Hart and Bryant 1997).

Active and potentially active faults affecting the Planning Area are listed in Table 3.7-2. Although recognized active faults are located within the City of Antioch, several major active faults are located within a few miles. The San Andreas, Hayward, Calaveras, and Rodgers Creek faults pose the greatest threat to producing significant earthquakes in the region. Other principal Bay Area faults capable of producing significant ground shaking in the Planning Area include the Concord–Green Valley, Clayton-Marsh Creek-Greenville, and Mount Diablo Thrust faults. In addition, the Antioch fault, which is considered to be potentially active but is not zoned under the Alquist-Priolo Act as potentially capable of surface rupture, is located less than 1 mile northeast of the Planning Area. Considerable seismic events can occur on faults with a long period of inactivity, although it is generally considered less likely.

Table 3.7-2 presents the relative location of the major fault zones and the maximum parameters for earthquakes on known major faults in the region. The magnitude (M) is a measure of the energy released in an earthquake. The estimated magnitudes, described as moment magnitudes (Mw) represent *characteristic* earthquakes on particular faults.[1] Intensity is a measure of the ground shaking effects at a particular location. However, ground movement during an earthquake can vary depending on the overall magnitude, distance to the fault, focus of earthquake energy, and type of geologic material. The composition of underlying soils, even those relatively distant from faults, can intensify ground shaking.

---

[1] Moment magnitude is related to the physical size of a fault rupture and movement across a fault. The Richter magnitude scale reflects the maximum amplitude of a particular type of seismic wave. Moment magnitude provides a physically meaningful measure of the size of a faulting event (CDMG, 1997b). The concept of “characteristic” earthquake means that we can anticipate, with reasonable certainty, the actual earthquake that can occur on a fault.

Table 3.7-2 Active and Potentially Active Faults Affecting the Planning Area

Fault	*Distance and Direction from Planning Area*	*Recency of Movement*	*Fault Classification* [1]	*Maximum Moment Magnitude (Mw)* [2]	*Maximum Intensity (MMI)* [3]
San Andreas	42 miles west	Historic (1906, 1989) Holocene	Active	7.9	VI-V
Hayward	24 miles west	Historic (1836, 1868) Holocene	Active	7.1	VI-V
Calaveras	18 miles southwest	Historic (1961, 1911, 1984) Holocene	Active	6.8	VII-VI
Concord-Green Valley	11 miles west	Historic (1955) Holocene	Active	6.7	VII-VI
Clayton-Marsh Creek-Greenville	7 miles west	Historic (1980) Holocene	Active	6.9	VII-VI
Mount Diablo Thrust	11 miles southwest	Historic	Active	6.7	VIII-VII
Rodgers Creek	36 miles northwest	Historic	Active	7.0	VI-V
Antioch	<1 mile northeast	Historic	Potentially Active	Not available	Not available

1. An “active” fault is defined by the State of California as a fault that has had surface displacement within Holocene time (approximately the last 10,000 years). A “potentially active” fault has shown evidence of displacement during Quaternary time (approximately the last 2 million years). The fault classifications are derived from the Fault Activity Map of California and Adjacent Areas (Jennings, 1994).
2. Moment magnitude (Mw) is related to the physical size of a fault rupture and movement across a fault. Moment magnitude provides a physically meaningful measure of the size of a faulting event (CDFG, 1997). The Maximum Moment Magnitude Earthquake, derived from the joint CDMG/USGS Probabilistic Seismic Hazard Assessment for the State of California (USGS, 1996).
3. Maximum Intensity derived from ABAG shaking hazard maps (ABAG, 20003).

Source: ESA, 2008.

The Modified Mercalli (MM) intensity scale (Table 3.7-3) is commonly used to measure earthquake effects due to ground shaking. The MM values for intensity range from I (earthquake not felt) to XII (damage nearly total), and intensities ranging from IV to X could cause moderate to significant structural damage.[2] For comparison, the 1906 San Francisco earthquake (Mw 7.9) produced strong (VII) shaking intensities, while the 1989 Loma Prieta earthquake, with an Mw of 6.9 produced moderate (VI) shaking intensities in the Planning Area (ABAG, 2008a, b).

---

[2] The damage level represents the estimated overall level of damage that will occur for various MM intensity levels. The damage, however, will not be uniform. Some buildings will experience substantially more damage than this overall level, and others will experience substantially less damage. Not all buildings perform identically in an earthquake. The age, material, type, method of construction, size, and shape of a building all affect its performance.

Table 3.7-3 Modified Mercalli Intensity Scale

Intensity Value	*Intensity Description*	*Average Peak Acceleration (% g)* [1]
I	Not felt. Marginal and long period effects of large earthquakes.	< 0. 17 g
II	Felt by persons at rest, on upper floors, or favorably placed.	0.17-1.4 g
III	Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.	0.17-1.4 g
IV	Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls and frame creak.	1.4–3.9 g
V	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.	3.5 – 9.2 g
VI	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle).	9.2 – 18 g
VII	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.	18 – 34 g
VIII	Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.	34 – 65 g
IX	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluvial areas sand and mud ejected, earthquake fountains, sand craters.	65 – 124 g
X	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.	> 124 g
XI	Rails bent greatly. Underground pipelines completely out of service.	> 1.24 g
XII	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.	> 1.24 g

1. g (gravity) = 980 centimeters per second squared. 1.0 g of acceleration is a rate of increase in speed equivalent to a car traveling 328 feet from rest in 4.5 seconds.

