C.5 GEOLOGY, SOILS, AND PALEONTOLOGY

C.5 GEOLOGY, SOILS, AND PALEONTOLOGY

This section describes existing geologic, soil, and paleontological conditions; associated geologic hazards; and potential impacts and mitigation measures for the proposed project and alternatives.

C.5.1 ENVIRONMENTAL BASELINE AND REGULATORY SETTING

Baseline geologic information was collected from published and unpublished geologic, seismic and geotechnical literature covering the proposed project and the surrounding area. The literature review was supplemented by a field reconnaissance of the project alignment. The literature review and field reconnaissance focused on the identification of specific geologic hazards.

C.5.1.1 Regional Overview

The proposed project is located in the Santa Clara Valley, at the southern margin of San Francisco Bay. Santa Clara Valley is bordered on the east by the Diablo Range and on the west by the Santa Cruz Mountains. The valley is part of a long, narrow, northwest-trending structural depression bounded by the Hayward and Calaveras faults on the east and the San Andreas and Monte Vista-Shannon faults on the west. The proposed project alignment overlies estuarine sediments deposited in San Francisco Bay and alluvial sediments deposited by Coyote Creek and other tributaries at the bay margin (Helley and Wesling, 1989).

C.5.1.2 Environmental Setting

C.5.1.2.1 *Physiography and Topography*

PG&E Co.'s proposed project extends from the City of Fremont in Alameda County, through parts of the City of San Jose, and into a small area of unincorporated land in Santa Clara County. The proposed project is on the northern portion of an approximately 30-mile long by 16-mile wide lowland alluvial plain, which slopes gradually northwest toward San Francisco Bay.

The northern end of the proposed 230 kV transmission line begins at the existing Newark Substation on the margin of tidal lowlands of San Francisco Bay. The proposed route generally follows the 1850 San Francisco Bay shoreline as mapped by Nichols and Wright (1971), and crosses Agua Caliente, Agua Fria, Penitencia and Coyote Creeks at elevations ranging from approximately 5 to 20 feet above mean sea level. All of the creek crossings are over unlined channels. The southern portion of the proposed route generally follows the course of Coyote Creek (at sea level to 5 feet elevation), where it traverses a broad plain containing artificial fill, crosses the Coyote Creek stream channel, and traverses elevated levee deposits (10 to 15 feet above sea level). The proposed Los Esteros Substation site is at an elevation of 10 to 15 feet on a broad floodplain that slopes about 1 degree to the northwest, away from Coyote Creek and consists of prime agricultural soils that are currently under cultivation. The proposed 115 kV distribution lines generally follow established roadways consisting of disturbed alluvial deposits and artificial fill. The Westerly Route Alternative primarily traverses human-made salt evaporation ponds and levees underlain by estuary and bay mud deposits at or slightly above sea level. Stream channelization, landfilling, highway construction, and commercial developments along the corridor have made substantial changes to the natural landscape.

C.5.1.2.2 *Geology*

The San Francisco Bay Basin comprises a fault-bounded trough structure that contains a thick sequence of Pleistocene through Holocene marine and non-marine sediments, deposited on a basement complex of Franciscan rocks as the basin subsided and as sea level fluctuated. The proposed and alternative routes cross similar geologic deposits. Holocene sediments in the project area consist of bay mud, which grades laterally and interfingers with stream channel, levee, and overbank floodplain deposits of Coyote Creek and other tributary streams (Helley and Wesling, 1990). These sediments consist of clay, silt, sand and gravel. The Holocene alluvium is underlain by more than 1,000 feet of Pleistocene alluvium and bay mud, consisting of gravel, sand, silt and clay. The Pleistocene sediments are subdivided into non-marine older alluvium and older bay mud (Helley, et al., 1972; 1979). These sediments are exposed at the surface from near the bay margins to the foot of the Diablo Range.

C.5.1.2.3 *Faults and Seismicity*

The seismicity of the San Francisco Bay area is dominated by the interaction of the San Andreas fault and the Hayward and Calaveras faults, with the Santa Clara Valley located between these two systems. These and other lesser faults are responding to stress produced by the relative motions of the Pacific and North American tectonic plates. The stress is relieved by right-lateral strike-slip, vertical or reverse slip faulting along the San Andreas, Hayward, and Calaveras faults and other associated faults. The effects of this deformation include mountain building, basin development, widespread regional uplift, and the generation of earthquakes. Figure C.5-1, Fault Map depicts the location of the proposed project in relation to known active and potentially active faults in the Santa Clara Valley area. The active and potentially active fault classifications have been developed by the California Division of Mines and Geology (CDMG) based on the age of most recent activity and are defined as described below:

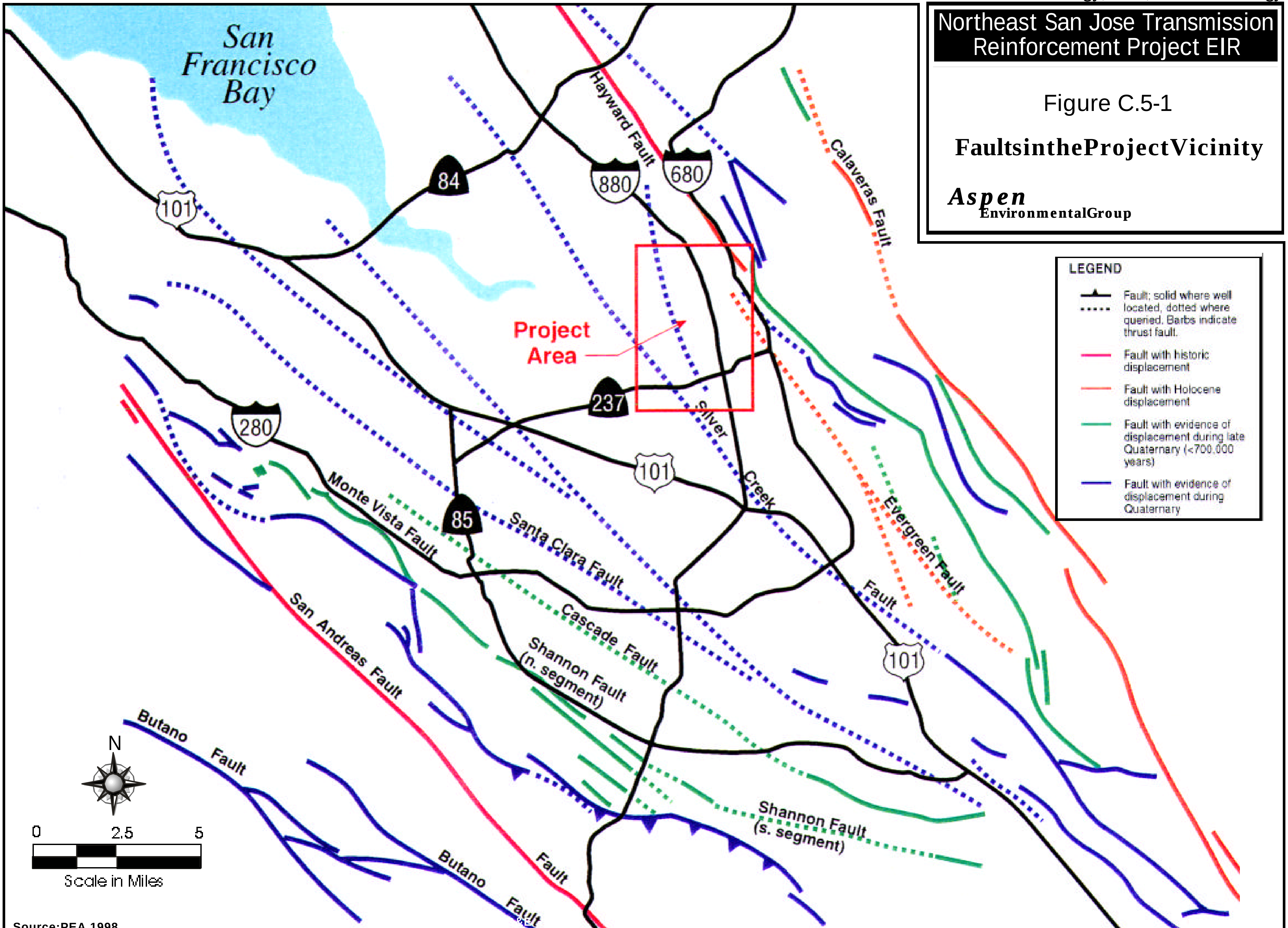
- Active faults are Historic and Holocene age faults that have had surface displacement within the past 11,000 years
- Potentially active faults are defined as Quaternary age faults that have evidence of displacement between about 11,000 years and 2 million years ago.

