CHAPTER 10

GEOLOGIC HAZARDS AND SOILS

INTRODUCTION

This chapter describes the existing geologic and soil conditions in the SCVJSS service area and identifies impacts associated with implementation of the 2015 Plan. Information on geology, soils, and seismicity characteristics and constraints was compiled using regional and site specific information from previously prepared geotechnical reports (Glenn A. Brown, 1996; About Earth, Incorporated, 1996). Due to the minor nature of the proposed upgrades at the SWRP and VWRP (reference Chapters 7 and 8), discussion of the existing conditions at the SWRP is not included in this chapter, and only the potential geologic hazards and soils impacts associated with the construction and operation of these upgrades are addressed.

SETTING

Regional Setting

Geography and Topography

The topography of the Santa Clarita Valley planning area is dominated by the Santa Clara River and the surrounding highlands (see Figure 10-1). The Santa Clara River, which is the valley's primary drainage course, flows westward through the planning area from Soledad Canyon in the east into the Santa Clarita Valley. The headwaters of the river are located east of the planning area within the San Gabriel Mountains. A southern branch of the Santa Clara River joins the main river course near Saugus. The Santa Clara River and its tributaries form a dendritic drainage pattern in the western half of the planning area and a trellis drainage pattern in the eastern half of the planning area. Year-round tributaries consist of the south-flowing Castaic Creek, Bouquet Canyon Creek, San Francisquito Creek, and Mint Canyon Creek, and the north-flowing Newhall and Placerita Creeks. North-flowing seasonal tributaries consist of streams emanating from Salt, Potrero, Elsmere, Sand, and Oak Spring Canyons. South-flowing ephemeral tributaries consist of the streams within Tick, San Martinez Chiquito, and San Martinez Grande Canyons. Castaic Lake, a man-made impoundment, is the largest surface water body within the planning area, with a maximum storage capacity of 323,700 acre feet of fresh water. Dry Canyon reservoir is located just north of the planning area. Both Castaic Lake and Dry Canyon Reservoir are fed by the California Aqueduct, which crosses the planning area to the east of San Fernando Road.

The mountainous areas within the planning area include the San Gabriel Mountains to the east and southeast, the Santa Susana Mountains to the south, the Topatopa and Piru Mountains to the north and northwest, and the Sierra Pelona Mountains to the northeast. While the floodplain of the Santa Clara River is fairly flat, most of the topography within the planning area is rugged and is characterized by steep-sided canyon lands. Elevations range from about 400 feet above mean sea level near the western boundary of the planning area along the Santa Clara River to over 4,000 feet above mean sea level within the San Gabriel Mountains in the southeastern extreme of the planning area.

Geology

The geology within the planning area is depicted in Figures 10-2 and 10-3. The planning area lies within the Transverse Ranges' Geomorphic Province, which is characterized by east-west trending mountain ranges and valleys formed by compressional forces across the big bend of the San Andreas Fault. The Transverse Ranges are relatively young geomorphic features that will continue to evolve under the current tectonic interaction between the Pacific and North American plates.

The Santa Clarita Valley planning area is primarily underlain by a thick sequence of Tertiary-age (2 to 65 million years old) sedimentary rocks. The sedimentary sequence rests on a basement complex composed of Mesozoic (older than 65 million years) and Precambrian (older than 500 million years) metamorphic and igneous rock bodies. Mantling the Tertiary sequence is a relatively thin section of Quaternary-age (younger than two million years) sedimentary rock and recent sediments. The San Gabriel Fault bisects the study area along a northwest-southeast direction. Pre-Pliocene rock units to the northeast of this fault are markedly different from those to the southwest of the fault (Dibblee, 1982).

The southwest portion of the planning area is primarily underlain by marine and nonmarine sedimentary rocks divided among the Modelo, Towsley, Pico, and Saugus Formations. The sedimentary sequence overlies a basement complex that is chiefly composed of Mesozoic-age metamorphic and igneous rocks. The Modelo, Towsley, and early Pico Formations were deposited in a marine environment at depths greater than 600 feet. These formations interfinger and have similar rock characteristics, and are differentiated primarily on the basis of fossils found within them. The Modelo, Towsley, and Pico Formations are comprised of bedded siltstone, mudstone, siliceous shale, and conglomerate. The latest Pico and earliest Saugus Formations were deposited as Southern California was uplifted and the shoreline moved westward to its current position. The upper Saugus Formation is a nonmarine stream and lakebed deposit. The Saugus Formation is characterized as a brown to reddish-brown, tan sandstone, and conglomerate with locally occurring greenish-gray siltstone. The ancient river terrace deposits that overlie the Saugus Formation and older formations are referred to as the Pacoima Formation. This formation includes poorly consolidated silt, clay, sand, gravel, and occasional organic-rich layers deposited along the banks of the rivers that crossed this area during the Pleistocene epoch.