Source: ABAG, 2003

San Andreas Fault

The San Andreas fault is located approximately 42 miles west of the Planning Area and is designated by the Alquist-Priolo Earthquake Fault Zoning Act as an active fault. The San Andreas Fault Zone was the source of the two major seismic events in recent history that affected the San Francisco Bay region. The 1906 San Francisco earthquake was estimated at M 7.9 and resulted in approximately 170 miles of surface fault rupture. Horizontal displacement along the fault approached 17 feet near the epicenter. The more recent 1989 Loma Prieta earthquake, estimated at M 7.1, resulted in widespread damage throughout the Bay Area. The USGS Working Group on California Earthquake Probabilities estimated there is a 21 percent chance of the San Andreas fault experiencing an earthquake of Mw 6.7 or greater in the next 30 years (USGS, 2003). This fault is not shown on Figure 3.7-3 due to the distance from the Planning Area.

Hayward Fault

The Hayward fault is located approximately 24 miles west of the Planning Area and is designated by the Alquist-Priolo Earthquake Fault Zoning Act as an active fault. A characteristic feature of the Hayward fault is its well-expressed and relatively consistent fault creep. Although large earthquakes on the Hayward fault have been rare since 1868, slow fault creep has continued to occur and has caused measurable offset. Fault creep on the East Bay segment of the Hayward fault is estimated at 9 millimeters per year (USGS, 1996). However, a large earthquake of about Mw 7.1 could occur on the Hayward fault. The USGS Working Group on California Earthquake Probabilities estimated there is a 27 percent chance of the Hayward fault experiencing an earthquake of Mw 7.1 or greater in the next 30 years (USGS, 2003). This fault is not shown on Figure 3.7-3 due to the distance from the Planning Area.

Calaveras Fault

The Calaveras fault is located approximately 18 miles southwest of the Planning Area and is designated by the Alquist-Priolo Earthquake Fault Zoning Act as an active fault. The Calaveras fault generally trends along the eastern side of the East Bay Hills, west of San Ramon Valley, and extends into the western Diablo Range, and eventually joins the San Andreas Fault Zone south of Hollister. The Calaveras fault has been the source of numerous moderate magnitude earthquakes, and the probability of a large earthquake (greater than Mw 6.8) to occur along the fault in the next 30 years is estimated at 11 percent (USGS, 2003).

Concord-Green Valley Fault Zone

The Concord and Green Valley faults are part of the larger San Andreas Fault System. The Concord fault extends from the northwestern slope of Mount Diablo north to Suisun Bay, where the Green Valley fault is generally thought to be connected to the Concord fault and continues north to Wooden Valley in Napa County. The Concord-Green Valley fault zone is located approximately 11 miles west of the Planning Area. This fault zone is judged capable of generating a maximum earthquake of Mw 6.7.

Clayton-Marsh Creek-Greenville Fault

The Clayton-Marsh Creek-Greenville fault extends along the base of the Altamont Hills, which form the eastern margin of the Livermore Valley. The fault is recognized as a major structural feature and has demonstrated activity in the last 11,000 years. The Clayton-Marsh Creek-

Greenville fault is located approximately 7 miles west of the Planning Area. This fault is judged capable of generating a maximum earthquake of Mw 6.9.

Mount Diablo Thrust Fault

The Mount Diablo Thrust fault is located approximately 11 miles southwest of the Planning Area but is not zoned under the Alquist-Priolo Earthquake Fault Zoning Act since it does not exhibit surficial displacement. This fault is judged capable of generating a maximum earthquake of Mw 6.7.

Rodgers Creek

The Rodgers Creek fault is an important branch of the larger San Andreas Fault system and is generally thought to be connected to the Hayward fault on the south side of San Pablo Bay. The Rodgers Creek fault is located in Sonoma County and is zoned under the Alquist-Priolo Earthquake Fault Zoning Act from Windsor Creek on the north almost to San Pablo Bay (Hart, 1998). The Rodgers Creek fault is approximately 36 miles northwest from the Planning Area and is judged capable of generating a maximum earthquake of Mw 7.0. This fault is not shown on Figure 3.7-3 due to the distance from the Planning Area.

Antioch Fault

The Antioch fault is mapped less than one (1) mile northeast of the Planning Area. The Antioch fault, mapped in 1973 after a pattern of property damage was noted, previously was considered active and was zoned under the Alquist-Priolo Earthquake Fault Zoning Act as potentially capable of surface rupture. However, a 1992 study by geologist C.J. Wills suggested that the Antioch fault should not be classified as active under the Alquist-Priolo Act and does not pose a surface-faulting hazard (Contra Costa Times, 2008). The fault is no longer zoned by the State of California as an earthquake fault zone under the Alquist-Priolo Act.

