4.6 GEOLOGY AND SOILS

This Section describes the existing geology and soil setting and potential effects from Project implementation on the pipeline alignment and the surrounding area. Descriptions and analysis in this Section are based on information contained in the Geological Technical Study dated September 25, 2008, which was prepared by Ninyo & Moore and included in this document as Appendix G.

4.6.1 Environmental Setting

Topography

The Project area transects the Sacramento Valley from just north of the town of Esparto in the west to the City of Roseville in the east. The western end of the Project area begins in the alluvial plain just below the Rumsey Hills, which are an extension of the Coast Range. The Project alignment crosses the flat Hungry Hollow Basin and extends through the Dunnigan Hills. In the Project area, the Dunnigan Hills rise gently on the west side of the hills, and drop off much more steeply in the east. The east side of the Dunnigan Hills has significant topographic relief, including undulating, steep hill slopes to nearly 50 degrees with incised stream valleys. The Dunnigan Hills end abruptly in the fluvial basin of the Sacramento Valley. The remainder of the Project area is in the Sacramento Valley, with the eastern few miles in the gentle rise of the lower Sierran foothills. Elevations in the Hungry Hollow are consistently near 175 feet above mean sea level. In the Dunnigan Hills portion of the Project area, the maximum elevation is slightly more than 250 feet. Through the Sacramento Valley, elevations range from 25 to 75 feet, rising to 125 feet at the eastern terminus of the Project alignment.

The Project alignment either crosses or comes close to several significant water bodies. In the western portion of the Project area just east of the town of Yolo, the alignment is within 1 mile of Cache Creek, a perennial stream with significant flow during the rainy season. Further east, the alignment crosses Knights Landing Ridge Cut, a significant flood-control canal; the Yolo Bypass, a significant flood-control structure; and the Sacramento River. Throughout the Project area, the alignment crosses numerous small streams, irrigation canals, and drainage canals. Many of these steep-banked streams and canals approach depths of 5 to 8 feet.

Regional Setting

The Project area is located in the Great Valley province, a northwest-trending asymmetrical structural basin bounded by Sierra Nevada province to the east and south, the Klamath Mountains to the north, the Cascade Range province to the northeast, and the Coast Ranges province to the west. The Great Valley is comprised of the Sacramento Valley to the north and the San Joaquin Valley to the south and is a nearly flat alluvial plain extending for about 450 miles from the Klamath Mountains south to the Tehachapi Mountains. The northerly portion of the Great Valley, the Sacramento Valley, is drained by the southerly flowing Sacramento River, whereas the San Joaquin River flows to the north draining the San Joaquin Valley. Both rivers ultimately empty into the San Francisco Bay.

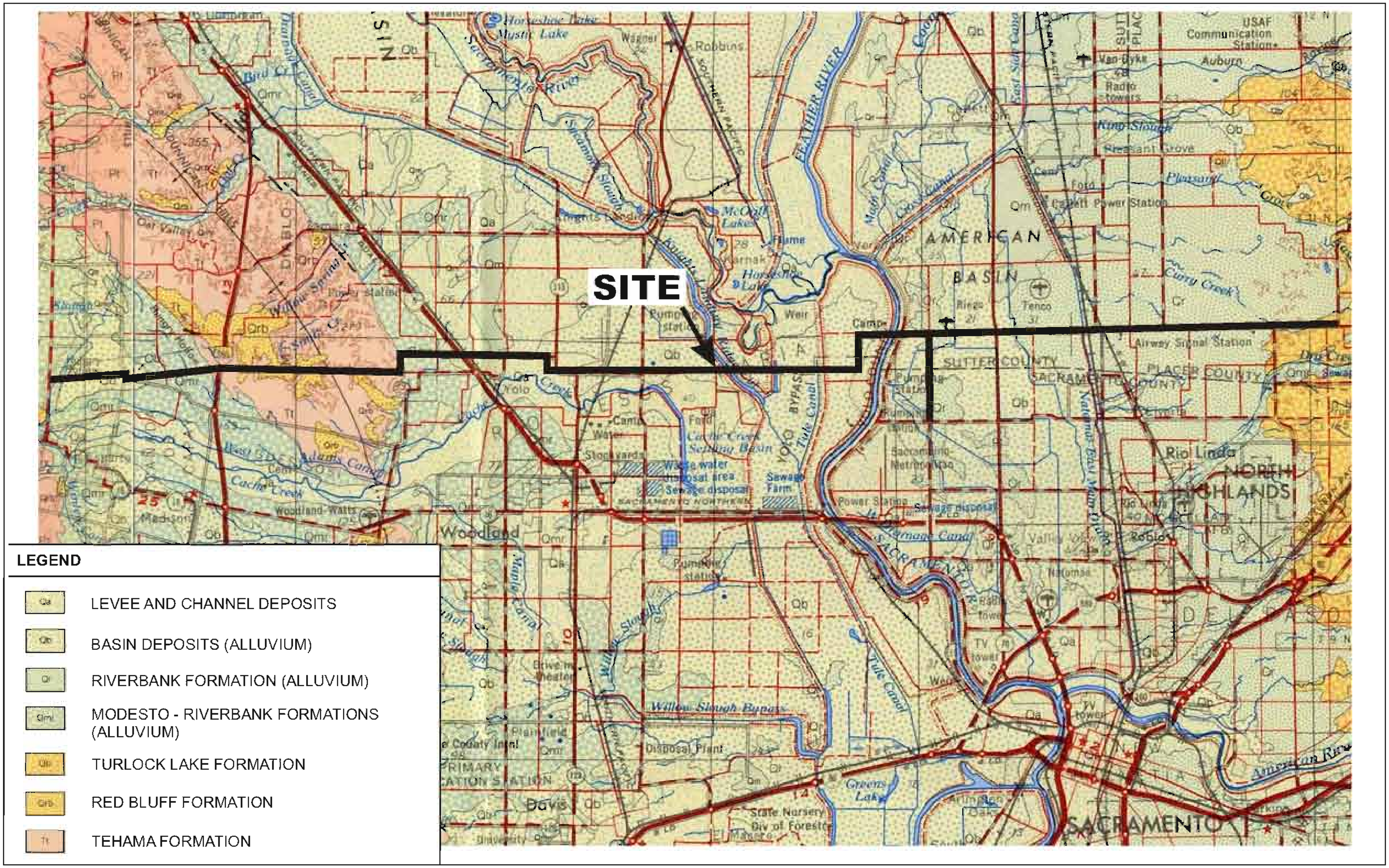
In broadest view, the Great Valley is a vast syncline filled with many thousands of feet of alluvial and fluvial sedimentary deposits of Jurassic to Recent age (the Great Valley Sequence). The sedimentary trough has a long stable eastern shelf supported by the subsurface continuation of the granitic Sierran slope and a short western flank expressed by the upturned edges of the basin sediments. Elevations of the alluvial plain are generally just a few hundred feet above sea level, with extremes ranging from a few feet below sea level to about 1,000 feet above. The only prominent topographic feature within the central part of the valley is Marysville (Sutter) Buttes, a Pliocene volcanic plug, which rises abruptly 2,000 feet above the surrounding valley floor. The study area is located in the southerly portion of the Sacramento Valley of the Great Valley.

Project Area Geology

The Project area is underlain generally by artificial fill, and Recent age natural surficial deposits of alluvium and basin deposits. In addition, formational units are present along the alignment including the Pleistocene-age Modesto, Turlock Lake, and Red Bluff Formations and Pliocene-age Tehama Formation. Geology in the Project area is shown on Figure 4.6-1. The unit descriptions are listed below:

Artificial Fill

Areas of human made fill are present along the proposed alignment. These soils occur in areas of existing improvements such as roads, levees, and buried utilities. Agricultural fill occurs as plowed topsoil in the agricultural fields. In general, the fill soils are expected to be relatively thin and derived primarily or entirely from the on-site soils. However, thicker fill soils can be expected in the earthen levees present along watercourses.



Source: Ninyo & Moore 2009.

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NORTH

0 1 2 4 Miles

Figure 4.6-1
Geology in the Project Region

Alluvium and Basin Deposits

Holocene or Recent age (within the last 11,000 years) alluvium and basin deposits have been mapped as underlying central portions of the pipeline alignment. The alluvium is the result of deposition of the Sacramento River, Cache Creek, and other river systems and typically consists of unconsolidated sand and silt. During the gold rush the base elevation of the Sacramento River was elevated by inflow of sands and gravels from upstream mine waste deposited over the then existing river bed sands and gravels. This rise in river level resulted in the construction of levees to protect the area from flooding. The resultant land use obscures the location of most past riverbed deposits; one of which went through what is now downtown Sacramento, out and past Southside Park, which still contains a lake that was an ancestral Sacramento River bed. The basin deposits were deposited in somewhat lower-energy depositional environments and consequently consist of finer-grained materials such as silts and clays. The basin deposits are interbedded with alluvial deposits. Other alluvial deposits crossing the alignment have been documented as riverbank and buried stream channel deposits, which include relatively permeable sands and gravels encased in less permeable silts and clays.

Modesto Formation

Materials of the late Pleistocene-age (12,000 to 43,000 years old) Modesto Formation are exposed in the western and eastern portions of the alignment. This formation is divided into an upper and lower member. The lower member of the Modesto Formation consists of slightly weathered gravel, sand, silt, and clay. The lower member is widespread and surrounds much of the Dunnigan Hills and Cache Creek. This unit is fluvial in nature and has almost no topographic relief. A linear feature created by the displacement of this unit extends to within less then 2 miles of the Project area. This linear structure may represent fault displacement along the Dunnigan Hills Fault that has been covered by modern sediments. The lower member of the Modesto Formation is the youngest unit in which there is evidence of possible fault displacement. The upper member of the Modesto Formation consists of unweathered gravel, sand, silt, and clay. The upper member is generally only a few feet thick, with poorly developed soil profiles having no B horizon (generally defined as the subsoil and the layer where clay concentrations may occur), and located on the lowest terrace level adjacent to modern streams and in incised alluvial fans.

Turlock Lake Formation

Materials of the Pleistocene-age (greater than 0.7 million years old) Turlock Lake Formation are exposed on the eastern end of the proposed alignment. This formation primarily represents eroded Pleistocene-age alluvial fans, and is found on terraces above the grade of modern streams. The Turlock Lake Formation typically consists of hard, cemented yellow brown silts and red brown sands with occasional gravel and clay beds.

Red Bluff Formation

In the westerly portion of the alignment, the Red Bluff Formation occurs throughout the Dunnigan Hills mostly along ridge tops. The Pleistocene-age (greater than 0.7 million years old) unit consists of distinct bright red to orange clayey gravels and cobbles in a silty or sandy matrix. The Red Bluff Formation overlies the Tehama Formation, which is described below.

Tehama Formation

The Tehama Formation occurs at the far west end of the alignment and throughout the Dunnigan Hills. Volcanoclastic rocks of non-marine origin make up this formation. The Tehama Formation is Pliocene in age (1.6 to 5 million years old) and is composed predominantly of cemented sand and silt with varying amounts of gravel and minor clay.

Soils

Soils are the byproduct of physical and chemical weathering of rock and sediments. They consist of mineral and organic matter created through physical, chemical, and biological processes. The Natural Resources Conservation Service (NRCS) prepares and maintains soil surveys that classify soil characteristics and their suitability for agriculture and development.