Northeast San Jose Transmission Reinforcement Project EIR

Figure C.5-1

Faults in the Project Vicinity

Aspen Environmental Group



Source: PEA, 1998.

The project area will be subject to strong ground shaking associated with earthquakes on the major active faults including the San Andreas, Hayward, and Calaveras faults, with a cumulative probability of 70 percent for one or more magnitude (M) 6.7 earthquakes in the next 30 years (WG99, 1999).

Fault Rupture

Large abrupt differential fault displacements comprise a severe earthquake hazard for an electrical substation. Toppling or severe distortion of the substation transformers and other electrical station components may occur in the vicinity of a surface earthquake rupture near the proposed substation site.

Fault rupture is a potential hazard at the proposed Los Esteros Substation, where the footprint overlies the potentially active trace of the northeast splay of the Silver Creek fault (Wagner, et al., 1991; Jennings, 1994). The Silver Creek fault was originally part of the State of California's Alquist-Priolo Fault Rupture Hazard Zone Maps (CDMG, 1980, 1982). The Special Studies Zone for the Silver Creek fault was recommended for removal after fault studies found no evidence of obvious surface rupture along its surface trace in southern San Jose. On its own initiative, the City of San Jose maintains a surface rupture study zone along the Silver Creek fault, and a number of other faults where State mandated hazard zones have been withdrawn (Weigers and Tryhorn, 1992).

Weigers and Tryhorn (1992) report that exploratory trenches across the Silver Creek fault south of San Jose show displacement of Plio-Pleistocene alluvium in over 100 trenches, but definitive determination of offset through overlying Holocene A-horizon soils was not possible. This report makes note that these soils are generally thin and consist of highly expansive clays, which exhibit abundant desiccation features, rodent burrows, and possible human disturbances. These disturbances allow the possibility of unrecognized Holocene displacement until absolute age dating of soils can be determined to eliminate all possibility. The lack of recognizable surface offset does not eliminate the possibility of Holocene activity. The difficulty in recognizing fault offset in cohesive sediments and clay soils is well documented by Bonilla and Lienkaemper (1991).

Strong Ground Shaking

Earthquakes are classified by their moment magnitude (M_W), reflecting the amount of energy released. Earthquakes of M_W 6.0 to 6.9 are classified as moderate, those between M_W 7.0 and 7.9 are classified as major, and those of M_W 8.0 or greater are classified as great. The 1868 M_W 7.0 Hayward Earthquake was caused by a rupture of the southern segment of the Hayward fault, which extended from Fremont north through Oakland, perhaps as far north as Berkeley. This event resulted in major damage to many large structures in the bay area (Toppozada and Parke, 1982). The 1906 M_W 7.8 San Francisco Earthquake was caused by a rupture of the San Andreas fault offshore, west of San Francisco, with surface rupture extending southward to near Hollister and northward into the ocean north of Point Arena. Severe damage to structures occurred throughout the bay area, including extensive ground failure and liquefaction effects in the project area along Coyote Creek (Lawson, 1908;

Egan, et al., 1992). The 1989 M_W 6.9 Loma Prieta Earthquake was caused by a rupture of the San Andreas fault in the southern end of the Santa Cruz Mountains and also caused widespread damage.

Regionally damaging earthquakes may also occur on other known faults in northern California. In addition, it is important to note that earthquake activity from unmapped subsurface faults or surface faults, which are classified as being potentially active, is a possibility that is currently not predictable without detailed studies investigating each fault.

Earthquake intensity has been described for centuries using terms describing the effects on human structures and observations. These observations have been used in various attempts to quantify the strength of earthquakes. The Modified Mercalli Intensity (MMI) scale is a subjective numerical index describing the severity of an earthquake in terms of its observed effects on humans, man-made structures, and the earth's surface. The MMI scale, as shown on Table C.5-1, is now widely accepted throughout the scientific community.

Table C.5-1 Modified Mercalli Intensity Scale

Intensity. A subjective measure of the force of an earthquake at a particular place as determined by its effects on persons, structures, and earth materials. The principal scale used in the United States today is the Modified Mercalli, 1956 version as defined below (modified from, Richter, 1958, p. 137-138):	
I.	Not felt.
II.	Felt by persons at rest, on upper floors, or favorably place.
III.	Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV.	Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing automobiles rock. Windows, dishes, doors rattle. Wooden walls and frame may creek.
V.	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing. Shutters, pictures move. Pendulum clocks stop, start, change rate.
VI.	Felt By all. Many frightened and run outdoors. Persons walk unsteadily. Window, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off wall. Furniture moved or overturned. Weak plaster and masonry D cracked.
VII.	Difficult to stand. Noticed by drivers of automobiles. Hanging objects quiver. Furniture broken. Weak chimneys broken at roof line. Damage to masonry D, including cracks, fall of plaster, loose bricks, stone, tiles and unbraced parapets. Small slides and caving in along sand or gravel banks. Large bells ring.
VIII.	Steering of automobiles affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall to 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.
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 of foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground and liquefaction.
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.
XI.	Rails bent greatly. Underground pipelines completely out of services.
XII.	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown in the air.
See Uniform Building Code for specifications on quality of masonry construction on ground shaking in Holocene to Plio-Pleistocene sediments.	

The intensity of earthquake-induced ground motions can also be described using peak site accelerations as measured by seismographs, represented as a fraction of the acceleration of gravity (g), and compared with the Modified Mercalli Scale. The maximum credible peak ground acceleration for the proposed project can be calculated from the distance of the proposed project to the most critical fault and the maximum credible earthquake magnitude for that fault, using any of a number of attenuation relationships relating to local surface geologic conditions.