Highly calichefied surface soils were observed by TerraSearch, Inc. staff in the northwestern portion of the Planning Area in September 2008. Sometimes fault zones act as impermeable layers and accumulated water deposits calcium-rich mineral salts in the soils over the years. The presence of calichefied soil may or may not be related to the Antioch Fault (Terrasearch, Inc., 2008).

Seismic and Geologic Hazards

Ground Shaking

Strong ground shaking from a major earthquake could affect the Planning Area during the next 30 years. An earthquake on any one of the active faults could potentially produce a range of ground shaking intensities at the Planning Area. Ground shaking may affect areas hundreds of miles distant from the earthquake's epicenter. Historic earthquakes have caused strong ground shaking and damage in the San Francisco Bay Area. The 1906 San Francisco earthquake, estimated at M 7.9, produced light (MM V) to moderate (MM VI) shaking intensities in the Planning Area (ABAG, 2008a). The most recent major earthquake in the Bay Area was the M 6.9 Loma Prieta earthquake on the San Andreas fault in October 1989. The Loma Prieta earthquake caused strong ground shaking for about 20 seconds and resulted in varying degrees of structural damage as far as 50 miles away from the epicenter. This event produced light (MM V) shaking intensities in the Planning Area (ABAG, 2008b).

The common way to describe ground motion during an earthquake is the duration of the shaking. However, a common measure of ground motion is also the peak ground acceleration (PGA). The PGA for a given component of motion is the largest value of horizontal acceleration obtained from a seismograph. PGA is expressed as the percentage of the equivalent acceleration of gravity (g), which is approximately 980 centimeters per second squared. (In terms of automobile acceleration, one "g" of acceleration is a rate of increase in speed equivalent to a car accelerating from a standstill to 60 mph in less than 3 seconds.) For comparison purposes, the maximum peak acceleration value recorded during the Loma Prieta earthquake was in the vicinity of the epicenter, near Santa Cruz, at 0.64 g. The lowest values recorded were 0.06 g in the bedrock on Yerba Buena Island. However, an earthquake on the San Andreas fault would likely produce more severe ground shaking than was observed during the Loma Prieta earthquake if the epicenter were closer in vicinity to the Planning Area. Probabilistic seismic hazard maps indicate that peak ground acceleration in the project region could reach or exceed 0.41g (USGS, 1996).

The intensity of ground shaking that would occur at the Planning Area as a result of an earthquake in the Bay Area is partly related to the size of the earthquake, it's distance from the site, and the response of the underlying geologic materials. A large earthquake on the Concord-Green Valley fault is projected to produce the maximum ground shaking intensities in Antioch with MM IX in Bay Mud deposits along the Suisun Bay, north of State Route 4. MM IX is associated with damage to buried pipelines and partial collapse of poorly-built structures. Strong ground shaking of MM VII would occur locally along creek beds in inland portions of Antioch and throughout the majority of the City. MM VII on the Modified Mercalli scale is associated with nonstructural damage. A large earthquake on the Hayward fault is projected to produce ground shaking intensities of MM VIII along the Suisun Bay, north of State Route 4, and less intense ground shaking in Upland Areas (City of Antioch, 2003).

New construction in Antioch is required to meet the requirements of the California Building Code. Buildings of special occupancy are required by the State to meet more stringent design requirements than the UBC. Special occupancy buildings include hospitals, schools, and other structures that are important to protecting health and safety in the community (City of Antioch, 2003).

Surface Fault Rupture

Seismically induced ground rupture is defined as the physical displacement of surface deposits in response to an earthquake's seismic waves. The magnitude, sense, and nature of fault rupture can vary for different faults or even along different strands of the same fault. Ground rupture is considered more likely along active faults, which are referenced in Table 3.7-2.

The Planning Area is not within an Alquist-Priolo Fault Rupture Hazard Zone, as designated through the Alquist-Priolo Earthquake Fault Zoning Act, and no mapped active faults are known to pass through the immediate project region. The Antioch fault, which is located less than 1 mile northeast of the Planning Area, was previously considered active and zoned under the Alquist-Priolo Earthquake Fault Zoning Act but is no longer considered active nor considered to pose a surface-faulting hazard. Although surface fault rupture is not necessarily restricted to the area within an Alquist-Priolo Earthquake Fault Zone, the potential risk of surface rupture is highest along recognized active faults. Thus, the risk of ground rupture at the Planning Area is considered low.

Liquefaction

Liquefaction is the rapid transformation of saturated, loose, fine-grained sediment to a fluid-like state caused by seismic ground shaking. Soils susceptible to liquefaction include saturated loose to medium dense sands and gravels, low-plasticity silts, and some low-plasticity clay deposits. Liquefaction and associated failures could damage foundations, disrupt utility service, and can cause damage to roadways.