Because published soil descriptions are focused primarily on agricultural needs and are limited to a depth of 5 to 6 feet, they do not provide information on deeper conditions. In the Project area, landfilling, highway and street construction, and flood-control structures may have caused substantial changes to native soil profiles. Therefore, soil conditions in developed area may differ significantly from mapped conditions and may be highly variable.

Soil properties of particular interest include shrink-swell, erosion, and corrosion potential, as these properties may impact Project facilities. In addition, the relative density or consistency of the soil, which can also be highly variable across a site, can also impact Project facilities. In particular, the presence of soft or loose soils, shallow groundwater, and shallow bedrock may impact design parameters and construction methods.

Fifty-four individual soil units, including combinations of one or more distinct soil types and slope conditions, are mapped by the NRCS in the Project area. Mapped soil units in the Project Area are provided in Figures 4.6-2A, 4.6-2B, and 4.6-2C, and their relevant properties are shown on Table 4.6-1.

Shallow Soils

Mapped soil units that are indicated to have thin (shallow) soils over bedrock (i.e., less than 6 feet) include:

- [104] Alamo-Fiddyment complex, depth to hard bedrock less than 40 inches;
- [BaE2] Balcom silty clay loam, depth to bedrock 20 to 40 inches;
- [141] Cometa-Fiddyment complex, depth to bedrock 20 to 40 inches;
- [SkD and SkF2] Sehorn clay, depth to (soft) bedrock 20 to 40 inches;
- [SlD] Shehorn cobbly clay, depth to (soft) bedrock 20 to 40 inches;
- [SmD, SmE2, and SmF2] Sehorn-Balcom complex, depth to (soft) bedrock 20 to 40 inches; and
- [Wn] Willows clay, marly variant, saline alkali.

Soils that are shallow to bedrock are found along Line 406 throughout the Dunnigan Hills along County Road (CR) 17 from roughly Interstate (I) 505 to CR-95A and in selected areas along the eastern 8 miles of Line 407, east of Pleasant Grove Road. Other soils along the alignment are sufficiently deep, and it is unlikely that bedrock would be encountered during construction.

Expansive Soils

Expansive soils are those that shrink and swell significantly as the soil dries and wets, respectively. Fifty-two of the 54 soil units in the Project area have been rated for shrink/swell potential and are described as having a moderate to high shrink/swell potential. Only sandy/gravelly streambed deposits are identified as having low shrink/swell potential.

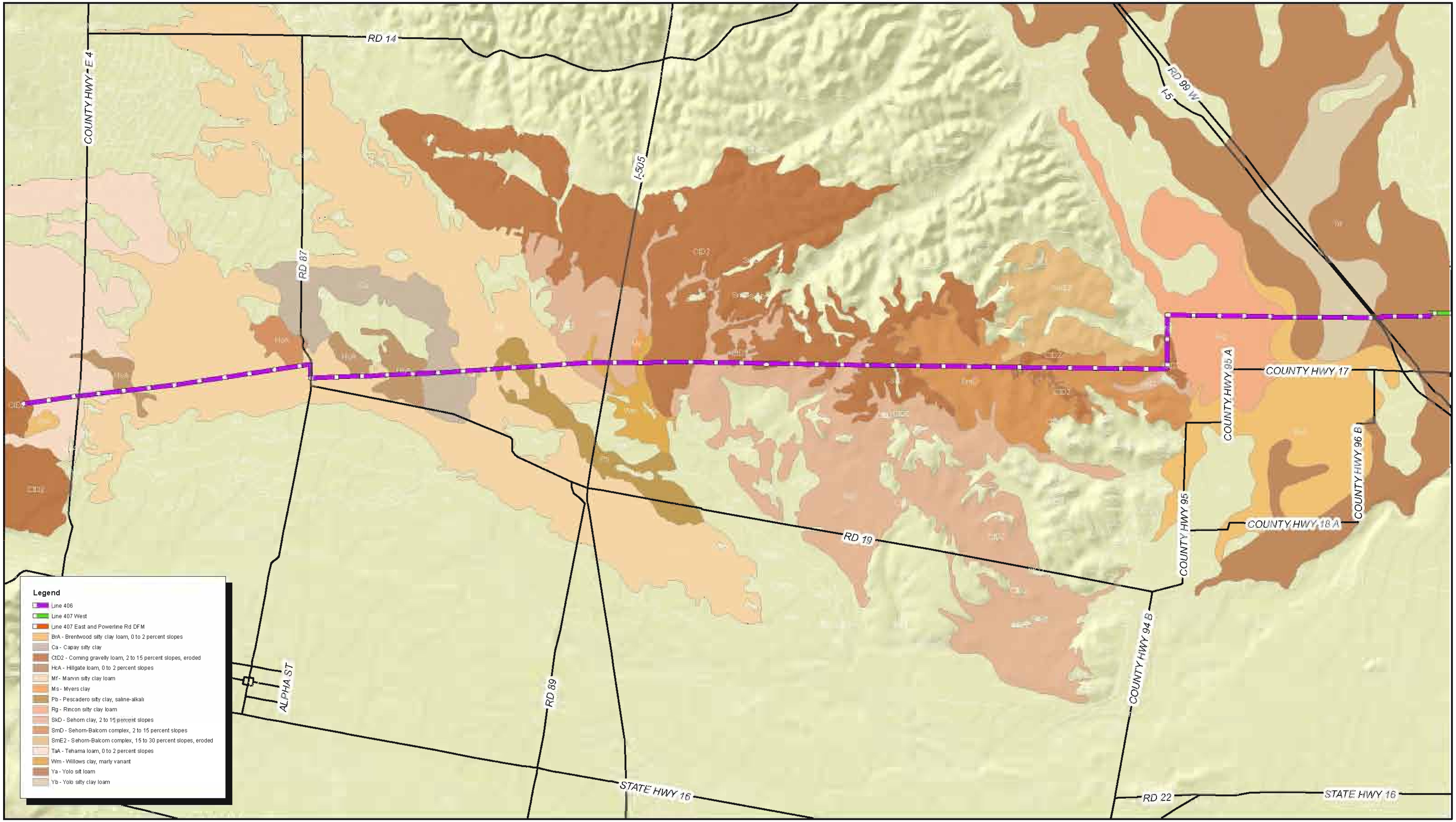
Flooded or Water-Logged Soils

Some soil types are characterized by periodic flooding or seasonal saturation in the near surface horizons. Soils with periodic flooding or seasonal saturation represent a special challenge for construction and include the following eight soil-mapping units:

- [Ck] Clear Lake clay;
- [Mf] Marvin silty clay loam;
- [146] Neuva loam, flooded;
- [Rh] Riverwash;
- [Sv] Sycamore complex, drained;
- [Sw] Sycamore complex, flooded;
- [Sr] Sycamore complex, silt loam, flooded; and
- [195] Xerofluvents (i.e., ephermeral stream-bed deposits), flooded.

Portions of the Project area that may be associated with flooded or saturated soils include the following areas, from west to east:

- Portions of Hungry Hollow between CR-85 and just west of CR-87 (western end of Line 406);
- Most of the Line 407 Project area in the vicinity of the Knights Landing Ridge Cut to approximately 4 miles east of the Sacramento River (flooded rice farming occurs east of the Sacramento River);
- Isolated locations throughout the Line 406 and Line 407 alignments where irrigation and drainage canals and streams cross the alignment; and
- Isolated locations within the Dunnigan Hills where seasonal runoff may collect.



Source: California Resource Agency and PG&E 2008.

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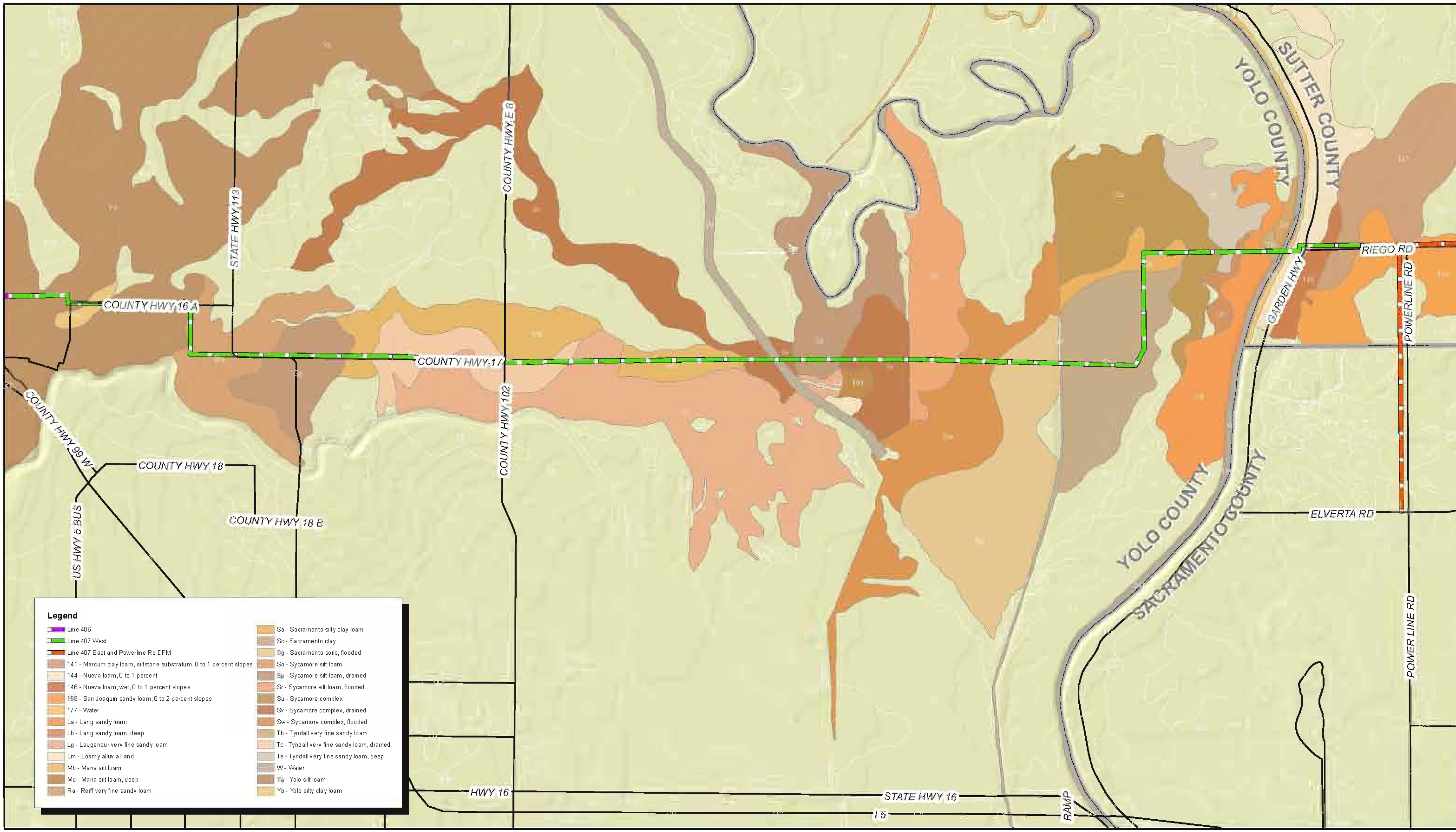
NORTH

4,500 2,250 0 4,500 Feet

Figure 4.6-2A
Soils Along the Proposed Project



Source: California Resource Agency and PG&E 2008.