Recent maps published by the CDMG (1996) estimated the peak ground acceleration with a 10 percent probability of excess in 50 years would be between 0.5 and 0.7 g for the project area. The characteristics of significant local faults that would contribute to the seismic shaking hazards along the proposed project are listed in Table C.5-2, Fault Activity.

Table C.5-2 Fault Activity in the Project Area

Fault/Fault Segment Name	Fault Style (1)	Assumed Fault/Segment Length (km)	Assumed Fault Slip Rate (mm/yr)	Notable Historic Surface Wave Magnitude, Ms (year in parentheses)	Estimated "Upper Bound" Moment Magnitude (M)
Thrust Faults					
Mission	R	26	3.0		6.4
Monte Vista-Shannon	R	41	0.4		6.8
Calaveras					
Northern Segment	RL	52	6.0	6.4 (1861)	6.8
Southern Segment	RL	106	15	5.9 (1979)	6.2
Concord-Green Valley	RL	66	6.0		6.9
Greenville	RL	73	2.0	5.6 (1980)	6.9
Hayward-Rodgers Creek					
Northern Segment	RL	43	9.0	6.8 (1836)	6.9
Southern Segment	RL	43	9.0		6.9
Southeast Extension	OBL	26	3.0		6.4
Rodgers Creek	RL	63	9.0		7.0
Multi-Segment Model (1868 Rupture) Northern + Southern Segments	RL	86	9.0	6.8 (1868)	7.1
San Andreas System					
North Coast Segment	RL	32	24		7.6
Peninsular Segment	RL	9	17		7.1
Santa Cruz Mtn Segment	RL	4	14	6.9 (1989)	7.0
Multi-segmented Model (1906 Rupture) North Coast +Peninsular + Santa Cruz Mtn Segments	RL	470	24	7.9 (1906)	7.9
San Gregorio	RL	129	5.0		6.2
Sargent	RL	53	3.0		6.8
Silver Creek	RL	58	?		?

Notes: (1) Fault Styles: RL = Right Lateral; R = Reverse; TH = Thrust; OBL = Oblique
Source: Fault data from CDMG Open File Report 96-08

Santa Clara County prepared a subarea plan for the baylands within its jurisdiction taking into account the seismic and nonseismic hazards associated with flatland deposits. The resulting report divided the flatland area into risk zones on the basis of potential for settlement and ground failure under both seismic and nonseismic conditions (Helley et al., 1979). These risk zones included use restrictions based on the nature of structures planned for development in certain areas and the acceptable risks involved with critical infrastructure elements. Much of the project area lies within Land-Use Planning

Risk Zones D_{LS} and D_{SL}. Risk Zone D is the most restrictive regarding the recommended structure types and uses, reserved for open space consisting of agriculture, marinas, public and private open spaces, marshlands and salt ponds, and small appurtenant buildings. The subscripts SL and LS represent significant hazards from shallow liquefaction and lateral spreading, respectively. The study area excluded the specific site of the proposed substation, between Coyote Creek and the Guadalupe River; however, the areas designated as Risk Zones D_{LS} and D_{SL} correspond to stream levee and floodbasin deposits along the two main drainages, which are mapped as the same deposits as at the proposed site.

Liquefaction Potential

Liquefaction is the phenomenon in which saturated granular sediments temporarily lose their shear strength during periods of strong, earthquake induced, ground shaking. The susceptibility of a site to liquefaction is a function of the depth, density, and water content of the granular sediments and the magnitude and frequency of earthquakes in the surrounding region. Saturated, unconsolidated silts, sands, and silty sands within 50 feet of the ground surface are most susceptible to liquefaction.

Liquefaction related phenomena include lateral spreading, ground oscillation, flow failures, loss of bearing strength, subsidence, and buoyancy effects (Youd and Perkins, 1978). Lateral spreading comprises the lateral displacement of superficial blocks of sediment as a result of liquefaction, and commonly occurs on gentle slopes between 0.3 and 3 degrees (Ziony, 1985). Lateral spreading is particularly likely in the vicinity of unlined stream and river channels or other sloping locations. The areas of the proposed project most susceptible to lateral spreading would be where the transmission line crosses the levees of Agua Caliente, Agua Fria, Penitencia, and Coyote Creeks.

In addition, densification of the soil resulting in vertical settlement of the ground can also occur. Lateral spreading and liquefaction were responsible for most of the damage reported along Coyote Creek from the October 1868 Hayward and the April 1906 San Francisco earthquakes (Lawson, 1908; Youd and Hoose, 1978; Egan et al., 1992). Damage induced by lateral spreading and liquefaction is generally most severe when liquefaction occurs within 15 to 20 feet of the ground surface.

Based on our review, the proposed project overlies tidal flat, stream channel and flood plain deposits. These soils typically contain sands and silts, and they may be potentially liquefiable, if they are saturated. Historically these deposits are subject to liquefaction and seismically induced lateral spreading (Lawson, 1908, Youd and Hoose, 1978).

Egan et al. (1992) found that the soils below the groundwater surface along Coyote Creek, in the vicinity of the proposed Los Esteros Substation, are moderately to highly susceptible to liquefaction. They concluded that the absence of observed liquefaction following the 1989 Loma Prieta earthquake was the combined result of moderate ground shaking amplitudes, the relatively short duration of strong ground shaking, and lower than historical groundwater levels. A change in any of these three factors, e.g., increased ground shaking amplitude, shallower groundwater, or longer duration of ground shaking, could have been sufficient to induce liquefaction at the site during the Loma Prieta earthquake.

C.5.1.2.4 *Soils*

The United States Department of Agriculture Soil Conservation Service (SCS) (now called the Natural Resources Conservation Service or NRCS) publishes soil survey reports for nearly all regions of California. The reports include detailed qualitative and quantitative descriptions of soil characteristics including color, texture, thickness, engineering properties, and the soil's suitability for specific crops. These soil characteristics are used to place the soils into six grades, which have been divided into broad subgrades on the general basis of soil use limitations and broad management requirements. These six grades generally indicate the soils ability to sustain intensive agriculture, including fertility, productivity, workability, suitability and restrictions for irrigation, and erosion hazard. In general, the lower the group number, the better the soil; and the higher the group number, the more limitations for agricultural production and continued usefulness of the soil (Gardner et al., 1958).

The soil descriptions presented in this section were compiled from data published by the SCS for Alameda (Welch et al., 1981) and Santa Clara Counties (Weir and Storie, 1947; Gardner et al., 1958; and USDA, 1968). Soils within the Santa Clara Valley vary from well-drained soils present in the alluvial fans and upper alluvial plain to poorly drained soils near the bay margin and lowland stream courses. Many of the soils in the project area are urbanized and have been disturbed, paved over, or replaced with artificial fill.

The soil characteristics that have the most significant impact on the design and operation of the proposed project are the shrink-swell potential and corrosivity.

- The **shrink-swell potential** is a reflection of the ability of some soils with high clay content to change in volume with a change in moisture content. This characteristic is related to the mineralogy of the clay and the mineral grain structure. Shrink-swell potential poses a less significant hazard where soil moisture is relatively constant, either always wet or always dry. This characteristic poses a significant hazard to sites which are drained or undergo seasonal variation in soil moisture content.