Liquefaction susceptibility maps prepared by the Association of Bay Area Governments (ABAG), which show areas with water-saturated sandy and silty materials, indicate the Planning Area has a liquefaction hazard of low to high (ABAG, 2007a). The area northeast of East Antioch Creek is mapped as having moderate liquefaction susceptibility, the East Antioch Creek corridor is mapped as a high susceptibility zone, and the portion of the site located southwest of the East Antioch Creek corridor is mapped as a low susceptibility zone. The southernmost edge of the Planning Area is mapped as having very low liquefaction susceptibility, which coincides with the location of sedimentary deposits of the Tulare Formation.

Preliminary soil investigations were conducted by Terrasearch, Inc. in September 2008. Five borings were drilled north of East Antioch Creek in areas of sandy near-surfaces soils. The borings indicated that there are approximately 18 feet of medium dense sand over clay to 50 feet depth. No groundwater was encountered within 20 feet depth. However, if groundwater were to rise to the surface, liquefaction of loose sands may result (Terrasearch, Inc., 2008).

Earthquake-Induced Settlement

Settlement of the ground surface can be accelerated and accentuated by earthquakes. Soft, water-saturated loose sands and soft, clay-rich sediments care subject to differential settlement. During an earthquake, settlement can occur as a result of the relatively rapid compaction and settling of subsurface materials (particularly loose, non-compacted, and variable sandy sediments) due to the rearrangement of soil particles during prolonged ground shaking. Settlement can occur both uniformly and differentially (i.e., where adjoining areas settle at different rates). Areas are susceptible to differential settlement if underlain by compressible sediments. It is possible that the Planning Area could be subjected to earthquake-induced settlement, particularly in the sandy soils located northeast of East Antioch Creek.

Soil Erosion

Soil erosion is the process by which soils are worn away from the earth’s surface by precipitation and runoff or wind. The rate of erosion depends on many factors, including soil type and geologic parent materials (inherent erodibility), degree of surface disturbance and resulting vegetative cover and degree of compaction, degree and length of slope, rainfall and/or wind amount and intensity, and erosion control practices. Soils that are high in silt and low in clay and organic matter are the most inherently erodible; but, regardless of soil texture, erosion potential may be high in steep, unvegetated areas-especially those areas disturbed by cut-and-fill or other construction activities. As indicated in Table 3.7-1, site soils are characterized as having a low to moderate hazard of erosion.

Landslides

Slope failures, commonly referred to as landslides; include many phenomena that involve the downslope displacement and movement of material, either triggered by static (i.e., gravity) or dynamic (i.e., earthquake) forces. A slope failure is a mass of rock, soil, and debris displaced downslope by sliding, flowing, or falling. Exposed rock slopes undergo rockfalls, rockslides, or rock avalanches, while soil slopes experience shallow soil slides, rapid debris flows, and deep-seated rotational slides. Landslides may occur on slopes of 15 percent or less; however, the probability is greater on steeper slopes that exhibit old landslide features such as scarps, slanted vegetation, and transverse ridges. Landslide-susceptible areas are characterized by steep slopes and downslope creep of surface materials. Debris flows consist of a loose mass of rocks and other granular material that, if saturated and present on a steep slope, can move downslope. The rate of rock and soil movement can vary from a slow creep over many years to a sudden mass movement. Landslides occur throughout the state of California, but the density of incidents increases in zones of active faulting.

Maps prepared by ABAG depicting the distribution of existing landslides show that the majority of the Planning Area is classified a “Flatland,” with the exception of the southernmost edge of the Planning Area, between SR 4 and the Union Pacific Railroad tracks, which is mapped as “Few Landslides” and corresponds with the sedimentary deposits of the Tulare formation (ABAG, 2007b). The hills in the southernmost portion of the Planning Area, which range from 15 to 30 percent slope, may be susceptible to landslide and slope instability hazards.

Preliminary test pit investigations in the southeastern portion of the Planning Area indicate that the sandstone and claystone hills have bedrock with bedding attitudes that range from 10 degrees to 20 degrees to the north. This means that any north facing cut slopes inclined at 2:1 (horizontal to vertical) will have the potential for instability (Terrasearch, Inc., 2008).

Differential Settlement

Settlement is the depression of the bearing soil when a load, such as that of a building or new fill material, is placed upon it. Soils tend to settle at different rates and by varying amounts depending on the load weight or change in properties over an area, which is referred to as differential settlement. Differential settlement of the loose soils generally occurs slowly, but over time can amount to more than most structures can tolerate. If not properly engineered, loose, soft, soils comprised of sand, silt, and clay have the potential to settle after a building or other load is placed on the surface. Differential settlement can damage buildings and their foundations, roads and rail lines, and result in breakage of underground pipes. It is possible that the Planning Area could be subjected to differential settlement, particularly in the sandy soils located northeast of East Antioch Creek.