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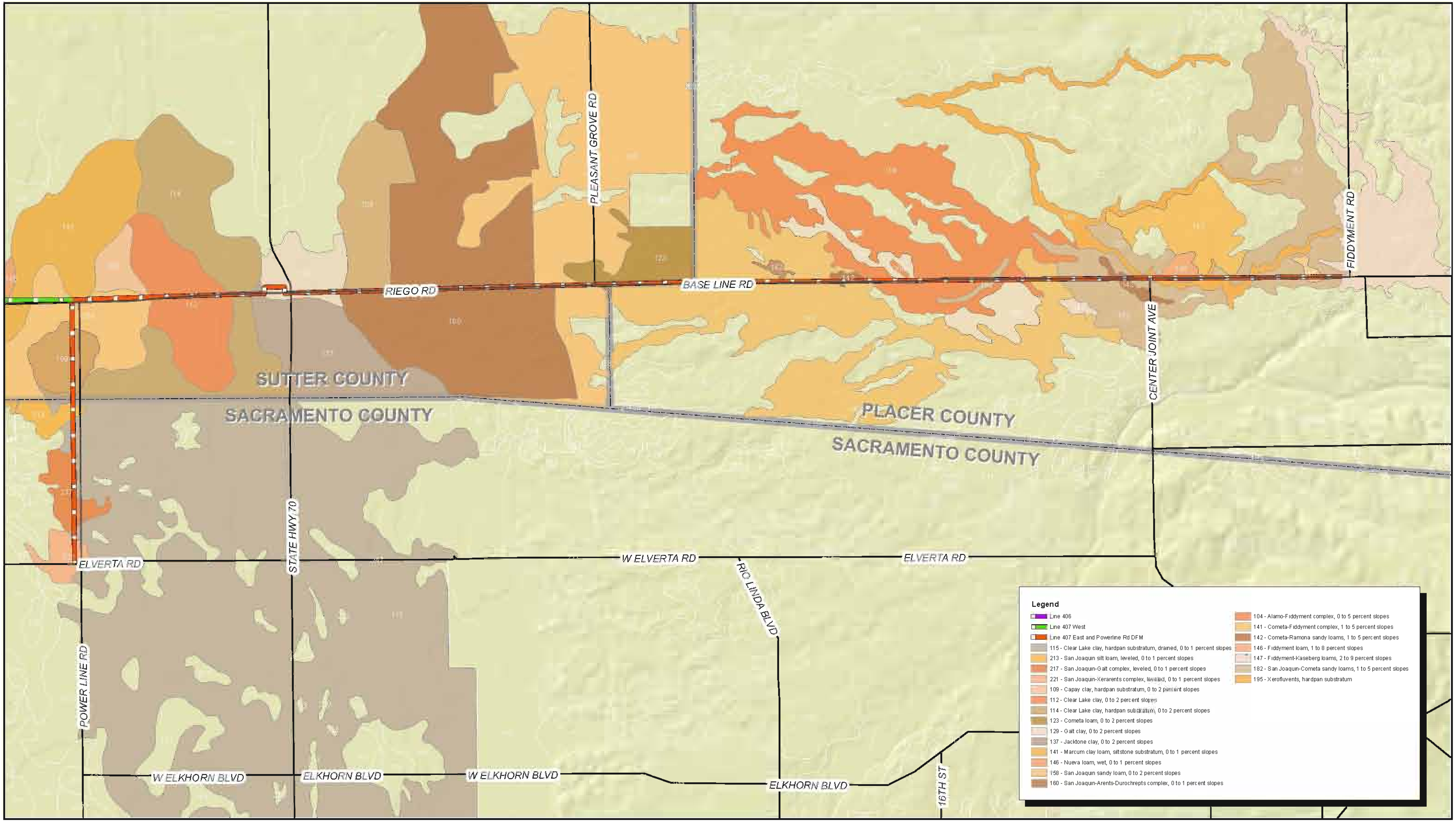
NORTH

4,500 2,250 0 4,500
Feet

Figure 4.6-2B
Soils Along the Proposed Project



Source: California Resource Agency and PG&E 2008.

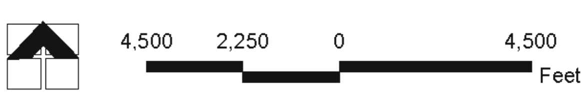


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Figure 4.6-2C
Soils Along the Proposed Project

1 **Table 4.6-1: Soils in the Project Area**

Name	Map Symbol	Percent Slope	Shrink-Swell Potential[1]	Erosion Potential[2]	Depth to Bedrock[3] (ft bgs)[4]	Nature of Bedrock[3]	Depth to Water[5] (ft bgs)	Corrosion Potential (Steel)
Alamo-Fiddyment complex	104	0 to 5	High		Less than 3	Hard		High
Balcom silty clay loam	BaE2	15 to 30	High	Moderate	1.5 to 3	Not rated		Not rated
Brentwood silty clay loam	BrA	0 to 2	High					High
Capay clay, hardpan substratum	109	0 to 2	High					High
Capay silty clay	Ca	0 to 1	High					High
Clear Lake clay	Ck, 112, and 115	0 to 2	High					High
Clear Lake clay, hardpan	114	0 to 2	High				2.5 to 6	High
Cometa-Fiddyment complex	141	1 to 5	High		1.5 to 3	Soft		High
Cometa-Fiddyment sandy loam	142	1 to 5	High					High
Cometa loam	123	0 to 2	High					Moderate
Corning gravelly loam	CtD2	2 to 15	High					High
Corning gravelly loam	CtE2	15 to 30	High	Moderate				High
Marcum clay loam, siltstone substratum	141	0 to 1	Moderate				1.5 to 2.5	High
Galt clay	129	0 to 2	High					High

Name	Map Symbol	Percent Slope	Shrink-Swell Potential[1]	Erosion Potential[2]	Depth to Bedrock[3] (ft bgs)[4]	Nature of Bedrock[3]	Depth to Water[5] (ft bgs)	Corrosion Potential (Steel)
Hillgate loam	HcA and HdA	0 to 2	Moderate					Moderate
Hillgate loam	HcC and HcC2	2 to 9	Moderate					Moderate
Marvin silty clay loam	Mf	0 to 1	High					High
Lang sandy loam, deep	Lb	0 to 1	High				2.5 to 6	High
Laugenour very fine sandy loam	Lg	0 to 1	Not rated				2.5 to 6	High
Loamy alluvial land, undifferentiated	Lm	Varies	High				2.5 to 6	High
Maria silt loam	Mb	0 to 1	Moderate					High
Maria silt loam, deep	Md	0 to 1	Moderate					High
Myers clay	Ms	0 to 1	High					High
Nueva loam	144	0 to 1	High				2.5 to 6	High
Nueva loam, wet	146	0 to 1	High				2.5 to 6	High
Pescadero silty clay	Pb	0 to 1	High				1.5 to 2.5	High
Reiff very fine sandy loam	Ra	0 to 1	Not rated					High
Rincon silty clay	Rg	0 to 1	High					High
Riverwash	Rh	Not rated	Low					Low

Name	Map Symbol	Percent Slope	Shrink-Swell Potential[1]	Erosion Potential[2]	Depth to Bedrock[3] (ft bgs)[4]	Nature of Bedrock[3]	Depth to Water[5] (ft bgs)	Corrosion Potential (Steel)
Sacramento clay, drained	Sd	0 to 1	High					High
Sacramento soils, undifferentiated	Sg	0 to 1	High					High
San Joaquin - Cometa sandy loam	182	1 to 5	High		2.5 to 5	Not rated		High
San Joaquin sandy loam	158	0 to 2	Not rated		1.5 to 3.5	Not rated		Moderate
San Joaquin sandy loam	181	1 to 5	High		2.5 to 5	Not rated		High
San Joaquin-Arents-Durochrepts complex	160	0 to 1	Not rated		1.5 to 3.5	Not rated		Moderate
Sehorn clay	SkD	2 to 15	High		1.5 to 3	Soft		High
Sehorn clay	SkF2	30 to 50	High	High	1.5 to 3	Soft		High
Sehorn cobbly clay	SlD	2 to 15	High		1.5 to 3	Soft		High
Sehorn-Balcom complex	SmD	2 to 15	High		1.5 to 3	Soft		High
Sehorn-Balcom complex	SmE2	15 to 30	High	Moderate	1.5 to 3	Soft		High
Sehorn-Balcom complex	SmF2	30 to 50	High	High				High
Soboba gravelly clay loam	Sn	0 to 1	Low					Moderate
Sycamore complex, silt loam	Sp	0 to 1	Moderate				2.5 to 6	High
Sycamore complex, silt loam, flooded	Sr	0 to 1	Moderate				2.5 to 6	High

Name	Map Symbol	Percent Slope	Shrink-Swell Potential[1]	Erosion Potential[2]	Depth to Bedrock[3] (ft bgs)[4]	Nature of Bedrock[3]	Depth to Water[5] (ft bgs)	Corrosion Potential (Steel)
Sycamore complex silty clay loam	Ss	0 to 1	Moderate				2.5 to 6	High
Sycamore complex	Su	0 to 1	Moderate					High
Sycamore complex	Sv	0 to 1	Moderate				2.5 to 6	High
Sycamore complex	Sw	0 to 1	Moderate				2.5 to 6	High
Tehama loam	TaA	0 to 2	Moderate					Moderate
Tyndall very fine sandy loam	Td	0 to 1	High				2.5 to 6	High
Willows clay	Wm and Wn	0 to 1	High				2.5 to 6	High
Xerofluvents, hardpan	195	Varies	Low					High
Yolo silt loam	Ya	0 to 1	Moderate					High
Yolo silty clay loam	Yb	0 to 1	Moderate					High

Notes:
[1] Based on Linear Expansivity Potential. [2] Estimated from slope. Soil with minimum slope not rated. [3] Depth to bedrock provided. [4] ft bgs = feet below ground surface.
[5] Depth to groundwater provided when noted in soil survey. Depth to water not provided if typically greater than 6 ft bgs.
Source: PG&E 2007.

Seismicity

The term seismicity describes the effects of seismic waves that radiate from an earthquake as it occurs. While most of the energy released during an earthquake results in the permanent displacement of the ground, as much as 10 percent of the energy may dissipate immediately in the form of seismic waves. To understand the implications of seismic events, a discussion of faulting and seismic hazards is provided below.

Faulting

Faults form in rocks when stresses overcome the internal strength of the rock, resulting in a fracture. Large faults develop in response to large regional stresses operating over a long time, such as those stresses caused by the relative displacement between tectonic plates. According to the elastic rebound theory, these stresses cause strain to build up in the earth's curst until enough strain has built up to exceed the strength along a fault and case a brittle fracture. The slip between the two stuck plates or coherent blocks generates an earthquake. Following an earthquake, strain will build once again until the occurrence of another earthquake. The magnitude of slip is related to the maximum allowable strain that can be built up along a particular fault segment. The greatest buildup in strain due to the largest relative motion between tectonic plates or fault blocks over the longest period will generally produce the largest earthquakes. The distribution of these earthquakes is a study of much interest for both hazard prediction and the study of active deformation of the earth's crust. Deformation is a complex process and strain caused by tectonic forces is not only accommodated through faulting, but also by folding, uplift, and subsidence, which can be gradual or in direct response to earthquakes.