- The **corrosivity** of a soil is an estimate of the potential for soil-induced chemical action that dissolves or weakens the structural materials. Corrosion potential is based mainly on the polysulfide content, texture, and acidity of the soil. The corrosion potential in the native soils of the tidal lowlands is high through much of the project area and could impact the chemical stability of concrete and uncoated steel used in transmission line support structures and underground transmission line conduit.

Significant soil characteristics for the soil associations encountered within the project area are summarized below.

Reyes-Urban Land Association. These soils occur in alluvium on tidal flats adjacent to the bay with slopes of 0 to 2 percent. These soils are typically over 60 inches deep, with very poorly drained strongly alkaline clay surface layers underlain by strongly alkaline silty clay, containing polysulfides below a depth of about 6 inches. Urban land consists of areas that are covered by industrial and commercial buildings, streets, and other structures. Many of these areas consist of heterogeneous fill made up of crushed rock and soil material. Soils of the Reyes-Urban Land Association within the project area lie mostly within salt evaporation ponds and along the bay margin.

Sunnyvale-Clear Lake-Urban Land Association. The soils of this association consist of poorly drained soils that formed in alluvium occupying low-lying areas adjacent to the tidal marsh areas of the bay. Sunnyvale soils have dark gray, slightly calcareous silty clay surface soils and light gray, strongly calcareous subsoils. Clear Lake soils have neutral to moderately alkaline clay surface layers underlain by calcareous clay and silty clay. These soils are over 60 inches deep and occur on slopes ranging mainly from 0 to 2 percent. Free water usually occurs at 3 to 5 feet depth from the surface, except where flood control structures have lowered the water table. Urban land consists of areas that are covered by houses, industrial buildings, paved areas, and other structures. The soil material has been altered or mixed during urban development, but the soil characteristics of the original soil material were probably similar to those of the Clear Lake soils. Soils of the Sunnyvale-Clear Lake-Urban Land Association generally lie east of the I-880 corridor where they have been converted to urban land, covered by residential developments. Sunnyvale soils also occur south of SR 237 and east of Coyote Creek where they are used for cultivating hay and are rated as Grade 3-A to 3-B soils.

Orestimba-Willows Association. These soils occur on low-level positions of the alluvial plains with poorly drained conditions in fine textured alluvium. Orestimba soils have grayish brown clay loam or silty clay loam surface soils and dark grayish brown clay loam subsoils. Willow soils have dark gray clay surface soils and light olive gray clay subsoils. These soils overlie mottled, variably textured substrata that are commonly calcareous. These soils are over 60 inches deep and occur on slopes of 0 to 2 percent. Free water usually occurs at 2 to 5 feet depth from the surface, except where artificial drainage has been installed. These soils exhibit low bearing strength and high shrink-swell behavior. Soils of the Orestimba-Willows Association occur along the I-880 corridor and have generally been converted to urban land, covered by residential developments and industrial complexes.

Yolo Association. This association consists of well-drained medium and moderately fine textured soils developed in medium textured sedimentary alluvium on level plains along the major drainages of Santa Clara Valley. Yolo soils have grayish brown loam and silty clay loam surface soils and brown silty loam and silty clay loam subsoils. In the project area, they are primarily of the Mocho group and overlie Tidal clay and silty clay and Cropley clay subsoils. These soils exhibit low to moderate bearing strength and moderate shrink-swell behavior depending on the type of subsoils. Soils of the Yolo Association are found within the project area along both sides of Coyote Creek. These soils are currently under cultivation for hay fields and truck crops and are rated as being Grade 1-A to 2-B.

Cropley-Rincon Association. The soils of this association consist of well-drained, moderately fine to fine textured soils developed in calcareous mixed alluvium occurring in moderately to gently sloping alluvial fans along the edge of Santa Clara Valley. Cropley soils have very dark gray clay surface soils and subsoils. Rincon soils have dark gray clay loam surface soils and grayish brown gravelly clay subsoils. These soils overlie mixed, typically calcareous alluvium that may vary from gravelly clay loam to clay. These soils exhibit low to moderate bearing strength and high shrink-swell behavior. Soils of the Cropley-Rincon Association lie east of the I-880 corridor and generally have been converted to urban land, covered by residential developments. Cropley-type subsoils are present at the proposed substation site beneath Yolo surface soils. These soils are currently under cultivation for hay fields and truck crops and are rated as being Grade 1-B.

Tidal Marsh Association. This association consists of tidal marshlands periodically covered by tidal water. The soils are generally very poorly drained strongly alkaline dark gray clay and silty clay, typically over 60 inches deep. These soils contain polysulfides below a depth of about 2 inches. Much of the soil in this association has been drained and removed from tidal influence by levees for use as salt evaporation ponds. Within salt evaporation ponds, these soils are affected by concentrations of salt and high acidity. These soils exhibit low bearing strength and high shrink-swell behavior. Soils of the Tidal Marsh Association have little potential for agricultural use and are best suited for wildlife habitat and open space.

C.5.1.2.5 *Paleontological Resources*

No paleontological sites of significance are known to exist within the project area. Because the project lies within an area of recent alluvial deposits, no significant paleontological resources are likely to be found within the project area.

C.5.1.3 Applicable Regulations, Plans, and Standards

Geologic resources and geotechnical hazards are governed primarily by local jurisdictions. The conservation elements and seismic safety elements of city and county General Plans contain policies for the protection of geologic features and avoidance of geologic hazards but do not specifically address transmission line construction. Local grading ordinances establish detailed procedures for excavation and earthwork required during trenching. In addition, building codes in each jurisdiction establish standards for construction of above ground structures and foundations.

California State regulations regarding construction within or near faults or earthquake hazard zones are covered under the Alquist-Priolo Act, first enacted in 1972. As currently amended, all structures intended for habitation proposed to be built near an active or potentially active fault require geotechnical surveys be performed to determine the exact location of the fault with respect to the proposed structure, and adhere to setback restrictions to minimize the risk from surface rupture hazards.

Faults are classified as historic (rupture within the past 200 years), Holocene (rupture within the last 200-11,000 years), Late Quaternary (rupture within the last 700,000 years), and undifferentiated

Quaternary (rupture during the last 2,000,000 years or faults that displace rocks of undivided Plio-Pleistocene age) (Wagner, 1991). An active fault, as defined by the Alquist-Priolo statutes, is any fault exhibiting surface rupture of historic or Holocene age. A potentially active fault is defined as any fault exhibiting surface rupture between 11,000 and 2,000,000 years (during the Quaternary period). Age designations are assigned by examining geologic evidence along faults to determine the youngest faulted unit, the oldest unfaulted unit, or the relative age of geomorphic features that were produced by fault rupture. Faults with evidence of no displacement in Quaternary time are classified as pre-Quaternary. Faults with insufficient evidence for classification and faults that may not have been fully evaluated for recency of displacement, are grouped with the pre-Quaternary faults.

The California Division of Mines and Geology (CDMG) is the State agency responsible for determining the activity of faults within the state, and for publishing maps depicting the location of known faults and their activity levels. Faults determined to be active are depicted on 7.5 minute quadrangle maps published by the CDMG which show the surface traces of the faults and their associated seismic hazard zones. These maps are revised as new data is collected and fault activity is reevaluated. Seismic safety standards have been incorporated into the Uniform Building Code to ensure that buildings are constructed to withstand the potential seismic loading produced by nearby earthquakes.