Expansive Soils

Expansive soils possess a “shrink-swell” behavior. Shrink-swell is the cyclic change in volume (expansion and contraction) that occurs in fine-grained clay sediments from the process of wetting and drying. Structural damage to buildings can occur over a long period of time, usually as a result of inadequate soil and foundation engineering or the placement of structures directly on expansive soils. Site soils northeast of East Antioch Creek have been characterized as having a low expansion potential, or shrink-swell behavior. Site soils northwest of East Antioch Creek have been characterized as having a moderate to high expansion potential.

Subsidence

Land surface subsidence can result from both natural and man-made phenomena. Natural phenomena include subsidence resulting from tectonic deformations and seismically induced settlements (see liquefaction); soil subsidence due to consolidation; subsidence due to oxidation or dewatering of organic-rich soils; and subsidence related to subsurface cavities. Subsidence or settlement related to human activities includes subsidence caused by decreased pore pressure due to the withdrawal of subsurface fluids, including water and hydrocarbons. Planning Area soils are considered susceptible to subsidence.

Ultramafic or Asbestos-Containing Soils

Asbestos is a term used for several types of naturally occurring fibrous minerals that are a human health hazard when airborne. Serpentinite may contain chrysotile asbestos, especially near fault zones. Ultramafic rock, a rock closely related to serpentinite, may also contain asbestos minerals. Asbestos is classified as a known human carcinogen by state, federal, and international agencies and is considered a toxic air contaminant by the California Air Resources Board (CARB).There are no mapped ultramafic or asbestos-containing soils in the Planning Area.

REGULATORY SETTING

State Regulations

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (formerly the Alquist-Priolo Special Studies Zone Act), signed into law December 1972, requires the delineation of zones along active faults in California. The Alquist-Priolo Act regulates development on or near active fault traces to reduce the hazard of fault rupture and to prohibit the location of most structures for human occupancy across these traces.[3] Cities and counties must regulate certain development projects within the delineated zones, and regulations include withholding permits until geologic investigations demonstrate that development sites are not threatened by future surface displacement (Hart, 1997). Surface fault rupture, however, is not necessarily restricted to the area within an Alquist-Priolo Zone.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act of 1990 addresses non-surface fault rupture earthquake hazards, including liquefaction and seismically induced landslides, and its purpose is to protect public safety from the effects of strong ground shaking, liquefaction, landslides, and other ground failure, and other hazards caused by earthquakes. The Act requires the State Geologist to delineate various seismic hazard zones and requires cities, counties, and other local permitting agencies to regulate certain development projects within these zones. Before a development permit is granted for a site within a seismic hazard zone, a geotechnical investigation of the site must be conducted and appropriate mitigation measures incorporated into the project design. As of October 2008, 22 official seismic hazard zone maps for the San Francisco Bay Area showing areas prone to

[3] A "structure for human occupancy" is defined by the Alquist-Priolo Act as any structure used or intended for supporting or sheltering any use or occupancy that has an occupancy rate of more than 2,000 person-hours per year.

liquefaction and landslides have been released, and additional maps for Contra Costa County are planned or in progress. None of the current maps encompass the City of Antioch (CGS, 2004).

California Building Code

The *California Building Code* is certified in the California Code of Regulations (CCR), Title 24, Part 2, which is a portion of the California Building Standards Code. Title 24 is assigned to the California Building Standards Commission, which, by law, is responsible for coordinating all building standards. Published by the International Conference of Building Officials, the Uniform Building Code (UBC) is a widely adopted model building code in the United States. The California Building Code incorporates by reference the UBC with necessary California amendments. About one-third of the text within the California Building Code has been tailored for California earthquake conditions. Although widely accepted and implemented throughout the United States, local, City and county jurisdictions can adopt the UBC either in whole or in part.

Local Regulations

Hillside Planned Development Ordinance

The City of Antioch has a Hillside Planned Development (HPD) Ordinance to protect hillsides, ridges, and ridgelines within the City (City of Antioch, 2003). The HPD Ordinance was revised and adopted in 1994 as part of the Zoning Ordinance and applies to those hillside areas in which one or more of the following apply:

- A predominant portion of the area has slopes in excess of 10 percent;
- A significant area of slopes of 25 percent or greater; or
- A significant ridgeline, hilltop, or exposed slope is located in the area.

The HPD Ordinance does not apply as the site does not meet any of the criteria listed above and no HPD Districts have been defined within the Planning Area.

City of Antioch Municipal Code

Title 8, Chapter 1, Section 8 of the City of Antioch Municipal Code establishes that all building permit applications must comply with the structural requirements of the California Building Code, as well as other pertinent laws and ordinances of the city or any other governmental body having jurisdiction over the city.

Title 9, Chapter 4, Article 5 of the City of Antioch Municipal Code requires that building permit applications for new development must be accompanied by a preliminary soils report that characterizes the soil qualities of the proposed development area. If the preliminary soil report indicates the presence of soil problems which, if not corrected, could lead to structural defects, a soil investigation must be prepared that recommends corrective actions to prevent structural damage where such soil problems exist. Soil investigations are approved by the City Engineer, and the building permit is conditioned upon the incorporation of the approved recommended corrective action in the construction.