Faults are mapped to determine earthquake hazards, since they occur where earthquakes tend to recur. A historic plane of weakness is more likely to fail under stress and strain than a previously unbroken block of crust. Faults are, therefore, a prime indicator of past seismic activity, and faults with recent activity are presumed to be the best candidates for future earthquakes. However, since slip is not always accommodated by faults that intersect the surface along traces, and since the orientation of stress and strain in the crust can shift, predicting the location of future earthquakes is complicated. Earthquakes sometimes occur in area with previously undetected faults or along faults previously thought inactive.

Local Faulting

Based on the tectonic setting and the historical record, the Project area is in a region that is characterized by a relatively low to moderate seismicity. Historical earthquakes of magnitude 6.0 or greater with epicenters within approximately 62 miles (100 km) of the Project Area are shown in Table 4.6-2.

Table 4.6-2: Historical Earthquakes in the Study Area

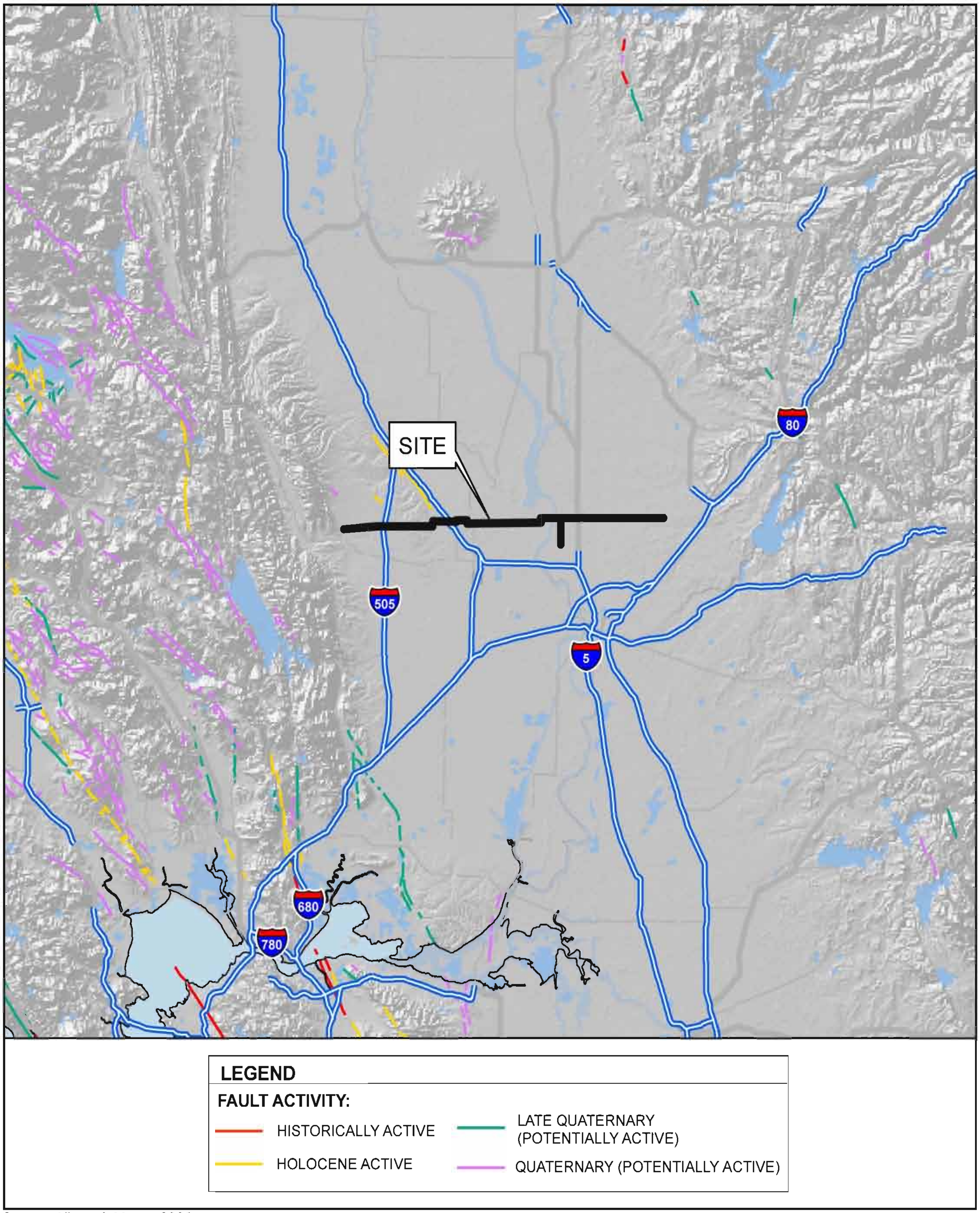
Date	Magnitude	Fault
5/19/1889	6.0	Great Valley fault system
4/19/1892	6.4	Great Valley fault system
4/21/1892	6.2	Great Valley fault system
3/31/1898	6.2	Unknown

Notes: The event in 1898 occurred in a northeastern part of the San Francisco Bay area, but the fault or fault system is unkown.
Source: PG&E 2007

Figure 4.6-3 shows fault location map for the region.

The pipeline alignment crosses three documented faults: the Great Valley, Dunnigan Hills, and Willows faults. The three faults are thought to exist at depth and do not reach the surface where they cross the proposed alignment (Kleinfelder 2007). The Great Valley fault is mapped near the westerly end of the alignment; the Dunnigan Hills fault is along the northeasterly side of the Dunnigan Hills, west of I-5; and the Willows fault is in the easterly portion of the alignment between the Sacramento River and the City of Roseville.

Great Valley Fault. The Great Valley fault is actually an extensive system of northerly-trending, westerly-dipping (inclined) thrust faults along the westerly margin of the Sacramento and San Joaquin valleys of the Great Valley. The faults have been referred to as “blind thrusts” because they occur at depth and do not intercept the ground surface; therefore, they are not considered to have the potential for ground surface rupture or subsequently, pipeline rupture. The fault system is considered to be a seismic source that could result in strong ground motions. The pipeline alignment crosses Segment 3 of the fault system which could generate an earthquake of magnitude 6.9.



Source: Ninyo & Moore 2008.

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15 7.5 0 15 Miles

Figure 4.6-3
Faults in the Project Region

Willows Fault. Surface expression of the Willows fault is not apparent. The Willows fault trace location is based largely on a linear differential of measured groundwater levels. The fault is designated as pre-Quaternary in age and is not considered active or “potentially active.” The fault is not considered a significant seismic source, nor is it considered capable of resulting in ground surface rupture.

Dunnigan Hills Fault. The Dunnigan Hills fault is considered to be a zone of discontinuous total lineaments near the base of the northeast-facing escarpment of the Dunnigan Hills. Similar to the Great Valley Fault, the Dunnigan Hills fault is classified as a blind thrust fault and is believed to exist at depth.

In 1982, the California Division of Mines and Geology (now called the CGS) performed a fault evaluation of the Dunnigan Hills fault as part of the Alquist Priolo fault zoning program and concluded that the fault did not meet the criteria of sufficiently active and well-defined and, therefore, was not designated as an Earthquake Fault (Alquist-Priolo) Zone. However, the Dunnigan Hills fault shows evidence of Holocene displacement (movement during the last 11,000 years), and there is evidence of surface rupture north of the proposed alignment near the town of Zamora; however, the fault becomes buried in the vicinity of the alignment (Kleinfelder 2007).

Based on a probabilistic seismic hazard model for California (USGS/CGS, 2002) peak horizontal ground accelerations having a 10 percent probability of exceedance in 50 years can be estimated to be about 0.4g (40 percent of gravity) at the west end of the alignment and about 0.2g at the east end of the alignment. This can be compared with potential ground accelerations having the same probability of occurrence of in excess of 0.7g in the San Francisco Bay Area. No portions of the pipeline alignment are in State of California-designated Earthquake Fault Zones which are areas that have a relatively high potential ground surface rupture due to faults. Table 4-6.3 lists active faults within approximately 62 miles (100 km) of the central portion of the pipeline alignment.

Table 4.6-3: Principal Active Faults

Fault	Distance (miles)[1]	Maximum Moment Magnitude[2]
Great Valley Segment 3	16	6.9
Great Valley Segment 4	19	6.6

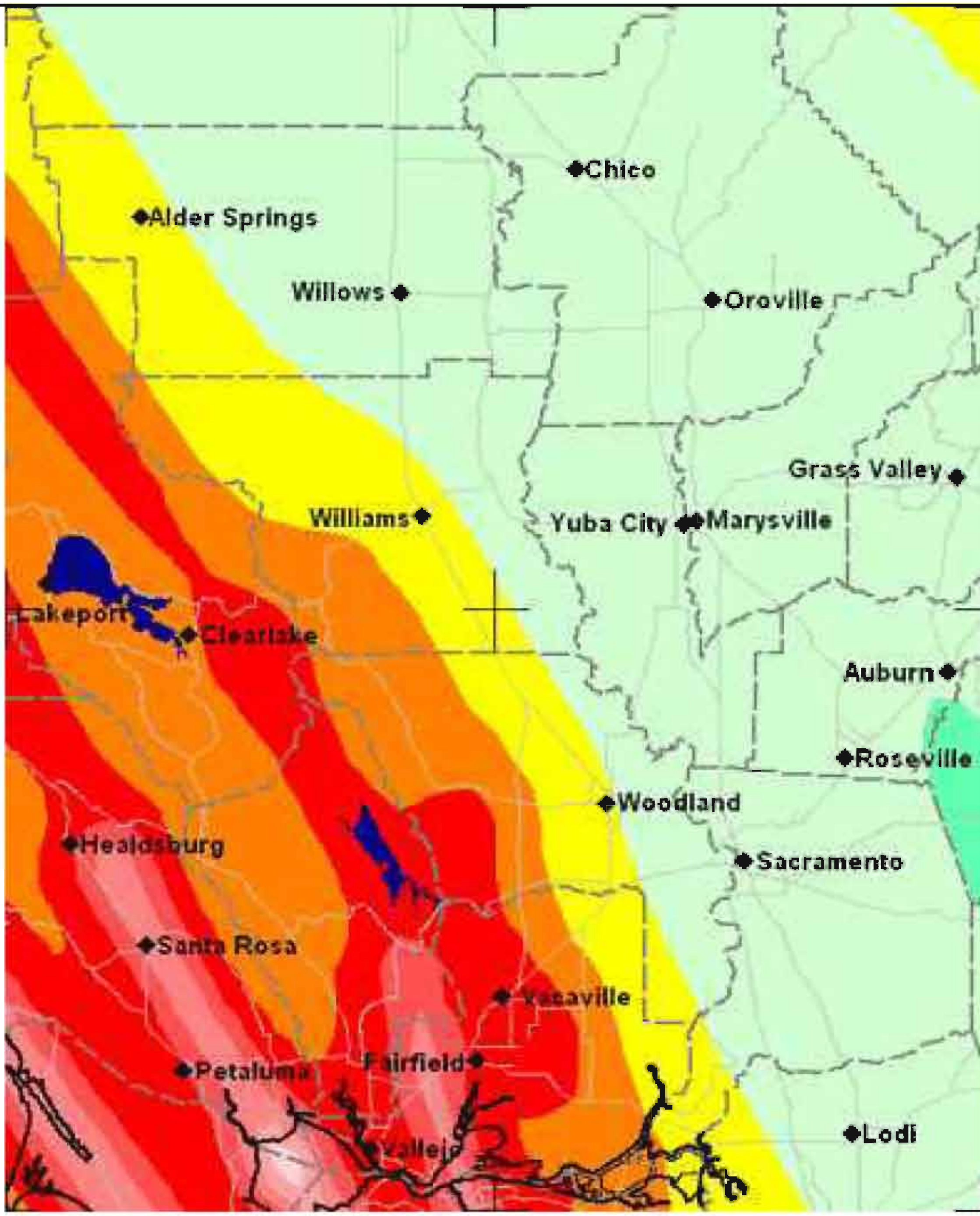
Fault	Distance (miles)[1]	Maximum Moment Magnitude[2]
Foothills	30	6.5
Great Valley Segment 5	32	6.5
Hunting-Creek-Berryessa	32	7.1
Concord	35	6.7
Great Valley Segment 2	39	6.4
West Napa	42	6.5
Bartlett Springs	45	7.6
Great Valley Segment 1	48	6.7
Callayomi	52	6.5
Maacama	54	7.5
Hayward	56	7.1