The northeastern portion of the planning area is underlain by marine and nonmarine sedimentary rocks of the San Francisquito, Vasquez, Mint Canyon, Castaic, and Saugus Formations. This sedimentary sequence overlies a basement complex that includes Precambrian-age anorthosite and Mesozoic-age granite and schist. The late Cretaceous-Paleocene-age San Francisquito Formation roughly consists of 7,500 feet of deep marine deposits that include alternating beds of tan sandstone, dark gray shale, and gray to brown pebble conglomerate. The Vasquez Formation is composed of roughly 4,000 feet of red to gray claystone, sandstone, and conglomerate. Locally, andesite and basaltic lava flows comprise the lower portion of the Vasquez Formation. The Vasquez Formation is a river deposit of Oligocene age (about 25 to 40 million years old). The upper Miocene (5 to 10 million years old) Mint Canyon Formation unconformably overlies the Vasquez Formation. The Mint Canyon Formation consists of roughly 5,500 feet of stream-laid cobble-pebble conglomerate with associated sandstone and claystone. The upper Miocene Castaic Formation is a marine deposit of dark gray, micaceous shale with minor sandstone interbeds. The upper Pliocene-Pleistocene Saugus Formation overlies the Castaic Formation in the northeastern portion of the planning area. The chiefly nonmarine Saugus Formation is as much as 1,600 feet thick and unconformably overlies the Castaic and Mint Canyon Formations (Jahns, 1954).

The geologic structure within the planning area is dominated by youthful folding and reverse faulting related to compression across the big bend of the San Andreas Fault. Fold axes and fault planes have a general northwesterly trend. The San Gabriel Fault is a high angle right-lateral strike-slip fault, which transects the planning area along a northwest-southeast direction. The Santa Susana Fault is a north-dipping reverse fault that surfaces near the southern edge of the planning area. The Del Valle and Holser Faults are south-dipping reverse faults. The Del Valle Fault is located in the western planning area, north of the Santa Clara River. The Holser Fault branches off from the San Gabriel Fault west of Saugus. Several prominent fold axes are mapped within the Santa Susana Mountains. These include the Oat Mountain syncline, the Pico anticline, the Weldon syncline, the Santa Clara River syncline, and the Del Valle anticline.

Seismicity

The Santa Clarita Valley lies within a region of high seismic potential, and has been subjected to numerous significant earthquakes within the past century. The 1971 San Fernando Earthquake (Richter magnitude 6.4) and the 1994 Northridge Earthquake (Richter magnitude 6.7) both caused significant damage within the valley. Earthquakes that occur in this area, as well as throughout Southern California, are the result of crustal deformation associated with the interaction of the Pacific and North American plates. The Pacific plate moves northward past the North American plate at a rate of approximately one-fourth to one-half inch per year. The boundary between these two plates occurs along the San Andreas Fault which, at its closest approach, is located approximately ten miles to the north of the planning area. A large westward bend in the San Andreas Fault to the north of the San Gabriel Mountains results in conversion of the right-lateral transform motion to compressional motion. The valley lies within a zone that has experienced significant crustal shortening due to compression across the San Andreas Fault. Reverse faults and folds have developed to accommodate this crustal shortening. The Santa Susana Mountains, which form the southern boundary of the valley, are a recent expression of these compressional forces (Ziony and Yerkes, 1985).