City of Antioch General Plan

The Environmental Hazards element of the City of Antioch General Plan contains a variety of recommendations for the prevention of damage and injury or death from geologic and seismic hazards. Ensuring public safety involves establishing goals and policies that consider all types of potential disasters and reducing the risk of personal injury and potential property damage.

11.3.2 Geology and Seismicity Policies

a. Require geologic and soils reports to be prepared for proposed development sites, and incorporate the findings and recommendations of these studies into project development requirements. As determined by the City of Antioch Building Division, a site-specific assessment shall be prepared to ascertain potential ground shaking impacts on new development. The site-specific ground shaking assessment shall incorporate up-to-date data from government and non-government sources and may be included as part of any site-specific geotechnical investigation. The site-specific ground shaking assessment shall in-clude specific measures to reduce the significance of potential ground shaking hazards. This site-specific ground shaking assessment shall be prepared by a licensed geologist and shall be submitted to the City of Antioch Building Division for review and approval prior to the issuance of building permits. For purposes of this policy, “development” applies to new structures and existing structures or facilities that undergo expansion, remodeling, renovation, refurbishment or other modification. This policy does not apply to second units or accessory buildings.

b. Provide information and establish incentives for property owners to rehabilitate existing buildings using updated construction techniques to protect against seismic hazards.

c. Encourage the purchase of earthquake insurance by residents and businesses.

d. Encourage continued investigation by State agencies of geologic conditions within the Bay Area to update knowledge of seismic hazards and promote public awareness.

e. Provide expedited review of any seismic- related revisions to the Uniform Building Code proposed by the State.

f. Work with PG&E, pipeline companies, and industrial uses to implement measures to safeguard the public from seismic hazards associated with high voltage transmission lines, caustic and toxic gas and fuel lines, and flammable storage facilities.

g. Require that engineered slopes be designed to resist seismically-induced failure.

h. Require that parcels overlying both cut and fill areas within a grading operation be over-excavated to mitigate the potential for seismically-induced differential settlement.

i. Limit development in those areas, which, due to adverse geological conditions, will be hazardous to the overall community and those who will inhabit the area.

j. Require evaluations of potential slope stability for developments proposed within hillside areas, and incorporate the recommendations of these studies into project development requirements.

k. Require specialized soils reports in areas suspected of having problems with potential bearing strength, expansion, settlement, or subsidence, including implementations of the recommendations of these reports into the project development, such that structures de-signed for human occupancy are not in danger of collapse or significant structural damage with corresponding hazards to human occupants. Where structural damage can be mitigated through structural design, ensure that potential soils hazards do not pose risks of human injury or loss of life in outdoor areas of a development site.

l. Where development is proposed within an identified or potential liquefaction hazard area (as determined by the City), adequate and appropriate measures such as (but not limited to) designing foundations in a manner that limits the effects of liquefaction, the placement of an engineered fill with low liquefaction potential, and the alternative siting of structures in areas with a lower liquefaction risk, shall be implemented to reduce potential liquefaction hazards. Any such measures shall be submitted to the City of Antioch Building Division for review prior to the approval of the building permits.

IMPACT ANALYSIS

SIGNIFICANCE CRITERIA

Implementation of the proposed Plan would have a potentially significant adverse impact if the Plan would:

Geology

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault;
  - Strong seismic ground shaking;
  - Seismic-related ground failure, including liquefaction;
  - Landslides.
- Result in substantial soil erosion or the loss of topsoil.
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

Mineral Resources

- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state.
- Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.

METHODOLOGY AND ASSUMPTIONS

This impact analysis focuses on potential effects on geology, soils, and seismicity associated with transit-oriented residential and commercial development in the Planning Area as proposed under the Hillcrest Station Area Specific Plan. The evaluation is based on review of project plans, applicable regulations and guidelines, and review of published geologic, soils, and seismic maps and studies.

SUMMARY OF IMPACTS

Because the Planning Area is not located within an Earthquake Fault Hazard Zone, the risk of surface fault rupture at the Planning Area is considered low. Potential geologic and soils impacts to proposed structures and infrastructure are primarily related to ground shaking and associated ground failure (e.g., liquefaction), soil expansion, settlement, and subsidence. Potential slope instability hazards are present in the hilly areas in the southernmost portion of the Planning Area, between SR 4 and the Union Pacific Railroad tracks. The potential for soil erosion would increase during construction, but would be addressed by mandatory compliance with existing regulations. As no significant mineral resource areas exist within or in the vicinity of the Planning Area, no impact related to the loss of availability for mineral resources would result.

IMPACTS AND MITIGATION MEASURES

3.7-1 ***Proposed development in the Planning Area could expose people or structures to surface fault rupture. (Less than Significant)***

The Planning Area is not located within an Alquist-Priolo Earthquake Fault Zone, and no active or potentially active faults exist on or in the immediate vicinity of the site. The Antioch fault, located less than 1 mile northeast of the Planning Area, is no longer considered active nor considered to pose a surface-faulting hazard. The closest known earthquake fault classified as active or potentially active (Clayton-Marsh Creek-Greenville) is located approximately 7 miles west of the Planning Area. Although surface fault rupture is not necessarily restricted to the area within an Alquist-Priolo Earthquake Fault Zone, the potential risk of surface rupture is highest along active faults. Thus, potential impacts related to surface fault rupture would be less than significant.