C.5.2 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES FOR THE PROPOSED PROJECT

C.5.2.1 Introduction

The impact assessment was developed based on a geologic, soils, and geotechnical engineering evaluation of the proposed project. The assumptions and justification for site-specific assessments are explained in the text.

C.5.2.2 Definition and Use of Significance Criteria

Geologic and soil conditions were evaluated with respect to the impacts the project may have on the local geology, as well as the impact specific geologic hazards may have upon the proposed substation and transmission lines and their related facilities. The significance of these impacts was determined on the basis of CEQA statutes, guidelines and appendices; thresholds of significance developed by local agencies; government codes and ordinances; and requirements stipulated by California Alquist-Priolo statutes. Significance criteria and methods of analysis were also based on standards set or expected by agencies for the evaluation of geologic hazards.

Impacts of the proposed project on the geologic environment would be considered significant if:

- Unique geologic features or geologic features of unusual scientific value for study or interpretation would be disturbed or otherwise adversely affected by the substation and transmission line alignment and consequent construction activities

- Known mineral and/or energy resources would be rendered inaccessible by substation and transmission line construction
- Agricultural soils would be converted to non-agricultural uses
- Geologic processes, such as landslides or erosion, could be triggered or accelerated by construction or disturbance of landforms
- Substantial alteration of topography would be required or could occur beyond that which would result from natural erosion and deposition.

Impacts of geologic hazards on the proposed project would also be considered significant if the following conditions existed:

- High potential for ground rupture due to presence of an active earthquake fault crossing the substation or transmission line routes with attendant potential for damage to the substation, transmission lines or other project structures
- High potential from earthquake-induced ground shaking to cause liquefaction, settlement, lateral spreading and/or surface cracking within the substation or along the transmission line routes, resulting in probable attendant damage to the proposed substation, transmission lines or other project structures
- Potential for failure of construction excavations or underground borings due to the presence of loose saturated sand or soft clay
- Presence of corrosive soils, which would damage the substation, underground portions of the transmission line, or the transmission line support structures.

C.5.2.3 Applicant Proposed Measures

Table C.5-3 presents the measures proposed in PG&E Co.'s Proponent's Environmental Assessment to reduce project impacts from geologic factors.

C.5.2.4 Geologic Impacts and Mitigation Measures for the Proposed Project

The conditions through the project area are similar, and the same potential hazards would affect the 230kV transmission line, substation, and 115kV upgrade. Therefore, this section covers all components of the proposed project.

Table C.5-3 Applicant Proposed Measures for Geologic Impacts

Impact	Measure
Geotechnical Hazards	
Ground Subsidence	**6.1a.** PG&E Co. will evaluate the potential for subsidence due to compaction from strong ground motions during design-level geotechnical investigations. The need to place additional fill or construct berms to reduce potential flooding because of past subsidence will also be evaluated. PG&E Co. will remove or rework near-surface deposits likely to experience settlement prior to placing new fill.
Expansive Soils, Soft or Loose Soils, and High Water Table	**6.2a.** PG&E Co. will evaluate the effects of expansive soils, soft or loose soils, and high water table on the facilities during design-level geotechnical studies. Where potential problems are known to exist, the near-surface expansive, soft and loose soils will be over-excavated during construction and replaced with engineered backfill, or other ground treatment will be performed. PG&E Co. will determine appropriate engineering and construction measures, such as ground improvement, piers, piling, and mud mats for implementation by the design-level geotechnical studies.
Erosion	**6.3a.** PG&E Co. will utilize comprehensive erosion-control measures to reduce short-term erosion and sedimentation, as well as to restore vegetation to pre-construction conditions. Such measures will include using drainage control structures to direct surface runoff downslope of disturbed areas, strictly controlling vehicular traffic, and minimizing the time between excavation and backfilling.
Seismic Hazards	
Ground Shaking	**6.5a.** Some types of substation equipment are very susceptible to damage from earthquakes. To address this problem, PG&E Co., in conjunction with other utilities throughout the United States and Canada, and equipment vendors and consultants, have revised IEEE 693, "Recommended Practices for Seismic Design of Substations." Within this document are equipment and voltage-specific seismic qualification requirements. These requirements are much more stringent than those in the Uniform Building Code. Qualification includes shake table testing and dynamic analysis. PG&E Co. will purchase equipment for the substation using the seismic qualification requirements in IEEE 693. When these requirements are followed, very little structural damage from levels approaching 1.0 g peak ground acceleration are anticipated. PG&E Co. will design the substation control building in accordance with the Uniform Building Code.
Liquefaction	**6.6a.** Liquefaction-related hazards to the project include lateral spreading and ground settlement. The extent and magnitude of these hazards depend on the thickness and lateral continuity of potentially liquefiable deposits, depth of groundwater, slope, and distance to a free face. PG&E Co. will perform an assessment to determine the presence or absence of liquefiable deposits beneath transmission towers and the preferred substation site. A site-specific assessment is required to determine the presence or absence of liquefiable deposits beneath the substation site and, if present, whether liquefaction will lead to unacceptable levels of permanent ground deformation. PG&E Co. will perform design-level geotechnical investigations, including test borings and analysis of existing data to analyze the possibility of liquefaction and to provide input for engineering design to mitigate the effects where needed. Possible mitigation, if required, might include pile foundations or ground improvement of liquefiable zones, flexible bus connections, and extra slack in underground cables to allow ground deformations without damage.

C.5.2.4.1 *Geotechnical Hazards*

Geotechnical hazards in the proposed project area include ground subsidence, ground deformation caused by expansive, soft or loose soils, high groundwater levels, erosion, and corrosive soils. These hazards may affect the long-term performance of building and equipment foundations and transmission line support structures from settlements or ground cracking.

Ground Subsidence (Impact G.1)

Subsidence is the settling of the ground surface caused by compaction of underlying unconsolidated sediments, often because of groundwater withdrawal. Subsidence also can result from strong ground motion, compaction, or oxidation of peat deposits. Ground subsidence typically is gradual, allowing correction of tilting and other damage to structures before significant damage occurs.

Past subsidence from groundwater withdrawal was as much as 3 feet along the proposed route, which increased the flooding potential. Groundwater recharge, initiated in 1971, has largely stopped subsidence in the Santa Clara Valley (Helley and LaJoie, 1979; Poland and Ireland, 1985). Impacts from subsidence would be less than significant with implementation of Applicant Proposed Measure 6.1a (**Class III**).

Expansive Soils, Soft or Loose Soils, and High Water Table (Impact G.2)

Expansive clay-rich soils may shrink or swell with changes in water content. Soils present along the proposed 230 kV transmission line route have high clay contents, and most have a moderate to high shrink-swell potential. In particular, soils of the Tidal Marsh, Pescadero, and Sunnyvale soils series developed on tidal flatland and floodbasin deposits in low-lying areas have a high shrink-swell potential.

Saturated loose sands and soft clays may pose difficulties in access for construction and in excavating for foundations for poles, piers, or pile caps, particularly for the power line poles within the salt ponds and tidal flats of the proposed route. Casing, sheet piling or other measures may be required. It is anticipated that the water table would be at approximately sea level along most of the proposed 230 kV transmission line route.