Several reverse and strike-slip faults are considered to have the potential to generate earthquakes across the planning area. Seismic Risk Zones have been developed based on the known distribution of historic earthquake events, evidence of past earthquakes, proximity to earthquake areas and active faults, and frequency of earthquakes in a given area. These zones are generally classified using either the California Division of Mines and Geology Maximum Expected Earthquake Intensity Map or Uniform Building Code Seismic Risk Map of the United States. Because of the number of active faults in Southern California, the Santa Clarita Valley planning area is located in the highest risk zone defined by both the CDMG and UBC standards (Zones III and IV, respectively). Listed in Table 10-1 are the known faults located within the planning area and the maximum probable earthquake expected to occur along each fault in any given one hundred-year period (Wesnousky, 1986).

Seismic-Related Geologic Hazards

The potential for injury within populated areas and damage to structures during earthquakes can result from surface rupture along an active fault, ground shaking from a nearby or distant earthquake, surface settlement, or liquefaction of soils. These hazards and their potential effects are described below.

Surface Rupture and Faulting

The hazard of surface rupture is generally limited to land immediately adjacent to an active fault. According to the CDMG, an active fault is one that has experienced surface displacement within approximately the past 11,000 years (defined geologically as the Holocene epoch). The Alquist-Priolo Special Studies Zone Act of 1972 requires that special geologic studies be

Table 10-1
QUATERNARY FAULTS

FAULT NAME	FAULT TYPE	FAULT LENGTH (mi.)	MOMENT MAGNITUDE[a]	ACTIVITY	DISTANCE (mi.) AND DIRECTION FROM SITE
Del Valle	Reverse	6	6.2	LQ	2 NW
Holser	Reverse	12	6.6	LQ	Site within zone
Oakridge	Reverse	24	6.9	H	6 SW
San Andreas	Rt. Lateral	110	7.4	A	19 NE
San Cayetano	Reverse	30	7.1	H	7 W
San Fernando	Reverse	11	6.5	A	21 SE
San Gabriel A	Rt. Lateral	29	7.0	LQ	1.33 NE
Santa Susanna	Reverse	24	6.9	LQ	2 SSW
Sierra Madre A	Reverse[b]	10	6.5	LQ	26 SE
Simi-Northridge	Reverse[b]	28	7.0	A	10 SSW

Source: Modified after Wesnousky, 1986.

Notes: A = Active in last 200 years H = Holocene - last 10,000 years LQ = Late Quaternary - less than 700,000 years

a) Moment-Magnitude as used by Wesnousky is the estimated earthquake expected for entire fault length together with slip rate and seismic moment. It is felt that it is more reasonable than an estimated Richter Magnitude used in design.

b) Fault type not precisely known.

conducted to locate and assess the activity level of any fault within a potential development site. The intent of the law is to minimize damage from fault rupture by avoiding certain types of construction across an active fault. The law requires that some structures, such as private dwellings, be set back at least 50 feet from the mapped trace of an active fault.

Ground Shaking

Earthquake-induced ground shaking is a common phenomenon throughout the SCVJSS area. The energy released during an earthquake is commonly presented in terms of its Richter scale magnitude (M), which only applies at the epicenter of the earthquake. In the past decade, the Los Angeles region has experienced numerous moderate to large earthquakes (i.e., greater than 5.0 on the Richter Scale). These, in addition to other seismic events, have produced significant damage from ground shaking, sometimes at locations distant from the areas of associated surface ruptures.

The ground acceleration experienced at a particular site during an earthquake may be measured in terms of a fraction or multiple of the normal gravitational acceleration (g). A qualitative assessment of the ground-shaking intensity may be presented using the Modified Mercalli intensity scale, which assigns the Roman numerals I through XII to an area based on observed earthquake damage and personal sensation of ground-shaking intensity. Mercalli designations are site specific and therefore vary from place to place for a given seismic event.

Potentially damaging ground shaking can occur, even at considerable distances from the event epicenter, depending on several factors, including:

- Earthquake Magnitude (i.e., a measure of the total energy released during the fault rupture)
- Epicentral Distance (i.e., the source to site distance)
- Subsurface Geologic Conditions Between the Source and the Site
- Subsurface Geologic Conditions at the Site

The U.S. Geological Survey (USGS) and California Institute of Technology operate hundreds of ground-motion accelerometers throughout Southern California. The data from these recording stations is publicly available. Using the existing ground acceleration data from nearby recording stations seated on similar geologic materials, the expected ground response to seismic events within the SCVJSS area can be assessed.