Notes
[1]Blake (2001)
[2]The reported potential maximum magnitudes are Maximum Moment Magnitudes rather than Richter Scale Magnitudes, a scale that is generally no longer used.
Source: PG&E 2007.

Figure 4.6-4 shows the potential ground accelerations in the regions having a 10 percent probability of being exceeded in 50 years.

Seismic Hazards

Seismic hazards pose a substantial danger to property and human safety and are present because of the risk of naturally occurring geologic events and processes impacting human development. Therefore, the hazard is as influenced by the conditions of human development as by the frequency and distribution of major geologic events. Seismic hazards present in California include ground rupture along faults, strong seismic shaking, liquefaction, ground failure, landsliding, and slope failure.



Shaking (%g)

Pga (Peak Ground Acceleration)

Firm Rock

< 10%
10 - 20%
20 - 30%
30 - 40%
40 - 50%
50 - 60%
60 - 70%
70 - 80%
> 80%

The unit "g" is acceleration of gravity.

Source: Ninyo & Moore 2008.

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NORTH

NOT TO SCALE

Figure 4.6-4
Peak Ground Acceleration
10 Percent of Being Exceeded in 50 Years

Fault Rupture

Fault rupture is a seismic hazard that affects structures sited above an active fault. The hazard from fault rupture is the movement of the ground surface along a fault during an earthquake. Typically, this movement takes place during the short time of an earthquake, but can also occur slowly over many years in a process known as creep. Most structures and underground utilities cannot accommodate the surface displacements of several inches to several feet commonly associated with fault rupture or creep.

Ground Shaking

The severity of ground shaking depends on several variables such as earthquake magnitude, epicenter distance, local geology, thickness and seismic wave-propagation properties of unconsolidated materials, groundwater conditions, and topographic setting. Ground shaking hazards are most pronounced in areas near faults or with unconsolidated alluvium.

The most common type of damage from ground shaking is structural damage to buildings. However, strong ground shaking can cause severe damage from falling objects or broken utility lines. Fire and explosions are also hazards associated with strong ground shaking.

While Richter magnitude provides a useful measure of comparison between earthquakes, the moment magnitude is more widely used for scientific comparison, since it accounts for the actual slip that generated the earthquake. Actual damage is due to the propagation of seismic or ground waves as result of initial failure, and the intensity of shaking is related as much to earthquake magnitude as to the condition of underlying materials. Loose materials tend to amplify ground waves, while hard rock can quickly attenuate them, causing little damage to overlying structures. For this reason, the Modified Mercalli Intensity (MMI) Scale provides a useful qualitative assessment of ground shaking. The MMI Scale is a 12-point scale of earthquake intensity based on local effects experienced by people, structures, and earth materials. Each succeeding step on the scale describes a progressively greater amount of damage at a given point of observation. The MMI Scale is shown in Table 4.6-4 along with relative ground velocity and acceleration.

Table 4.6-4: Modified Mercalli Intensity (MMI) Scale

Richter Magnitude	Modified Mercalli Intensity	Effects	Average Peak-Ground Velocity (centimeters/ seconds)	Average Peak Acceleration
0.1 to 0.9	I	Not felt. Marginal and long-period effects of large earthquakes.	—	—
1.0 to 2.9	II	Felt by only a few persons at rest, especially on upper floors of building. Delicately suspended objects may swing.	—	—
3.0 to 3.9	III	Felt quite noticeable in doors, especially on upper floors of building, but many people do not recognize it as an earthquake. Standing cars may rock slightly. Vibration like passing a truck. Duration estimated.	—	0.0035 to 0.007 g
4.0 to 4.5	IV	During the day, felt indoors by many, outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensations like heavy truck striking building. Standing cars rocked noticeably.	1 to 3	0.015 to 0.035 g
4.6 to 4.9	V	Felt by nearly everyone, many awakened. Some dishes, windows, broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.	3 to 7	0.035 to 0.07 g
5.0 to 5.5	VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of falling plaster and damaged chimneys. Damage	7 to 20	0.07 to 0.15 g

Richter Magnitude	Modified Mercalli Intensity	Effects	Average Peak-Ground Velocity (centimeters/ seconds)	Average Peak Acceleration
		slight.		
5.6 to 6.4	VII	Everyone runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well built, ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars.	20 to 60	0.15 to 0.35 g
6.5 to 6.9	VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monument walls, and heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving in cars disturbed.	60 to 200	0.35 to 0.7 g
7.0 to 7.4	IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.	200 to 500	0.7 to 1.2 g

Richter Magnitude	Modified Mercalli Intensity	Effects	Average Peak-Ground Velocity (centimeters/ seconds)	Average Peak Acceleration
7.5 to 7.9	X	Some well-built structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Railway lines bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks.	≥ 500	>1.2 g
8.0 to 8.4	XI	Few, if any masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.		
≥ 8.5	XII	Total damage. Waves seen on ground. Lines of sight and level distorted. Objects thrown into the air.		
Source: Wood, H. O., and F. Neumann 1931.				

Ground Failure

Ground failure includes liquefaction and the liquefaction-induced phenomena of lateral spreading and lurching.

Liquefaction is a process by which sediments below the water table temporarily lose strength during an earthquake and behave as a viscous liquid rather than a solid. Liquefaction is restricted to certain geologic and hydrologic environments, primarily recently deposited sand and silt in areas with high groundwater levels. The process of liquefaction involves seismic waves passing through saturated granular layers, distorting the granular structure and causing the particles to collapse. This causes the granular layer to behave temporarily as a viscous liquid rather than a solid, resulting in liquefaction.

Liquefaction can cause the soil beneath a structure to lose strength which in turn causes a structure to settle or tip. Loss of bearing strength and floatation can also cause light structures to rise buoyantly through the liquefied soil.

Lateral spreading is lateral ground movement, with some vertical component, as the result of liquefaction. In effect, the soil rides on top of the liquefied layer. Lateral spreading can occur on relatively flat sites with slopes less than 2 percent, under certain circumstances, and can cause cracking and settlement.

Lurching is the movement of the ground surface toward an open face when the soil liquefies. An open face could be a graded slope, stream bank, canal face, gully, or other similar feature.

Landslides and Slope Failure

Landslides and other forms of slope failure form in response to the long-term geologic cycle of uplift, mass wasting, and disturbance of slopes. Mass wasting refers to a variety of erosional processes from gradual downhill soil creep to mudslides, debris flows, landslides, and rock fall, processes that are commonly triggered by intense precipitation, which varies according to climactic shifts. Often, various forms of mass wasting are grouped together as landslides, which are generally used to describe the downhill movement of rock and soil.

Geologists classify landslides into several different types that reflect differences in the type of material and type of movement. The four most common types of landslides are translational, rotational, earth flow, and rock fall. Debris flows are another common type of landslide similar to earth flows, except that the soil and rock particles are coarser. Mudslide is a term that appears in non-technical literature to describe a variety of shallow, rapidly-moving earthflows.

4.6.2 Regulatory Setting

Federal

With respect to soil erosion and sedimentation, the Clean Water Act (CWA) section 402 mandates that certain types of construction activity comply with the requirements of the U.S. Environmental Protection Agency's (EPA) National Pollution Prevention Discharge Elimination System (NPDES) stormwater program. Construction activities that disturb one or more acres of land must obtain coverage under the NPDES general construction activity stormwater permit, which is issued by the Central Valley Regional Water Quality Control Board (CVRWQCB). Obtaining coverage under the NPDES general construction activity stormwater permit generally requires that the project applicant complete the following steps:

- File a Notice of Intent with CVRWQCB that describes that proposed construction activity before construction begins;
- Prepare a Storm Water Pollution Prevention Plan (SWPPP) that describes Best Management Practices (BMPs) that will be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction; and
- File a notice of termination with CVRWQCB when construction is complete and the construction area has been permanently stabilized.

State

Alquist-Priolo Earthquake Fault Zoning Act

In response to the severe fault rupture damage of structures by the 1971 San Fernando earthquake, the State of California enacted the Alquist-Priolo Earthquake Fault Zoning Act in 1972. This act required the State Geologist to delineate Earthquake Fault Zones (EFZs) along known active faults that have a relatively high potential for ground rupture. Faults that are zoned under the Alquist-Priolo Act must meet the strict definition of being “sufficiently active” and “well-defined” for inclusion as an EFZ. The EFZs are revised periodically and they extend 200 to 500 feet on either side of identified fault traces. No structures for human occupancy may be built across an identified active fault trace. An area of 50 feet on either side of an active trace is assumed to be underlain by the fault, unless proven otherwise. Proposed construction in an EFZ is permitted only followed the completion of a fault location map prepared by a California Professional Geologist.

California Building Standards Code

Title 24 of the California Code of Regulations, also known as the California Building Standards Code, sets forth minimum requirements for building design and construction. The California Building Standards Code is a compilation of three types of building standards from three different origins:

- Building standards that have been adopted by State agencies without change from the building standards contained in national model codes;

- Building standards that have been adopted and adapted from the national model code standards to meet California conditions; and
- Building standards, authorized by the California legislature, that constitute extensive additions not covered by the model codes that have been adopted to address particular California concerns.

In the context of earthquake hazards, the California Building Standards Code's design standards have a primary objective of assuring public safety and a secondary goal of minimizing property damage and maintaining function during and following seismic events. Recognizing that the risk of severe seismic ground motion varies from place to place, the California Building Standards Code seismic code provisions will vary depending on location (Seismic Zones 0, 1, 2, 3, and 4; with 0 being the least stringent and 4 being the most stringent).