There is a possibility that transmission line poles could be damaged by settlement or differential settlement that may occur where there are soft or loose deposits or rapid lateral variations in strength. In addition, there is potential for tilting or misalignment of substation equipment without proper engineering and construction if design does not adequately anticipate soil conditions. Design-level investigation, engineering, and appropriate construction practices will reduce these potential impacts to less than significant levels. PG&E Co.'s Applicant Proposed Measure 6.2a requires a design-level geotechnical investigation to evaluate the effects of expansive soils, soft or loose soils, and a high water table on the proposed facilities, but does not adequately describe the studies that would be needed to define the level of impact and subsequent design features that would reduce impacts to non-significant levels. Therefore, Mitigation Measure G-1, below, is recommended to further clarify these requirements (**Class II**).

G-1 PG&E Co. shall perform design-level geotechnical studies including soil sampling, free-swell tests, density tests, and cone penetrometer tests (CPT) or soil borings to determine the extent of and potential for expansive soils, soft or loose soils, and the presence of a high water table. Where potential problems are found to exist, the near-surface expansive and soft or loose soils shall be over-excavated during construction and replaced with engineered backfill or other ground treatment shall be performed such as ground densification, installation of piers or piles, or mud mats.

Conversion of Agricultural Soils (Impact G.3)

The proposed substation site is to be located in an agricultural field currently occupied by greenhouses. Development of the substation in this location would replace fertile soils currently used for agricultural production with an area of engineered fill and pavement. These agricultural soils are rated as being of Grade 1-B (Gardner et al., 1958) and are classified as the Mocho series of the Yolo association. As described in Section C.5.1.2.4 above, these soils are among the most productive and intensively cultivated in the Santa Clara Valley. Mocho series soils are found mainly along the lower courses of Coyote Creek, the Guadalupe River, and other creeks on both sides of the valley and developed on recent alluvial fans and flood plains. These soils are used to grow truck crops in the proposed project area and are rated as excellent for that purpose. Much of this type of soil has been converted to non-agricultural uses throughout the Santa Clara Valley.

The development of the substation on the proposed site would permanently remove 24 acres of agricultural soils from cultivation and render the site useless for future agricultural purposes. This conversion of agricultural soils to a non-agricultural use is considered a significant and non-mitigable impact (**Class I**).

Erosion (Impact G.4)

Activities such as excavating, pier drilling, grading, trenching, and backfilling have the potential to cause increased soil erosion because of surface disturbance and vegetation removal. Sedimentation into streams may increase if disturbed soil is left exposed during periods of heavy precipitation and surface runoff. Wind-blown dust may be generated during construction activities without proper controls. Implementation of Applicant Proposed Measure 6.2b will reduce this impact to a less than significant level (**Class III**).

Corrosive Soils (Impact G.5)

The corrosion potential in the native soils of the tidal lowlands is high throughout much of the project area and could impact the chemical stability of concrete and uncoated steel used in transmission line support structures and underground transmission line conduit. The corrosivity of a soil is an estimate of the potential for soil-induced chemical action that dissolves or weakens the structural materials. Corrosion potential is based mainly on the polysulfide content, texture, and acidity of the soil. PG&E Co. has not proposed measures to protect its facilities from corrosion; therefore Mitigation Measure G-2 is recommended.

G-2 PG&E Co. will perform corrosivity testing on a site-specific basis for each support structure to be located within areas with high potential for corrosive soils. Remediation measures or soil treatment procedures should be implemented on a site-specific basis based upon the soil test results.

C.5.2.4.2 *Seismic Hazards*

Seismic hazards include potential surface fault rupture, strong vibratory ground motions from local and regional seismic sources, and liquefaction-related ground deformation.

Fault Rupture (Impact G.6)

The Silver Creek fault and an unnamed fault, both with poorly constrained activity, are mapped near the proposed 230 kV transmission line route. The unnamed fault is also mapped as crossing the proposed substation site.

Regional fault maps (Jennings, 1994; Wagner et al., 1991) show that the northern part of the approximately 43-mile-long Silver Creek fault extends across the project area, ranging from 0.88 mile west of the proposed substation site, to 2.34 miles west of where the route borders the Bayside Business Park. A similar unnamed fault is mapped along Zanker Road and extending north through the Fremont Raceway site, may be a splay of the northern Silver Creek fault. This fault ranges from a distance of 1.04 miles west of the proposed 230 kV transmission line route, at Milepost 4.7 within the former Fremont Airport site, to 0.0 mile where it crosses the proposed route between Mileposts 2.5 and 2.7 beneath Salt Pond A23.

These faults are considered potentially active faults under the Alquist-Priolo Act from the inferred offset of buried Pleistocene stream channels identified in water-well logs (CDWR, 1975). They are not included in a Special Studies Zone because of an absence of documented Holocene offset (CDMG, 1982; Bryant, 1981a,b). Because these faults were previously considered active, the City of San Jose currently maintains a surface rupture study zone along the southern part of the Silver Creek fault, south of the intersection between Highway 101 and Capitol Expressway in San Jose. The City requires a 50-foot setback for new structures from the mapped surface trace of the fault. Specific studies are not required by the City for the northern part of the fault in the proposed project area because the fault is likely to be inactive. However, the northern Silver Creek fault and the unnamed eastern splay are poorly characterized and the possibility of future earthquakes cannot be completely discounted.

The northern part of the Silver Creek fault is inferred to extend beneath Santa Clara Valley, between the town of Evergreen on the south and Alameda Creek in Fremont on the north (Wagner et al., 1991). The fault is mapped from the inferred offset of buried Pleistocene stream channels identified in water-well logs (CDWR, 1975), but is buried under Holocene alluvium and has no documented surface geomorphic expression. Trenches across the inferred northern part of the fault have not identified the fault or any evidence of surface fault rupture.

In the vicinity of the Trimble-Montague 115kV upgrade, regional fault maps (Jennings, 1994; Wagner et al., 1991) show that the northern part of the approximately 43-mile-long Silver Creek fault extends across the proposed power line upgrade, approximately 1,000 feet west of the intersection of Trimble Road and Montague Expressway.

A similar unnamed fault extends beneath the substation site east of Zanker Road, and may be an eastern splay of the northern Silver Creek fault. It is inferred to extend between the intersection of SR 237 and Coyote Creek in San Jose on the south and Durham Road east of Interstate 880 in Fremont on the north. This fault is mapped based on the inferred offset of subsurface deposits identified via correlation of well logs (CDWR, 1975); however, based on published geologic mapping (Helley and Wesling, 1989) and examination of topographic maps, there is no surface geomorphic expression of this secondary fault. In addition, there is no evidence that either the Silver Creek fault, or the nearby secondary fault splay, influence the flow of groundwater beneath Santa Clara Valley (CDWR, 1975; Iwamura, 1995).

In conclusion, there is no evidence to suggest the possibility of fault rupture at any of the project facilities, and there are minimal hazards related to fault rupture. Impacts on the proposed project would be less than significant (**Class III**), and no mitigation is required.