Mitigation Measures

No mitigation measures are required.

3.7-2 ***Proposed development in the Planning Area could expose people or structures to seismic hazards such as ground shaking or liquefaction. (Less than Significant)***

Ground shaking generated during an earthquake could result in structural damage to structures and project-related infrastructure. Seismic-related ground shaking is an unavoidable hazard in the San Francisco Bay Area. Structures and associated infrastructure proposed under the Hillcrest Station Area Specific Plan would likely experience at least one major earthquake (greater than Richter magnitude 6.7) during their functional lifetime. The degree of hazard depends on the geologic condition of the site, construction materials, and construction quality. The intensity of such an event would depend on the causative fault and distance to the epicenter, the moment magnitude, and the duration of shaking.

Although some structural damage is typically not avoidable, building codes and construction standards established by the California Building Code and contained in Title 24 of the CCR protect against building collapse and major injury during a seismic event. Future development in the Planning Area would be required to meet the requirements of the California Building Code to help prevent extensive structural damage due to seismic-related ground shaking.

Future development in the Planning Area may also be susceptible to secondary seismic hazards such as liquefaction. Soils containing a high percentage of sands are generally most susceptible to liquefaction. Surface soils in the Planning Area range from clay and silty clay loam to fine-grained sand. Liquefaction susceptibility maps prepared by ABAG indicate the Planning Area has a liquefaction hazard of low to high, with the highest hazard along the East Antioch Creek channel and moderate liquefaction hazard in northeast corner of the site, north of the creek. Liquefaction-induced ground failure can result in damage to underground utilities, shallow foundations, and paved areas.

Both the City of Antioch Municipal Code and the City of Antioch General Plan require the preparation of site-specific geologic and soils reports for all new development, and require that the findings and recommendations of these studies be incorporated into project development. These reports must be submitted to the City of Antioch Building Division for review and approval prior to the issuance of building permits, and the building permit conditioned upon the incorporation of the approved recommended corrective action in the construction.

The proposed Plan includes high density development, with building heights ranging from one to eight stories, throughout most of the Planning Area. Development is expected on soils which are expected to significantly amplify ground-shaking. Even though all construction must meet the Uniform Building Codes standards for Seismic Risk Zone 4, there will be new development and new population that will be potentially impacted by ground-shaking and other seismic hazards.

The proposed Plan designates the northeast corner of the Planning Area, where the hazard of liquefaction is considered moderate as high density transit area mixed-use. It is anticipated that as part of the site preparation of this area that significant fill will be added to raise the elevation. Standard practices for placing and compacting fill material should reduce the likelihood of liquefaction and seismically-induced settlement. The area with the highest hazard level of liquefaction, the East Antioch Creek corridor, is designated as open space, which should limit the impact of potential liquefaction and seismically-induced settlement on people and structures.

Existing Policies and Requirements that Reduce the Impact

Mandatory compliance with the building codes and construction standards established in the California Building Code, the requirements of the City of Antioch Municipal Code, and policies contained in the City of Antioch General Plan would reduce seismic-related ground shaking and liquefaction to less than significant levels.

Mitigation Measures

No mitigation measures are required.

3.7-3 ***Implementation of the Hillcrest Station Area Specific Plan could expose proposed structures and infrastructure to geologic hazards, including expansive soils, differential settlement, and subsidence. (Less than Significant)***

Sediments underlying the Planning Area are alluvial soils that range from clay and silty clay loam to fine-grained sand. The composition of these soils is likely to vary over distance and depth. Soil properties will be determined with site-specific investigations. In the northeastern portion of the Planning Area, there are approximately 18 feet of sand over clay to 50 feet depth. The southeastern hills are composed primarily of sandstone and claystone. Until confirmation, it is assumed that proposed structures could be subject to soil expansion, settlement, and subsidence.

Soils containing a high percentage of clays are generally most susceptible to expansion. According to soil survey information provided in the Contra Costa County Soil Survey, soils northeast of East Antioch Creek (DaC) are characterized as having a low expansion potential, or shrink-swell behavior. Soils southwest of East Antioch Creek (ZaA, CaC, LhE, DdE) and the So soils found in the northern portion of the creek are characterized as having moderate to high expansion potential. Expansive soils can damage foundations of aboveground structures, paved roads and streets, and concrete slabs. Due to the nature of site soils, corrective measures to address the potential for expansive soils to increase structural damage will need to be implemented.

If not properly engineered, loose, soft, soils composed of sand, silt, and clay have the potential to settle after a building or other load is placed on the surface. Differential settlement of loose soils would be a concern in areas that have not previously supported structures and where new structures would place loads heavier than the soils could tolerate. Differential settlement can damage buildings and their foundations, roads and rail lines, and result in breakage of underground pipes. In the absence of a site-specific geotechnical investigation, it is assumed that the Planning Area could be subjected to differential settlement, particularly in the sandy soils located northeast of East Antioch Creek.