Pipeline Industry Guidelines

In addition to all other applicable Federal and State codes and regulations, and industry standards for pipeline design, the CSLC requires that the pipeline design also meet the requirements of current seismological engineering standards such as the "Guidelines for the Design of Buried Steel Pipe" by American Lifeline Alliance and "The Guidelines for the Seismic Design and Assessment of Natural Gas and Liquid Hydrocarbon Pipelines" by the Pipeline Research Council International, Inc. The CSLC also requires that all engineered structures, including pipeline alignment drawings, profile drawings, buildings and other structures, and other appurtenances and associated facilities, to be designed, signed, and stamped by California registered professionals certified to perform such activities in their jurisdiction.

Regional Water Quality Control Board

With respect to soil erosion and sedimentation, the RWQCB regulates State water quality standards in the vicinity of the Project area. Beneficial uses and water quality objectives for surface water and groundwater resources in the Project area are established in the water quality control plans (basin plans) of each RWQCB as mandated by the State Porter-Cologne Act and the CWA. The RWQCBs also implement the CWA section 303(d) total maximum daily load (TMDL) process, which consists of identifying candidate water bodies where water quality is impaired by the presence of pollutants. The TMDL process is implemented to determine the assimilative capacity of the water body for pollutants of concern and to establish equitable allocation of allowable pollutant loading within the watershed. Section 401 of the CWA requires an applicant pursuing a federal permit to conduct any activity that may result in a discharge of a pollutant to obtain a water quality certification or waiver from the RWQCB.

The RWQCBs primarily implement basin plan policies through issuing waste discharge requirements for waste discharges to land and water. The RWQCBs are also responsible for administering the NPDES permit program, which is designed to manage and monitor point and nonpoint source pollution. NPDES stormwater permits for general construction activity are required for projects that disturb more than one acre of land. Municipal NPDES stormwater permits are required for urban areas with populations greater than 100,000.

The general NPDES stormwater permits for general construction activities require the applicant to file a Notice of Intent (NOI) to discharge stormwater with the RWQCB and to prepare and implement an SWPPP. The SWPPP would include a site map, description of stormwater discharge activities, and a list of BMPs that would be employed to prevent water pollution. It must describe BMPS that would be used to control soil erosion and discharges and other construction-related pollutants (e.g., petroleum products, solvents, cement) that could contaminate nearby water resources. It must demonstrate compliance with local and regional erosion and sediment control standards, identify responsible parties, provide a detailed construction timeline, and implement a BMP monitoring and maintenance schedule.

Local

There are no local regulations pertaining to geology and soils in the Project area.

4.6.3 Significance Criteria

An adverse impact on geology and soils is considered significant and would require mitigation if:

1. Settlement of the soil could substantially damage structural components;
2. Agricultural productivity would be reduced for longer than 3 years because of soil mixing, structural damage, or compaction;
3. Ground motion due to a seismic event or any resulting phenomenon such as liquefaction or settlement could substantially damage structural components;

4. Rupture of a known earthquake fault as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map could expose people or structures to potential adverse effects;

5. Damage resulting from any of the above conditions could result in an inadvertent or uncontrolled release of hazardous, harmful or damaging substances into the environment;

6. Result in substantial soil erosion or the loss of topsoil;

7. Erosion rates would be increased, or soil productivity would be reduced by compaction or soil mixing, to a level that would prevent successful rehabilitation and eventual reestablishment of vegetative cover to the recommended or pre-construction composition and density; or

8. Any Project activity or condition that would adversely affect the stability or proper functioning of any levee or levee system.

4.6.4 Applicant Proposed Measures

No Applicant Proposed Measures (APMs) have been identified by PG&E related to geology and soils.

4.6.5 Impact Analysis and Mitigation

Impact Discussion

Soil Settlement

The Project would not cause settlement of the soil that could substantially damage structural components. Compressible soils are present in areas along the pipeline route. Buried pipelines typically do not cause underlying soils to settle as they represent less load than the weight of the soil mass removed to install the pipe. Poorly-compacted backfill over the newly installed pipe may constitute a compressible soil that may settle in time and/or with the introduction of water. Loads imposed by surface improvements may cause compressible soils to settle.

Techniques that would be used to remedy compressible soils include removal and recompaction (to improve their density), surcharging, compaction grouting, deep soil compaction, deep foundations, or foundations specially designed to tolerate the anticipated settlement. The six aboveground facilities (discussed in Section 2.0, Project Description) are the only structures that would be constructed above the pipeline. The use of the above techniques would result in no or minimal adverse impacts to structural components from the settlement of soils. Any potential adverse impacts would be less than significant (Class III).

Agricultural Productivity

Open trenching techniques would generally be used in agricultural areas. During excavation topsoil would be removed, stockpiled, and replaced in accordance with landowner negotiations. Topsoil stockpiles would be placed on one side of the trench, while overburden and construction activities would occur on the other side of the trench. Some excess overburden would be stockpiled and removed. This approach would minimize any potential soil mixing. Replacement of the topsoil in agricultural areas would be done in accordance with landowner negotiations; therefore, structural damage and compaction would not impact agricultural productivity. Therefore, any potential adverse impacts to agricultural productivity because of soil mixing, structural damage, or compaction would be less than significant (Class III).

Release of Substances into the Environment

The Project would not result in an inadvertent or uncontrolled release of hazardous, harmful or damaging substances into the environment. The SWPPP would include list of BMPs that would be employed to prevent water pollution. A frac-out is possible during HDD, which could degrade water quality as a result of drilling muds being discharged into a stream or river. As proposed in APM HWQ-5 and APM BIO-23, PG&E would develop an HDD Fluid Release Contingency Plan that would require mitigation in the unlikely event of a frac-out resulting in discharge of drilling mud that would potentially result in adverse impacts to water quality. The plan would include measures to contain and clean up any drilling mud inadvertently released. Impacts would be less than significant (Class III).

Soil Erosion and Topsoil

The Project would not result in substantial soil erosion or the loss of topsoil. As proposed in APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7, PG&E would implement measures contained within the Water Quality Construction Best Management Practices Manual, in addition to those in an Erosion Control and Sediment Transport Plan and the SWPPP for the Project, and any subsequent permit obligations pertaining to pollution. Collectively, these measures would ensure that all erosion control plans are implemented and BMPs are employed to prevent erosion and improper conveyance of stormwater during construction and operation. Impacts would be less than significant (Class III).

Vegetative Cover

The Project would not increase erosion rates, or reduce soil productivity by compaction or soil mixing, to a level that would prevent successful rehabilitation and eventual reestablishment of vegetative cover to the recommended or pre-construction composition and density. The discussion under Soil Erosion and Topsoil above addresses erosion rates, while the discussion under Agricultural Productivity addresses soil mixing. PG&E's Water Quality Construction Best Management Practices Manual (PG&E 2006) includes BMPs that would minimize impacts on erosion and vegetative cover such as:

- Preserve existing vegetation whenever possible;
- Whenever possible, minimize disturbed areas by locating temporary roadways to avoid stands of trees and shrubs, and follow existing contours to reduce cutting and filling;
- Consider the impact of grade changes to existing vegetation and the root zone;
- Use one or more of the below temporary soil stabilization practices, when applicable - hydraulic mulch, hydro seeding, soil binders, straw mulch, geotextiles, and/or plastic covers and erosion control blankets/mats;
- Implement before the onset of precipitation; and
- Implement BMPs such as fiber rolls or gravel bag berms to break up the slope lengths.

Revegetation of disturbed areas would be accomplished under APM BIO-16, APM BIO-17, and APM BIO-19 as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a. The BMPs and APMs referenced above would result in successful rehabilitation and reestablishment of vegetative cover to the recommended or pre-construction composition and density and therefore there would be less than significant impacts (Class III).

Levee or Levee System

Project activities or conditions would not adversely affect the stability or proper functioning of any levee or levee system. The Project includes planned HDD crossings beneath several flood control levees. The possible degradation of the integrity and stability of the levees due to the crossings is a concern. The geotechnical design report for the Project (Kleinfelder 2007) has provisions to protect the levees, including settlement monitoring during construction and grouting (sealing) the pipeline/boring configuration to prevent water seepage along it. The HDD crossings would occur beneath the levees and adjoining channels and would have entry and exit points several hundred feet beyond the landsides of the levees.

Implementation of the recommendations of the geotechnical report and the requirements of the jurisdictional agencies would result in less than significant impacts to the stability or performance of the flood control levees (Class III).

Impact GEO-1: Known Earthquake Faults / Ground Motion

The Project would result in a risk of damage to structures from ground motion due to a seismic event or resulting phenomenon such as liquefaction or settlement, or from rupture of a known earthquake fault as delineated on the most recent Alquist Priolo Earthquake fault Zoning Map (Potentially Significant, Class II).

Seismicity (which includes active faults, ground shaking, and soil liquefaction) is the primary geologic hazard that could affect the proposed Project facilities. A portion of the proposed Project pipeline facilities would be located in a seismically active region. Three faults are identified crossing the proposed pipeline alignment, the Great Valley, Dunnigan Hills, and Willows faults. All three faults are believed to exist at depth and do not reach the surface. The Great Valley and Dunnigan Hills faults are considered active.

There is a potential for liquefaction to occur along portions of the pipeline alignment as a result of ground shaking during earthquakes. Liquefaction can cause settlement of soils and the structures on which they are built. Because liquefied soils behave as a liquid for a short time, there may also be a tendency for buoyant facilities to float. Liquefiable soils and its effects can be remedied by removal and recompaction, of deep foundations extending into underlying competent materials, deep dynamic compaction, vibro-compaction, other soil modifications, and/or structural designs incorporated to withstand the potential effects of liquefied soil conditions.

Due to the proposed pipeline crossing of the three faults, the Project area is subject to ground shaking due to earthquakes. Historically, the area has experienced a low to moderate seismicity. The Project could be exposed to ground motion due to a seismic event or any resulting phenomenon such as liquefaction or settlement that could substantially damage structural components.

MM GEO-1 Site Specific Seismic Field Investigation

PG&E shall perform a site-specific seismic field investigation as part of its detailed design phase for the proposed Project. The field investigation would determine whether any engineering/design solutions are needed to mitigate against any hazards of seismic displacements along the fault crossings. If the field investigation determines the presence of any active faults in project location, then the following shall be completed:

PG&E shall determine the engineering/design solutions that are appropriate to mitigate against the hazard of seismic displacements along any active faults.

PG&E shall develop a computer model to determine the soil-pipe interaction with the proposed applied displacement. The model would evaluate various combinations of pipe wall thickness and pipe grade to determine which pattern yields the best performance under displacement conditions. The design shall also incorporate additional methods as necessary.

PG&E shall design the proposed pipelines and any other proposed facilities using industry standards for seismic-resistant design in liquefaction-prone areas.

PG&E shall provide a copy of the final design, as well as any related geotechnical information, to the CSLC before construction of the proposed Project.

A certified engineer shall observe the construction excavation in the vicinity of the fault crossings to verify that the design assumptions are valid and the design measures (if any) are centered in the correct location.