Ground Shaking (Impact G.7)

Judging from activity of the major seismic sources (Table C.5-2), it is likely that the project would be exposed to at least one earthquake exceeding M 6.7 located close enough to produce strong ground shaking. The greatest potential for large ground motion in the project area is expected from the southern segment of the Hayward fault. The Hayward fault produced a large historical earthquake in 1868 and currently is considered to be the most probable source of a major earthquake in the San Francisco Bay area (WGCEP, 1990, WG99, 1999).

Peak ground acceleration (PGA, expressed in relation to acceleration of gravity which is 32 ft/sec^2) was estimated for the project area using attenuation models for ground motions developed by Idriss (1991), Sadigh, et al. (1993) with Geomatrix (1996) update; and Abrahamson and Silva (1997). Ground motion parameters for each seismic source are presented in Table C.5-2. Damage has occurred in past earthquakes to some poorly constructed structures where peak ground accelerations were on the order of 0.2 times gravity (0.2 g).

Based upon a probabilistic seismic hazard assessment for California made by the CDMG and the U.S. Geological Survey (Petersen et al., 1996), estimates of peak ground accelerations for 10 percent probability of exceedance in 50 years range from 0.57 g (gravity acceleration) at the southern end of the transmission line route (proposed substation site) to 0.62 g at the northern end of the transmission line route (Newark Substation). PG&E Co. has reviewed historical damage to determine the vulnerabilities of each specific type of equipment including immediate visits to facilities following past earthquakes. PG&E Co. personnel were in Los Angeles and Japan reviewing damages shortly after the recent Northridge and Kobe earthquakes (PG&E Co., 1998, 2000). The Institute of Electrical and

Electronics Engineers (IEEE) 693, "Recommended Practices for Seismic Design of Substations," has specific requirements to mitigate these and the other types of damage that 230 kV equipment has been subjected to in the past.

Generally, the facilities can tolerate ground deformations of a few inches without damage to equipment or structures. Transmission lines, power lines, and pole lines can generally accommodate strong ground shaking and moderate ground deformations. Wind loading design requirements are generally more demanding than those from strong seismic shaking. Implementation of Applicant Proposed Measure 6.5a would reduce this impact to a less than significant level (**Class III**).

Liquefaction (Impact G.8)

Liquefaction is a process whereby strong ground shaking causes saturated unconsolidated sediments to lose strength and behave as a fluid. This subsurface process can cause ground deformation at the surface, including lateral spreading, differential compaction or settlement, and sand boils. Loss of bearing strength and ground movements associated with liquefaction may result in damage to human-made structures. Possible impacts to the 230 kV transmission line include liquefaction-induced failure of stream banks and levees along the proposed route.

Deposits susceptible to liquefaction are present throughout the 230 kV transmission line route; however, the greatest liquefaction hazard is within deposits along Coyote Creek (Egan et al., 1992). These deposits have a high likelihood of liquefying during long-duration, strong ground motion exceeding 0.2 g peak ground acceleration.

The 1868 Hayward earthquake and the 1906 San Francisco earthquake produced sand boils, ground cracking, lateral spreads of stream banks, land subsidence, and increased base flow to Coyote Creek along the proposed 230 kV transmission line route (Lawson, 1908; Youd and Hoose, 1978). Ground cracking was reported up to 1,500 to 2,000 feet west of the Coyote Creek Bridge on the Milpitas-Alviso Road in 1906. Research conducted by Egan et al. (1992) found that deposits below the groundwater surface at Coyote Creek are moderately to highly susceptible to liquefaction. If this route is selected, further characterization of the potential for liquefaction-induced differential settlement and lateral spreads may be required.

PG&E Co.'s Applicant Proposed Measure 6.6a requires a design-level geotechnical investigation to evaluate the effects of potentially liquefiable materials on the proposed facilities, but does not adequately describe the studies which would be needed to define the level of impact and subsequent design features that would reduce impacts to non-significant levels. Therefore, Mitigation Measure G.3, below, is recommended to further clarify these requirements.

G-3 PG&E Co. shall perform design-level geotechnical investigations including soil borings and/or cone penetrometer tests (CPT), and grain-size analyses to determine the thickness, extent and lateral continuity of potentially liquefiable deposits, depth to ground water and distance to a free face. A site-specific assessment is necessary for each transmission tower along Coyote Creek and at the proposed substation site because of the high potential of liquefaction and the history of liquefaction at the site. Where potentially liquefiable deposits are found to exist, the data collected during the investigation will provide input for the engineering design of the foundations. These designs shall incorporate mitigation measures such as soil densification techniques, pile foundations, and over-excavation of shallow zones and replacement with engineered fill.

C.5.2.4.3 *Paleontological Resources*

Because the project is within an area of recent alluvial deposits, no impacts to paleontological resources are anticipated during construction or operation of the 230 kV transmission line along the proposed route.

C.5.2.5 Cumulative Impacts and Mitigation Measures

Potential cumulative geologic impacts are limited to loss of unique geologic features, substantial alteration of the topography, or loading of liquefaction-susceptible materials from the proposed project and one or more future projects. Seismic impacts comprise the impact of the geologic environment on the project and are not cumulative. Construction of the proposed project would contribute only a negligible increase to the potential cumulative geologic impacts. Any future impacts associated with cumulative projects in the immediate vicinity of the project would be primarily attributable to those other future projects.

C.5.3 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES: ALTERNATIVES

Similar geologic materials as described for the proposed route would be encountered along the alternative routes and result in similar levels of risk from geologic hazards. Specific differences are described for each alternative segment alternative below.

C.5.3.1 Proposed Route, Underground through Business Park

Geologic impacts for the underground segment alternative would include liquefaction potential, potential differential settlements during strong ground shaking, and the presence of corrosive soils. The potential for liquefaction along this segment is similar to that of the segment it replaces, but this segment significantly reduces the risk of lateral spreading posed by the proposed project alignment located along the levee at the western edge of the business park. The potential for differential settlements would be the same as for the segment of the proposed project that this alternative would replace. Applicant Proposed Measure 6.1a (see Table C.5-3) would apply to the underground segment and the segment of the proposed project it would replace. The presence of unconsolidated soils, corrosive soils, and liquefiable soils are potentially significant impacts that can be reduced to non-significance through the implementation of Mitigation Measures G-1, G-2, and G-3 (**Class II**).

C.5.3.2 I-880-A Alternative

Geologic impacts for this alternative would include surface fault rupture, liquefaction potential, and potential differential settlements due to strong ground shaking. This alternative crosses the potentially active eastern segment of the Silver Creek fault in three locations, whereas the proposed project segment it replaces has only one crossing. Because overhead transmission lines can generally withstand the effects of surface rupture, this is an adverse but not significant impact (**Class III**). The potential for liquefaction along this segment is similar to that of the segment it replaces. However, this segment significantly reduces the risk of lateral spreading to the proposed project alignment where it crosses the stream channels and tidal flatlands. The potential for differential settlements would be the same as for the proposed project. Applicant Proposed Measure 6.1a would apply to the I-880-A Alternative. Mitigation Measures G-1 and G-3 should be implemented.