Liquefaction

Liquefaction in soils and sediments occurs when granular material is transformed from a solid state to a liquid state as a result of loss of grain-to-grain contact resulting from earthquake shaking. Earthquake-induced liquefaction most often occurs in areas underlain by unconsolidated, saturated sediments.

The SCVJSS area covers a large expanse of low-lying, alluvial-filled (unconsolidated granular sediment) basin area. Some areas within the basin are susceptible to liquefaction. In particular, areas adjoining rivers or river channels or areas near the shore may have a higher potential for liquefaction due to a relatively high water table proximate to unconsolidated granular sediments. Although portions of the SCVJSS service area are susceptible to liquefaction, no incidents of damage to SCVJSS facilities due to soil liquefaction have been reported to date.

Vertical Amplification

Vertical amplification occurs when earthquake energy waves are magnified in certain types of soils and topographically enclosed areas, causing locally increased ground shaking. Vertical amplification has the potential to occur within SCVJSS service areas that are underlain with younger, unconsolidated alluvial materials, especially when such materials are located in narrow canyons. These conditions result in the transmission of earthquake energy at higher shear wave amplitudes than in other materials, such as older more consolidated alluvium and competent bedrock. Areas susceptible to vertical amplification have the potential to experience more severe damage during an earthquake than do other areas. Amplification may also be caused by the reflection of shear waves back and forth in a restricted canyon, which would result in the temporary increase in shear wave size.

Tsunamis and Seiches

A tsunami (seismic sea wave) or a seiche is a fast-moving, powerful wave or series of waves generated by an earthquake, underwater landslide, or violent volcanic eruption. The size and speed of these waves can be great and can cause extensive damage to adjacent low-lying areas. Due to the 35-mile distance between the plant and the ocean as well as the significant plant elevation above sea level, there is no potential hazard from tsunamis.

Non-Seismic Geologic Hazards

Geologic hazards that could occur in the SCVJSS service area that are independent of seismic activity include landslides, subsidence, erosion, shrink/swell of soil, and loss of mineral resources. Other hazards, including volcanic and geothermal activity, do not occur in the SCVJSS service area and will not be discussed.

Landslides

Landslides occur in areas with unstable slopes. Unstable slopes could experience rapid earth movement in the form of a landslide with or without a seismic trigger. Landslides can occur as rock falls, mud and debris flow, and creep. The movement can be sudden or gradual. Areas in the service area bounded by slopes that are unstable because of erosion, improper construction, overwatering, deep weathering, or structural orientation of geologic formations could create landslide hazards for nearby SCVJSS facilities.

Subsidence

Measurable ground subsidence occurs in areas where groundwater extraction, oil production, or other mining activities have created subsurface voids, resulting in the sinking of the ground surface. There are several basins within the Transverse Ranges, including the Ventura Basin, noted for petroleum production.

Erodible Soils

Erosion is defined as the *wearing away of the land surface by running water, wind, ice, or other geological agents* (U.S. Soils Conservation Service [USSCS], 1969). Accelerated erosion occurs where natural erosion has been significantly increased by human or domestic animal activity (USSCS, 1969). High erosion potential in soils is primarily associated with loose textures (i.e., sand-size particles) and steep slopes. Loose soils can be eroded by water or wind, whereas clay soils are normally susceptible only to water erosion because of the strong cohesive forces that bind clay particles together. Generally, if wind and water conditions are the same, loose soils will erode at a faster rate than clay soils. (Marsh, 1983).

Expansive Soils

Shrink-swell is that characteristic of a soil that determines its volume change with change in moisture content. Shrink-swell in soils is measured by the volume change resulting from the shrinking soil when it dries and by the expansion of the soil as it takes up moisture (USSCS, 1969). The volume change behavior of soils is influenced by the amount of moisture change, the amount of clay in the soil, and the type of mineral (e.g., montmorillinite) in the clay. In general, soils with a high clay content shrink and swell the most, although the type of clay is an important contributing factor (USSCS, 1969). Damage to structures, such as cracking of foundations, could result from differential movements or several alternating periods of shrink and swell.

Mineral Resources

The CDMG has classified the land in the Saugus-Newhall and Palmdale regions into Mineral Resource Zones (MRZ-1 through MRZ-4) according to the presence or absence of significant sand, gravel, or stone deposits that are suitable as sources of Portland cement concrete grade aggregate (Jospeh, et al, 1987). This classification was prepared pursuant to the Surface Mining and Reclamation Act of 1975 (Article 4, Section 2761) and assists the CDMG Board in the designation of lands containing significant aggregate resources in the Los Angeles area.