Rationale for Mitigation

The seismic field investigation would determine whether engineering/design solutions are needed to mitigate against any hazards of seismic displacements along the fault crossings. Any necessary design features would ensure strength and ductility of the pipeline facilities in order to reduce the potential impacts associated with displacement caused by surface faulting and liquefaction.

4.6.6 Impacts of Alternatives

A No Project Alternative as well as twelve options have been proposed for the alignment in order to minimize or eliminate environmental impacts of the proposed Project and to respond to comments from nearby landowners. The twelve options, labeled A through L, have been analyzed in comparison to the portion of the proposed route that has been avoided as a result of the option. Descriptions of the options can be found in Section 3.0, Alternatives and Cumulative Projects, and are depicted in Figure 3-2A through Figure 3-2K.

No Project Alternative

Under the No Project Alternative, no impacts to geology or soils would result. The No Project Alternative would eliminate any potential direct or indirect impacts to settlement, agricultural productivity, damage from ground motion or earthquakes, release of damaging substances, soil erosion, vegetative cover or levees that could result from the installation of pipelines, the construction of aboveground stations, and other construction-related activities.

Option A

The geologic and topographic conditions associated with Option A are similar to those described above for the proposed Project. Option A would cross one soil type not crossed by the proposed Project: Zamora loam. Table 4.6-5 contains the relevant properties of additional soils encountered under Option A.

Table 4.6-5: Properties of Zamora Loam

Name	Map Symbol	Percent Slope	Shrink-Swell Potential[1]	Erosion Potential[2]	Depth to Bedrock[3] (ft bgs)[4]	Nature of Bedrock[3]	Depth to Water[5] (ft bgs)	Corrosion Potential (Steel)
Zamora Loam	Za	0 to 1	Not available	Not available	More than 6.6	Not available	More than 6.6	Not available

Notes:
[1] Based on Linear Expansivity Potential. [2] Estimated from slope. Soil with minimum slope not rated. [3] Depth to bedrock provided. [4] ft bgs = feet below ground surface.
[5] Depth to groundwater provided when noted in soil survey. Depth to water not provided if typically greater than 6 ft bgs.
Source: PG&E 2007.

With respect to the disruption of agricultural soils, Option A would reduce the segmentation of agricultural fields in Yolo County by avoiding the placement of pipeline through 8 of the 16 agricultural fields that the proposed project would cross for Line 406. Instead, the majority of the construction activities under Option A would parallel agricultural parcel boundaries; regardless, both Option A and the proposed project alignment would traverse agricultural soils. Option A would increase the pipeline length by 2,200 feet, which would have slightly greater impacts on soils in general. However, similar to the proposed Project, impacts to agricultural soils resulting from Option A would be less than significant (Class III).

Like the proposed Project, Option A would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option A would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. The recommendations of the geotechnical report for the proposed project would be implemented under Option A to minimize impacts to levees.

In addition, Option A would implement the SWPPP BMPs that prevent water pollution. APM HWQ-5 and APM BIO-23 would be implemented under Option A to reduce potential impact of a frac-out. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option A.

Geologic impacts of Option A would be slightly more than under the proposed project. Similar to the proposed Project, Option A would cross the Great Valley fault. The proposed Project would cross an inferred alignment of the Dunnigan Hills fault, which is assumed to be buried in the vicinity of the proposed Project. However, Option A would cross the southern end of the Dunnigan Hills Fault in the vicinity of apparent surface rupture. As discussed in Impact GEO-1, the Dunnigan Hills fault and the Great Valley fault are considered active. Due to the proximity to the Dunnigan Hills fault, Option A would be subject to a greater risk of seismic hazards than the proposed Project. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option A would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Option A would result in slightly greater potential impacts to agricultural soils and slightly greater geologic impacts than the proposed Project.

Option B

The geologic and topographic conditions associated with Option B are similar to those described above for the proposed Project. Option B would cross one soil type not crossed by the proposed Project: Zamora loam. Table 4.6-5 contains the relevant properties of additional soils encountered under Option B.

With respect to the disruption of agricultural soils, Option B would reduce segmentation of agricultural fields in Yolo County by avoiding the segmentation of 13 of the 16 agricultural fields that the proposed project would cross for Line 406. Instead, the majority of the construction activities under Option B would parallel agricultural parcel boundaries. Regardless, both Option B and the proposed project alignment would traverse agricultural soils. Option B would increase the pipeline length by 2,600 feet, which would have slightly greater impacts on soils in general. However, similar to the proposed Project, impacts to agricultural soils resulting from Option B would be less than significant (Class III).

Like the proposed Project, Option B would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option B would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. The recommendations of the geotechnical report for the proposed Project would be implemented under Option B to minimize impacts to levees. In addition, Option B would implement the SWPPP BMPs that prevent water pollution. APM HWQ-5 and APM BIO-23 would be implemented under Option B to reduce potential impact of a frac-out. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option B.

Geologic impacts of Option B would be similar to the proposed project. Similar to the proposed Project, Option B would cross the Great Valley fault and be located approximately 5 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option B would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Option B would result in slightly greater potential impacts to agricultural soils and similar geologic impacts to the proposed Project.

Option C

The geologic and topographic conditions associated with Option C are similar to those described above for the proposed Project. Option C would not cross additional soil types.

With respect to the disruption of agricultural soils, Option C would avoid the segmentation of 3 of the 16 agricultural fields that the proposed project would cross for Line 406. Instead, construction activities under Option C would parallel agricultural parcel boundaries. Regardless, both Option C and the proposed project alignment would traverse agricultural soils. Option C would increase the pipeline length by 1,150 feet, which would have slightly greater impacts on soils in general. However, similar to the proposed Project, impacts to agricultural soils resulting from Option C would be less than significant (Class III).

Like the proposed Project, Option C would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option C would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. The recommendations of the geotechnical report for the proposed Project would be implemented under Option C to minimize impacts to levees. In addition, Option C would implement the SWPPP BMPs that prevent water pollution. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option C.

Geologic impacts of Option C would be similar to the proposed project. Similar to the proposed Project, Option C would cross the Great Valley fault and be located almost 9.5 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option C would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Option C would result in slightly greater potential impacts to agricultural soils and similar geologic impacts to the proposed Project.

Option D

The geologic and topographic conditions associated with Option D are similar to those described above for the proposed Project. Option D would not cross additional soil types.

With respect to the disruption of agricultural soils, Option D would reduce the segmentation of agricultural fields in Yolo County by avoiding placement of the pipeline through 10 of the 16 agricultural fields that the proposed project would cross for Line 406. Instead, construction activities under Option D would parallel agricultural parcel boundaries, mostly adjacent to CR-17. Regardless, both Option D and the proposed project alignment would traverse agricultural soils. Option D would increase the pipeline length by 860 feet, which would have slightly greater impacts on soils in general. However, similar to the proposed Project, impacts to agricultural soils resulting from Option D would be less than significant (Class III).

Like the proposed Project, Option D would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option D would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. The recommendations of the geotechnical report for the proposed Project would be implemented under Option D to minimize impacts to levees. In addition, Option D would implement the SWPPP BMPs that prevent water pollution. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option D.

Geologic impacts of Option D would be similar to the proposed project. Similar to the proposed Project, Option D would be located less than 2 miles from the Great Valley fault and approximately 6.5 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option D would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Option D would result in slightly greater potential impacts to agricultural soils and similar geologic impacts to the proposed Project.

Option E

The geologic and topographic conditions associated with Option E are similar to those described above for the proposed Project. Option E would not cross additional soil types.

With respect to the disruption of agricultural soils, Option E would reduce segmentation of agricultural fields in Yolo County by avoiding the placement of pipeline through 10 of the 16 agricultural fields that the proposed project would cross for Line 406. Instead, construction activities under Option E would parallel agricultural parcel boundaries, mostly adjacent to CR-19. Regardless, both Option E and the proposed project alignment would traverse agricultural soils. Option E would increase the pipeline length by 3,480 feet, which would have slightly greater impacts on soils in general. However, similar to the proposed Project, impacts to agricultural soils resulting from Option E would be less than significant (Class III).

Like the proposed Project, Option E would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option E would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. The recommendations of the geotechnical report for the proposed Project would be implemented under Option E to minimize impacts to levees. In addition, Option E would implement the SWPPP BMPs that prevent water pollution. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option E.

Geologic impacts of Option E would be similar to the proposed project. Similar to the proposed Project, Option E would be located less than 2 miles from the Great Valley fault and approximately 6.5 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option E would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Option E would result in slightly greater potential impacts to agricultural soils and similar geologic impacts to the proposed Project.

Option F

The geologic and topographic conditions associated with Option F are similar to those described above for the proposed Project. Option F would not cross additional soil types.

With respect to the disruption of agricultural soils, Option F would increase segmentation of agricultural fields in Yolo County. Whereas the proposed Project would segment grazing land, Option F would instead segment an agricultural field with row crops. Regardless, both Option F and the proposed project alignment would traverse agricultural soils. Option F would not increase the pipeline length. Similar to the proposed Project, impacts to agricultural soils resulting from Option F would be less than significant (Class III).

Like the proposed Project, Option F would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option F would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. The recommendations of the geotechnical report for the proposed Project would be implemented under Option F to minimize impacts to levees. In addition, Option F would implement the SWPPP BMPs that prevent water pollution. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option F.

Geologic impacts of Option F would be similar to the proposed project. Similar to the proposed Project, Option F would be located approximately 9 miles from the Great Valley fault and approximately 1 mile from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option F would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Option F would have similar potential impacts on agricultural soils and similar geologic impacts to the proposed Project.

Option G

The geologic and topographic conditions associated with Option G are similar to those described above for the proposed Project. Option G would not cross additional soil types.

With respect to the disruption of agricultural soils, Option G would reduce segmentation of agricultural fields in Yolo County by not segmenting one of the agricultural fields that the proposed project would cross for Line 406. Instead, construction activities under Option G would parallel the agricultural parcel boundaries. Regardless, both Option G and the proposed project alignment would traverse agricultural soils. Option G would not increase the pipeline length. Similar to the proposed Project, impacts to agricultural soils resulting from Option G would be less than significant (Class III).

Like the proposed Project, Option G would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option G would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. In addition, Option G would implement the SWPPP BMPs that prevent water pollution. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option G.

Geologic impacts of Option G would be similar to the proposed project. Similar to the proposed Project, Option G would be located almost 12 miles from the Great Valley fault and almost 3 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option G would be potentially significant (Class II).

Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Therefore, Option G would have similar potential impacts on agricultural soils and similar geologic impacts to the proposed Project.

Option H

The geologic and topographic conditions associated with Option H are similar to those described above for the proposed Project. Option H would cross eleven soil type not crossed by the proposed Project. Table 4.6-6 contains the relevant properties of additional soils encountered under Option H.

With respect to the disruption of agricultural soils, Option H would increase the segmentation of agricultural fields in Yolo County for Line 407 West. The proposed Project would bisect four agricultural fields, whereas Option H would bisect eight. Regardless, both Option H and the proposed project alignment would traverse agricultural soils. Option H would decrease the pipeline length by 2,900 feet, which would have slightly fewer impacts on soils in general. Similar to the proposed Project, impacts to agricultural soils resulting from Option H would be less than significant (Class III).