C.5.3.3 I-880-B Alternative

Geologic impacts for this alternative would include liquefaction potential and potential differential settlements due to strong ground shaking. The potential for liquefaction along this segment is similar to that of the proposed project segment it replaces. However, this alternative segment significantly reduces the risk of lateral spreading posed by the proposed project where it crosses stream channels, tidal flatlands, and along the levee at the western edge of the business park. The potential for differential settlement would be the same as for the segment of the proposed project this segment would replace. Applicant Proposed Measure 6.1a would apply to the I-880-B Alternative. Mitigation Measures G-1 and G-3 should also be implemented.

C.5.3.4 Westerly Route Alternative

Geologic impacts for this alternative would include liquefaction potential, potential differential settlements during strong ground shaking, and the presence of corrosive soils. The potential for liquefaction along this alternative is similar to that of the proposed project, except this route crosses thicker deposits of bay mud, which may experience more intense seismic wave amplification resulting in stronger ground shaking. The potential for lateral spreading along this alternative would be less than the proposed project, which follows the levee at the western edge of the business park and along the western bank of Coyote Creek near the sludge drying ponds. The potential for differential settlements would be the same as for the proposed project. The potential for corrosive soils would be greater for this alternative than for the proposed project, with more support structures being located within Tidal Marsh soils across the salt ponds. Therefore, Mitigation Measure G-2 would be required to reduce corrosivity impacts to non-significant levels (**Class II**). Applicant Proposed Measures 6.1a would apply to the Westerly Route Alternative. Mitigation Measures G-1 and G-3 should also be implemented to reduce potential impacts from sol conditions and liquefaction.

C.5.3.5 Westerly Upgrade Alternative

Geologic impacts for this alternative would be the same as for the Westerly Route Alternative (see Section C.5.3.4). However, this alternative would result in construction of two new sets of transmission lines, and two older lines (115kV lines to Santa Clara) would be removed. Because the new lines would be constructed under current engineering standards and with new materials, this alternative would have an overall reduced risk of damage due to geologic hazards, including liquefaction, differential settlement, and lateral spreading.

C.5.3.6 Substation Alternatives

C.5.3.6.1 *Northern Receiving Station (NRS) Alternative*

Geologic impacts for this alternative substation site include liquefaction potential and potential differential settlements during strong ground shaking. The NRS Alternative is located on flood basin deposits having moderate liquefaction potential and potential for differential settlement. This alternative substation location does not have potential for surface rupture that is present at the proposed substation site. Strong ground shaking from earthquakes occurring on the San Andreas fault would be more intense at this location because it is 2.5 miles closer to the fault than the proposed project location. This location is also 2.5 miles further away from the Hayward fault than the proposed project location. This alternative would avoid the conversion of agricultural soils to a non-agricultural use as at the proposed substation site. Mitigation Measures G-1 (soil conditions) and G-3 (liquefaction) would apply. Applicant Proposed Measure 6.1a would apply to the Northern Receiving Station.

C.5.3.6.2 *Zanker Road Substation Alternative*

Geologic impacts for this alternative substation site include liquefaction potential and potential differential settlements during strong ground shaking. This alternative site has the same liquefaction potential and potential for differential settlement as at the proposed Los Esteros Substation, but it does not have potential for surface rupture as exists at the proposed site. Strong ground shaking from earthquakes would be approximately the same at this location as at the proposed project location. This alternative would avoid the conversion of agricultural soils to a non-agricultural use as at the proposed substation site. Mitigation Measures G-1 (soil conditions) and G-3 (liquefaction) would apply. Applicant Proposed Measure 6.1a would apply to the Zanker Road Substation alternative.

C.5.3.7 Trimble-Montague 115 kV Upgrade Alternatives

C.5.3.7.1 *Barber 115 kV Alternative*

Geologic impacts for this alternative would include surface fault rupture, liquefaction potential, and potential differential settlements during strong ground shaking. This alignment crosses the eastern segment of the Silver Creek fault very near Coyote Creek at the western end of Technology Drive. The potential for liquefaction along this segment is similar to that of the 115kV segment it would replace (along Trimble Road and Montague Expressway), but this segment has a slightly higher risk of lateral spreading than the proposed project alignment due to its proximity to Coyote Creek west of the end of Technology Drive. The potential for differential settlement due to strong ground shaking from earthquakes would be approximately the same as for the proposed project 115kV segment. Mitigation Measures G-1 (soil conditions) and G-3 (liquefaction) would apply. Applicant Proposed Measures 6.1a would apply to the Barber 115 kV Alternative.

C.5.3.7.2 *Underground Trimble-Montague 115 kV Alternative*

Geologic impacts for this alternative would include surface fault rupture, liquefaction potential, and potential differential settlements during strong ground shaking. This alignment crosses the Silver Creek fault west of Montague Expressway and possibly the eastern segment of the Silver Creek fault near Coyote Creek. Implementation of Applicant Proposed Measure 6.5a should be applied to this underground alternative segment. The potential for liquefaction and for differential settlement due to strong ground shaking from earthquakes would be approximately the same for this segment as for the proposed project segment it would replace. Mitigation Measures G-1 (soil conditions) and G-3 (liquefaction) would apply. Applicant Proposed Measures 6.1a would apply to the Underground Trimble-Montague 115 kV alternative.

C.5.4 THE NO PROJECT ALTERNATIVE

The No Project Alternative would not have any impact on the geologic conditions of the project area. The No Project Alternative would avoid the conversion of agricultural soils to a non-agricultural use at the proposed substation site.

C.5.5 MITIGATION MONITORING PROGRAM

Table C.5-4 presents the mitigation monitoring program for geology, soils, and paleontological resources.

Table C.5-4 Mitigation Monitoring Program

Impact (Class)	Mitigation Measure	Location	Monitoring/Reporting Action	Effectiveness Criteria	Responsible Agency	Timing
Proposed Project and Alternatives						
G.2 Expansive Soils, Soft or Loose Soils, and High Water Table (**Class** II)	**G-1** Conduct design-level geotechnical surveys in areas classified as having moderate to high shrink-swell potential, soft or loose soils, or high ground water table. Remove or rework deposits found to be susceptible to shrink-swell, subsidence or compaction. Install mud mat to prevent infiltration of high ground water table.	Areas having soils with moderate to high shrink-swell potential, soft or loose soils, or having a high ground water table	Approved engineer shall review and approve geotechnical report, grading plans, and foundation designs	Foundation design implementation prevents differential settling to extent feasible	CPUC, local planning agencies	Prior to construction
G.5 Corrosive Soils (**Class** II)	**G-2** Conduct site-specific soil corrosivity testing in areas classified as having moderately to highly corrosive soils. Remove or amend soil deposits found to be highly corrosive.	Areas with moderately to highly corrosive soils especially within tidal flats	Approved engineer shall review test results and approve remediation plans, and foundation designs	Plan/remediation prevents corrosion of foundations to extent feasible	CPUC, local planning agencies	Prior to construction
G.8 Liquefaction (**Class** II)	**G-3** Conduct design-level geotechnical investigations to determine the location, lateral extent, and thickness of potentially liquefiable deposits. Install pile foundations and use other soil densification methods as needed.	Areas having high potential for liquefaction, especially along Coyote Creek and constructed levees	Approved engineer shall review and approve construction plans	Plan/remediation prevents liquefaction/differential settling to extent feasible	CPUC, local planning agencies	Prior to construction

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