The Santa Clara River Valley, which runs from near Soledad Pass, east of the Saugus-Newhall Region, into Ventura County, and a number of streams tributary to the Santa Clara River have been zoned as MRZ-2 (approximately 10 square miles). This zoning indicates that significant mineral deposits are present, or it is judged that a likelihood for their presence exists (Jospeh, et al, 1987). The Valencia and Saugus WRP facilities are within this MRZ-2 Zone. The majority of the SCVJSS service area is zoned as MRZ-3, which indicates that data is not available to assess the presence of mineral deposits.

Valencia WRP Geologic Setting

The VWRP site is located within the central portion of the Transverse Ranges Geomorphic Province. This province is characterized by east-west trending mountains and valleys. The east-west structural trend of the Transverse Ranges contains major faults such as the San Gabriel Fault, which strikes about N 60° W, and the San Andreas Fault, which in general forms the northern boundary of the San Gabriel Mountains, and folded structures oblique to that trend. The several basins within the Transverse Ranges include the Ventura Basin, which is noted for its great accumulation of sedimentary rocks and petroleum production. The site is located within the southeastern portion of the Ventura Basin in Los Angeles County. The geologic logs for two exploratory oil wells, one (Superior Oil NLF 37-8) located about 6,000 feet northeast of the VWRP and the other (General Exploration NLF 1) about 8,000 feet to the southwest, suggest that a thickness of more than 12,000 feet of sedimentary rocks underlie the site.

Tertiary Units

The tertiary geologic units that underlie the site are the Miocene Modelo Formation, the Mio-Pliocene Towsley Formation, and the Pliocene Pico Formation. These formations are composed of marine sandstone, siltstone, mudstone, and conglomerate. Age differences have been established through the use of microfossils. These formations contain significant oil reserves. Seven oil fields are situated within a 10-mile radius of the VWRP property. Exploratory oil wells in proximity of the plant have not indicated the presence of economic quantities of petroleum reserves.

Quaternary Units

The Quaternary geologic units that underlie the site from oldest to youngest are the Saugus and Pacoima Formations and Holocene alluvium and river channel deposits.

Saugus Formation

The Saugus Formation straddles the Tertiary and Quaternary periods. The Saugus Formation, a relatively young sedimentary deposit consisting mainly of terrestrial mudstones, siltstones, sandstones, and conglomerates, has been folded and/or faulted and is present as a steeply dipping strata with dips varying from about 60 to 85 degrees to the south. Strikes typically vary from about N 60° E to N 80° W. A few faults are observed in the Saugus bedrock with similar structural trends. Locally, a structural block of Saugus occurs east of the site as a topographic highland of steeply dipping Saugus strata. It is hypothesized that this hill is a block of Saugus sediments uplifted by movement along the Holser Structural (Fault) Zone. The Saugus Formation was encountered in the excavation located at the southeast end of the VWRP flow equalization basin.

Pacoima Formation

The Pacoima Formation is composed of a series of stream terrace deposits (Oakeshott, 1958). The Pacoima Formation lies on and abuts against the Saugus Formation over a major unconformity. The Pacoima Formation is considered to have been deposited in middle to early late Pleistocene time. Mapping shows the Pacoima Formation exposed on the gentle slopes west of the site and west of the Santa Clara River (Weber, 1982). Dips in the Pacoima Formation range from 20 degrees to the northeast to horizontal. The down-cutting action of the Santa Clara River has created a near vertical bluff along the western property line of the site, where an erosion protection wall has recently been constructed. Close observation of this bluff indicates that the exposed Pacoima Formation contains at least three relic paleosols (ancient soil profiles) that vary in thickness from several inches to over five feet. Between paleosols, typical rust colored, friable, medium to fine grained sands and localized silt and clay strata occur. At the top of the bluff near the aeration basin, an immature soil profile about two feet thick is exposed and appears to cross formational contacts. Some artificial fill containing pipes and other debris is locally present within and overlying the soil profile. A portion of the Pacoima unit adjacent to the outcrops of Saugus Formation at the southeast corner of the site contains a well developed paleosol that is referred to as the Post-Saugus Paleosol. Its thickness typically ranges from three to five feet. However, some borings indicate this unit may thicken to 20 feet or more and suggest "boggy" conditions. It is characterized by dark-grey to black colored sands, silts and clay that contain some lenses of peat. This paleosol acts locally as a very effective confining layer to the aquifer within the deformed Saugus Formation in the vicinity of the VWRP

flow equalization basin. This paleosol is overlain by mottled rust, light brown and grey silts and fine to medium sands containing local carbon streaks and sparse gravelly strata.