Like the proposed Project, Option H would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option H would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. The recommendations of the geotechnical report for the proposed project would be implemented under Option H to minimize impacts to levees. In addition, Option H would implement the SWPPP BMPs that prevent water pollution. APM HWQ-5 and APM BIO-23 would be implemented under Option H to reduce potential impact of a frac-out. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option H.

Table 4.6-6: Option H New Soil Types

Name	Map Symbol	Percent Slope	Shrink-Swell Potential[1]	Erosion Potential[2]	Depth to restrictive feature[3] (ft bgs)[4]	Nature of restrictive feature[3]	Depth to Water[5] (ft bgs)	Corrosion Potential (Steel)
Clear Lake Clay, Hardpan substratum, drained,	115	0 to 1	High	Slight	3.3-6.6	Duripan	5-6	Not Available
Cosumnes Silt Loam, Partially drained	127	0 to 2	High	Slight	More than 6.7	Not Available	3	Not Available
Galt Clay, Leveled	151	0 to 1	High	Slight	3.3	Hardpan	More than 6.7	Not Available
Sacramento Clay	Sc	0 to 1	Not Available	Not Available	More than 6.7	Not Available	3-5	Not Available
Sacramento Silty clay loam	Sa	0 to 1	Not Available	Not Available	More than 6.7	Not Available	3-5	Not Available
Sailboat silt loam, partially drained	206	0 to 2	Not Available	Slight	Not Available	Not Available	3-5	Not Available
San Joaquin-Galt Complex Leveled	217	0 to 1	High	Slight	1.7-3.3	Hardpan	Not Available	Not Available
San Joaquin -Zerarents Complex, leveled	221	0 to 1	Low to High	Slight	2- more than 5	Hardpan	Not Available	Not Available
San Joaquin silt loam, leveled	213	0 to 1	High	Slight	1.9-3.3	Hardpan	Not Available	Not Available
Tyndall very fine sandy loam, deep	Te	0 to 1	Not Available	Not Available	More than 6.7	Not Available	3-7	Not Available
San Joaquin-Durixeralfs complex	216	0 to 1	High	Slight	2-3.3	Hardpan	Not Available	Not Available

Notes:
[1] Based on Linear Expansivity Potential. [2] Estimated from slope. Soil with minimum slope not rated. [3] Depth to bedrock provided. [4] ft bgs = feet below ground surface.
[5] Depth to groundwater provided when noted in soil survey. Depth to water not provided if typically greater than 6 ft bgs.
Source: PG&E 2007.

Geologic impacts of Option H would be the same as the proposed project. Similar to the proposed Project, Option H would be located almost 22 miles from the Great Valley fault and approximately 11 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option H would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Therefore, Option H would have slightly fewer potential impacts on agricultural soils and similar geologic impacts to the proposed Project.

Option I

The geologic and topographic conditions associated with Option I are similar to those described above for the proposed Project. Option I would not cross additional soil types.

With respect to the disruption of agricultural soils, Option I would increase segmentation of agricultural fields in Placer County by bisecting three agricultural fields and along the boundary of a fourth agricultural field. The proposed Project would not bisect agricultural fields. Regardless, both Option I and the proposed project alignment would traverse agricultural soils. Option I would increase the pipeline length by 2,900 feet, which would have slightly greater impacts on soils in general. However, similar to the proposed Project, impacts to agricultural soils resulting from Option I would be less than significant (Class III).

Like the proposed Project, Option I would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option I would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. The recommendations of the geotechnical report for the proposed Project would be implemented under Option I to minimize impacts to levees. In addition, Option I would implement the SWPPP BMPs that prevent water pollution. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option I.

Geologic impacts of Option I would be similar to the proposed project. Similar to the proposed Project, Option I would be located approximately 32 miles from the Great Valley fault and almost 22 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option I would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Option I would have slightly greater potential impacts on agricultural soils and similar geologic impacts to the proposed Project.

Option J

The geologic and topographic conditions associated with Option J are similar to those described above for the proposed Project. Option J would not cross additional soil types.

With respect to the disruption of agricultural soils, Option J would be similar to the proposed Project. Option J would not bisect agricultural fields, but instead would parallel agricultural parcel boundaries. Regardless, both Option J and the proposed project alignment would traverse agricultural soils. Option J would increase the pipeline length by 5,300 feet, which would have slightly greater impacts on soils in general. Similar to the proposed Project, impacts to agricultural soils resulting from Option J would be less than significant (Class III).

Like the proposed Project, Option J would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option J would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. The recommendations of the geotechnical report for the proposed Project would be implemented under Option J to minimize impacts to levees. In addition, Option J would implement the SWPPP BMPs that prevent water pollution. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option J.

Geologic impacts of Option J would be similar to the proposed project. Similar to the proposed Project, Option J would be located approximately 32 miles from the Great Valley fault and almost 22 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option J would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Therefore, Option J would have slightly greater potential impacts on agricultural soils and similar geologic impacts to the proposed Project.

Option K

Option K. a portion of Line 406 East would be rerouted to the north to place the pipeline outside of a 1,500-foot safety buffer around a planned elementary school to be located south of Baseline Road. Rather than follow Baseline Road, Option K would bisect annual grassland.

The geologic and topographic conditions associated with Option K are similar to those described above for the proposed Project. Option K would not cross additional soil types.

With respect to the disruption of agricultural soils, Option K would be similar to the proposed Project. Option K would not bisect agricultural fields, but would instead bisect annual grassland. Regardless, both Option K and the proposed project alignment would traverse agricultural soils. Option K would increase the pipeline length by 70 feet, which would have slightly greater impacts on soils in general. Similar to the proposed Project, impacts to agricultural soils resulting from Option K would be less than significant (Class III).

Like the proposed Project, Option K would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option K would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. In addition, Option K would implement the SWPPP BMPs that prevent water pollution. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option K.

Geologic impacts of Option K would be similar to the proposed project. Similar to the proposed Project, Option K would be located approximately 32 miles from the Great Valley fault and almost 23 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option K would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Option K would have slightly greater potential impacts on agricultural soils and similar geologic impacts to the proposed Project.

Option L

Under Option L, a portion of the proposed Project adjacent to Base Line Road would be constructed utilizing HDD instead of trenching. Option L would not change the location of the route, but would change the construction method from trenching to HDD.

The geologic and topographic conditions associated with Option L are similar to those described above for the proposed Project. Option L would not cross additional soil types.

With respect to the disruption of agricultural soils, Option L would be similar to the proposed Project, and impacts to agricultural soils resulting from Option L would be less than significant (Class III).

Like the proposed Project, Option L would require implementation of APM HWQ-1, MM HWQ-1, MM SW-1, and APM BIO-7 in order to reduce impacts to soil erosion or loss of topsoil to a less than significant level of impact. Option L would also require implementation of APM BIO-16, APM BIO-17, and APM BIO-19, as well as MM BIO-1a, MM BIO-1b, MM BIO-1c, and MM BIO-2a, in order to reduce impacts to soils and vegetative cover to a less than significant level. In addition, Option L would implement the SWPPP BMPs that prevent water pollution. Similar to the proposed Project, impacts to agricultural productivity, soil erosion and topsoil, vegetative cover, release of substances into the environment, and levee or levee system would be less than significant (Class III) under Option L.

Geologic impacts of Option L would be similar to the proposed project. Similar to the proposed Project, Option L would be located approximately 32 miles from the Great Valley fault and almost 23 miles from the Dunnigan Hills Fault. As discussed in Impact GEO-1, the Great Valley Fault and the Dunnigan Hills Fault are considered active. Similar to the proposed Project, impacts for known earthquake faults / ground motion associated with Option L would be potentially significant (Class II). Implementation of MM GEO-1 would be required to reduce impacts to less than significant.

Option L would have similar potential impacts to the proposed Project.

Table 4.6-7: Comparison of Alternatives for Geology and Soils

Alternative	Comparison with Proposed Project
No Project	No Impacts
Option A	Slightly Greater Impacts
Option B	Slightly Greater (soils) / Similar (geologic) Impacts
Option C	Slightly Greater (soils) / Similar (geologic) Impacts
Option D	Slightly Greater (soils) / Similar (geologic) Impacts
Option E	Slightly Greater (soils) / Similar (geologic) Impacts
Option F	Similar Impacts
Option G	Similar Impacts
Option H	Slightly Fewer (soils) / Similar (geologic) Impacts
Option I	Slightly Greater (soils) / Similar (geologic) Impacts
Option J	Similar Impacts
Option K	Similar Impacts
Option L	Similar Impacts
Source: Michael Brandman Associates 2009.	

The comparative analysis of the options to the proposed Project focuses on the only difference between them on geology and soils issues, which is agricultural productivity. Therefore, the options are similar to the proposed Project for all significance criteria except agricultural productivity.

4.6.7 Cumulative Projects Impact Analysis

The cumulative environment for geology and soils includes the Project area. Other projects within this Project's vicinity that would potentially have a geology and soils cumulative effect include: the Sutter Pointe Specific Plan, new road construction in Sutter County, the Placer Vineyards Specific Area Plan, the Sierra Vista Specific Plan, and the Natomas Levee Improvement Plan. Concurrent with the proposed Project, the construction of these projects could result in an overall increase of potential affects to geology and soils within the cumulative environment.

There would be no cumulative impacts from ground motion, liquefaction, or settlement, or earthquake faults, or associated damage. That is because the proposed Project and the other projects listed above are not in active earthquake fault zones.

There would be no cumulative impacts from soil erosion or soil settlement because the proposed Project would minimize those impacts, as would the other projects as part of their permitting and construction process.

There would be an adverse cumulative impact to agricultural productivity due to permanent conversion of agricultural lands to other uses in some of the above Projects. The proposed Project would have only short-term temporary impacts on agricultural productivity due to impacts on soils.

The Natomas Levee Improvement Plan is the only project that would include potential impacts to levees on the Sacramento River as a result of proposed levee improvements. The Natomas Levee Improvement Plan includes raising, reinforcing, and reshaping existing levees. The proposed Project would employ HDD methodologies in the crossing of the Sacramento River and its major tributaries, thereby avoiding any direct impacts to those levees.

Climate change may also have a cumulative effect on soils. Snow pack in the mountains is expected to decrease, and may subsequently lead to a decrease in streamflow (Climate Action Team [CAT] Report March 2006) in the area of this

Project. The potential decrease in streamflows and therefore flooding would result in a lower risk of soil erosion.

4.6.8 Summary of Impacts and Mitigation Measures

The proposed pipeline would cross three faults, the Great Valley, Dunnigan Hills, and Willows faults. The Project area is subject to ground shaking due to earthquakes. The Project could be exposed to ground motion due to a seismic event or any resulting phenomenon such as liquefaction or settlement that could substantially damage structural components. There is also a potential for liquefaction to occur along portions of the pipeline alignment as a result of ground shaking during earthquakes. These potential impacts would be reduced to less than significant with the implementation of Mitigation Measure GEO-1. Table 4.6-8 summarizes the impacts and mitigation measures for geology and soils.

Table 4.6-8: Summary of Geology and Soils Impacts and Mitigation Measures

Impact	Mitigation Measure
GEO-1. Known Earthquake Faults/Ground Motion	**GEO-1.** Site Specific Seismic Field Investigation
Source: Michael Brandman Associates 2009.	