In the absence of a site-specific geotechnical investigation, the Planning Area is also considered susceptible to land surface subsidence due to consolidation, oxidation, or dewatering of organic-rich soils, and subsidence related to subsurface cavities.

As required by the City of Antioch Municipal Code and the City of Antioch General Plan, at a minimum, building permit applications must be accompanied by a preliminary soils report that characterizes soil properties in the development area. If the preliminary soils report indicates the presence of expansive soils, settlement, and potential for subsidence, a soils investigation report must be prepared that provides recommendations to offset potential soil problems, and the recommendations must be incorporated into project development.

Existing Policies and Requirements that Reduce the Impact

Mandatory compliance with the City of Antioch Municipal Code and policies contained in the City of Antioch General Plan would ensure impacts related to geologic hazards, such as expansive soils, differential settlement, and subsidence to less-than-significant levels for the proposed Plan.

Mitigation Measures

No mitigation measures are required.

3.7-4 ***Proposed development along the two southernmost hills adjacent to SR 4 could be susceptible to seismically-induced landslides or other slope failures, potentially resulting in damage to structures and private property. (Less than Significant)***

With the exception of the hillside areas along the southern boundary, the surface topography of the Planning Area is relatively level, and potential slope instability hazards are minimal. Hilly areas in the southernmost portion of the Planning Area, between SR 4 and the Union Pacific Railroad tracks, range from 15 to 30 percent slope. Preliminary test pit investigations in the southeastern portion of the Planning Area indicate that the sandstone and claystone hills have bedrock with bedding attitudes that range from 10 degrees to 20 degrees to the north. This means that any north facing cut slopes inclined at 2:1 (horizontal to vertical) will have the potential for instability. (Terrasearch, Inc., 2008) Without proper engineering controls, re-grading and development of this area could result in slope instability, potentially resulting in damage to structures and private property.

Under the proposed Plan, the steep slope areas in the southernmost portion of the Planning Area would be significantly graded to level the topography and allow for transit area mixed-use development. In the absence of a site-specific slope stability analysis, landslide and slope instability hazards under this scenario are considered potentially significant. Compliance with existing regulations and the proposed plan policies would reduce the potential impact to less than significant levels.

Specific Plan Policies that Reduce Impact

EH-30 A slope stability analysis of the hillsides along the southernmost portion of the Planning Area shall be conducted prior to the issuance of any grading permits in this area.

- If slope stability and/or landslides are expected to be an issue, the slope stability analysis shall recommend measures to ensure that future development projects in this area be designed and constructed to avoid seismically-induced landslides or other slope failures. Recommendations can include:
- Requiring that the slope is cut at a flatter angle, such as 2.5:1 or 3:1 for slopes greater than 30 feet high; or,

- Requiring that the slope is excavated and re-built as engineered fill buttress slopes inclined at 2:1 for slopes up to 30 feet high and inclined at 2.5:1 for slopes greater than 30 feet high.
- Detailed grading plans and construction drawings incorporating the recommended measures shall be submitted to the City of Antioch Building Department for approval prior to the issuance of building permits.

Mitigation Measures

No mitigation measures are required.

3.7-5 *Future development in the Planning Area could result in increased soil erosion. (Less than Significant)*

The USDA Soil Survey for Contra Costa County indicates the hazard of erosion of site soils varies from slight where gently sloping, to moderate in the hilly areas at the southeast portion of the Planning Area.

Erosion hazards would be highest during construction activities. Construction activities such as excavation, backfilling, grading, and demolition can remove stabilizing vegetation and expose areas of loose soil that, if not properly stabilized during construction, can be subject to soil loss and erosion by wind and stormwater runoff.

Per the City of Antioch Municipal Code, all construction activities are required to include engineering practices for erosion control. Further, as discussed in Section 3.9, Hydrology and Water Quality, future development projects in the Planning Area would be required to comply with NPDES General Construction Permit requirements. Project applicants would be required to prepare a Storm Water Pollution Prevention Plan (SWPPP) to minimize the discharge of pollutants, including silt and sediment, during construction. The SWPPP would need to include measures to control erosion and effectively manage runoff and retain sediment on-site during construction.

Under the proposed Plan, the steep slope areas in the southernmost portion of the Planning Area would be significantly graded to level the topography and allow for transit area mixed-use development. The hazard of erosion in the southernmost portion of the Planning Area is characterized as moderate, and could be exacerbated by grading activities during construction. However, compliance with existing policies and regulations would reduce the impact to less than significant levels.

Existing Policies and Requirements that Reduce Impact

Mandatory compliance with the City of Antioch Municipal Code and NPDES General Construction Permit requirements would reduce impacts related to erosion hazards to less-than-significant levels.

Mitigation Measures

No mitigation measures are required.

This page left intentionally blank.