Holocene Alluvium and River Channel Deposits

These deposits of light grey to tan colored silt, sand, gravel, cobbles with a few boulders are largely restricted to the river channel on the westerly side of the site. Their regional thickness within the Santa Clara River floodplain can range from 54 to 80 feet below ground surface (Joseph, et al, 1987).

Information from near the County Line Stream Gaging Station downstream of the site suggests a total thickness in this area of about 20 feet.

Table 10-2 provides a general lithologic description of the stratigraphic units, that have been used to correlate between borings and trenches. It should be noted that the units listed in Table 10-2, except for the Post-Saugus Paleosol, are capable of storing and transmitting water.

Table 10-2
SITE LITHOLOGY

UNIT	LITHOLOGIC DESCRIPTION
Saugus Formation	Tan to light brown sandstone, siltstone, mudstone, and gravelly sandstone.
Post-Saugus Paleosol	Tan to light brown sandstone, siltstone, mudstone, and gravelly sandstone.
Pacoima Formation	Rust colored silty to slightly clayey sand, with few gravelly zones, generally very friable with local silt and clay strata.
Holocene Alluvium	Rust colored silty to slightly clayey sand, with few gravelly zones, generally very friable with local silt and clay strata.

Stratigraphy

The stratigraphic section in the vicinity of the plant property as determined from previous interactions coupled with information from borings and excavations on site is provided in Table 10-3 (Winterer and Durham, 1962; Weber, 1982).

Table 10-3
SITE STRATIGRAPHY

EPOCH	UNIT	ESTIMATED THICKNESS
Holocene	Local Stream & River Alluvium	20 ft
Lower Upper Pleistocene	Pacoima Formation	100 ft
Plio-Pleistocene	Saugus Formation	7000 ft
Pliocene	Pico Formation	1300 ft
Mio-Pliocene	Towsley Formation	1500 ft
Miocene	Modelo Formation	2000 ft

Faults

Faults with movement within the last 200 years that are of immediate concern in the Transverse Ranges' Geomorphic Province are the San Andreas, San Fernando, and the Simi-Northridge. Other faults that have had Early Holocene, or Late Quaternary offsets include the Del Valle, Holser, Oakridge, San Cayetano, San Gabriel, Santa Susanna, and Sierra Madre. Information on faults of concern in the Transverse Ranges Geomorphic Province is provided in Table 10-1.

One fault of concern to the VWRP is the Holser Fault. The site is located within the Holser Structural (Fault) Zone (Weber, 1982). The Holser Fault is considered to be an extension of the San Gabriel Fault. The Holser Fault Zone consists of several closely spaced faults that have offset Late Quaternary Formations. There is discrepancy in the literature regarding the activity of the San Gabriel and Holser Faults during the Holocene. However, geographical investigations at the VWRP have not found evidence suggesting the fault is active (i.e., movement within the last 11,000 years).

An offset of 800 feet at the base of the Saugus Formation across the fault has been reported (Winterer and Durham, 1962). The inferred sense of movement is up on the south side of the fault. However, trenching studies on the site do not indicate any fault related offsets in the younger Pacoima Formation, which directly overlies the Saugus, although some minor warping in the Pacoima Formation was observed at one location (About Earth, Inc., 1996). In addition, sand filled fractures were observed in several trenches. These features are semi-parallel to the main structural trends but do not appear to be faults as indications of offset strata are lacking. They may be related to infilling of shrinkage cracks, lurching phenomena adjacent to the river, or liquefaction of finer grained sands during earthquakes and high stands of groundwater.

Trenching studies coupled with Saugus Formation exposures on the property indicate that the southern boundary of the Holser Structural (Fault) Zone is located very close (within 30 to 50 feet) to the trace of the Holser Fault. In a review of historical aerial photographs of the VWRP site (AEI, 1996), vague lineaments were observed along the approximate concealed trace of the Holser Fault (Winterer and Durham, 1962). However, it can not be conclusively determined if the lineaments are a product of the Holser Fault or the Santa Clara River. It is possible that the fault is influencing the river alignment.

Seismicity

The site, as all of the Southern California area, is located in a seismically active region and will experience slight to very intense ground shaking as the result of movement along various active faults in the region. Among the 34 fault systems within a search radius of 60 miles, the most significant fault system is the Holser Fault, which is located beneath the site (Winterer and Durham, 1962; Weber, 1982).

The development of seismic input parameters for structural design requires knowledge of the faults surrounding the site, the magnitude of earthquakes that each fault can generate, and the attenuation or magnification of ground acceleration that may occur at a given site if an earthquake occurs along a particular fault. Research of historical earthquake events that have occurred in the general study area as well as a deterministic and probability evaluation of seismic parameters for potential on-site ground motion consideration can be readily performed with computer data bases and associated software, such as computer programs EQSEARCH, EQFAULT, and FRISK89 (Blake, 1993a, 1993b, and 1993c). Two terms used to describe earthquakes are *maximum credible* and *maximum probable.* The maximum credible earthquake (MCE) refers to the maximum earthquake that appears capable of occurring under the presently known tectonic framework. The maximum probable earthquake (MPE) refers to the maximum earthquake that is likely to occur during a 100-year interval and is often used in design of earthquake resistant structures. The maximum credible magnitudes that may impact the site due to the Holser Fault is 6.75 while the maximum probable magnitude is 6.25. The computed largest credible peak acceleration that may impact the site is 0.82g, while the computed largest probable peak acceleration is 0.748g. The computed largest credible repeatable high ground acceleration that may impact the site is 0.54g, while the computed largest probable repeatable high ground acceleration is 0.49g.

It has been indicated that the site was within a zone of concentrated ground breakage during the 1994 Northridge earthquake (The Earthquake Engineering Research Institute, 1994). The computed maximum site intensity during the time period of 1800 to 1995 is VIII (Mercalli Scale).

Hydrogeology

The project site is located in the Eastern Groundwater Basin. The major aquifer in the vicinity is the Saugus Aquifer. Groundwater occurs in confined and unconfined conditions beneath the site, and all of the geologic units described above are capable of storing and transmitting water. Economic quantities of groundwater are also contained within the Saugus Formation, where it exists locally under confined conditions. Perched groundwater is sometimes contained in the Pacoima Formation above the basal Post-Saugus Paleosol, and to much lesser extent, within the Holocene alluvium. The basal Post-Saugus Paleosol acts as an upper confining member or aquitard to groundwater contained in the Saugus Aquifer over at least the easterly portion of the site. This groundwater was encountered during previous construction at the VWRP when excavation activities removed the paleosol in the eastern portion of the site. Groundwater flow was copious, delivering 250 gallons per minute (equilibrium flow after storage depletion) over several months, and continues to deliver 250,000 gallons per day at present. Static depths to groundwater in the eastern portion of the site were measured to range from 18 to 27 feet below ground surface in 1989-1990. A recent geotechnical investigation measured comparative depths to groundwater on February 17, 1995, between a point 20 feet east of the Santa Clara River bluff and a horizontal distance to surface water in the river. These measurements showed similar depths to groundwater in the western portion of the site, 30.5 feet below the top of the bluff.

IMPACTS AND MITIGATION MEASURES OF THE 2015 PLAN ALTERNATIVES

Methodology and Assumptions for Impact Analysis

The impacts in this section were evaluated based on standard geologic and soil practices and geotechnical studies conducted at the VWRP. This impact analysis is based on the assumption that all structures and facilities will be constructed according to UBC standards for Seismic Risk Zone IV to minimize the potential for injury caused by structural failure from primary and secondary hazards during an earthquake.

Criteria for Determining Significance

The significance criteria of this analysis were developed from Appendices G and I of the State CEQA Guidelines and from professional practice. The project would result in a significant impact if it would:

- Cause substantial flooding, erosion, or siltation.
- Expose people, structures, or property to major geologic hazards such as earthquakes, landslides, mudslides, or ground failure.
- Result in unstable earth conditions or changes in geologic substructure.
- Result in disruptions, displacements, compaction, or overcovering of soil.
- Result in a change in topography or ground surface relief features.
- Result in an increase in wind or water erosion of soils, either onsite or offsite.
- Be located in an Earthquake Fault Zone, a known active fault zone, or an area characterized by surface rupture that might be related to a fault.
- Be located in substrate consisting of material that is subject to liquefaction or other secondary seismic hazards in the event of ground shaking.
- Display evidence of static hazards, such as having the potential for landsliding or having excessively steep slopes that could result in slope failure.
- Be located in soil characterized by shrink-swell potential that might result in deformation of foundations or damage to structures.

Impacts that do not meet one or more of these criteria are considered less than significant.

The following discusses the potential impacts on the site based on CEQA guidelines and professional practices.

The Recommended Project

VWRP Expansion Construction Impacts

Impact: *Potential for Increased Short-Term Erosion During Construction at the VWRP.* During construction of new facilities at the VWRP, earth moving operations could increase the potential for short-term erosion. The storage and movement of soil greatly affects the amount of erosion that occurs. If soil is improperly stored or transported, wind and water can erode the soil. Although the VWRP site is nearly level, there would be an increase in short-term wind and water erosion and an increase in sedimentation rates associated with construction. Construction of proposed facilities would cause minor changes to topography. Proper design and precautions taken during construction and operation of facilities will prevent any potential impacts.

Mitigation Measure 10-1: *Prepare and Implement an Erosion Control and Rehabilitation Plan.* The Districts will develop and implement an erosion control and rehabilitation plan to reduce the effects of construction activities and proposed facilities on increased wind and water erosion rates. This plan would be implemented through the Storm Water Pollution Prevention Permit, which is discussed in Chapter 17, Water Quality.

VWRP Expansion Operations Impacts

Impact: *Potential for Structural Damage and Injury Resulting from Siting the VWRP Expansion in Seismic Risk Zone IV.* Movement on the Holser Fault could cause extensive damage via ground rupture and ground shaking. Displacement on nearby faults, such as the San Gabriel Fault, could also cause extensive ground shaking.

Mitigation Measure 10-2: *Implement Appropriate Seismic Engineering Considerations for Facilities.* The Districts, at a minimum, will build all structures in compliance with the requirements of the State of California and the UBC; these standards were developed to minimize exposure of people, structures, or property to geologic hazards. Any additional recommendations made in supplemental geologic studies currently underway will be incorporated into building design to maximize structural integrity of buildings during an earthquake. Future proposed critical structures identified as straddling the Holser Fault will be relocated, if possible, or strengthened to withstand the effects of ground shaking resulting from an MPE.

Impact: *Potential for Structural Damage Resulting from Siting the VWRP Expansion on Ground Subject to Liquefaction.* The phenomenon of liquefaction occurs when the depth to groundwater is less than 30 feet, and fine-grained non-cohesive materials are subjected to strong earthquake excitation. These conditions are present on the property. Sand filled dikes, observed within the Pacoima Formation, suggest that historically, the site may have experienced at least low level liquefaction.

Mitigation Measure 10-3: *Implement Appropriate Liquefaction Engineering Considerations for Facilities.* Districts Nos. 26 and 32 would implement appropriate engineering or construction siting considerations. Such consideration could include, but would not be limited to, the following:

- Constructing thicker pavements or slabs for facilities.
- Relocating facilities to avoid construction on soils with liquefaction potential.
- Pressure grouting of high-risk soil horizons.
- Excavating soils with high liquefaction potential and replacing them with engineering-quality fill.
- Constructing pore pressure relief drains to reduce liquefaction potential.

Implementing appropriate engineering or siting considerations would reduce the effects of construction on ground subject to liquefaction to a less than significant level.

Impact: *Potential for Structural Damage Resulting from Siting the VWRP Expansion on Ground Subject to Subsidence or on Expansive Soils.* The extraction of groundwater, gas, oil, or geothermal energy has not caused land subsidence in the vicinity of the VWRP. The oxidation of peat observed in the Post-Saugus Paleosol has not caused measurable settlements. Hydrocompaction problems are common within the watershed of the upper Santa Clara River, however, no collapsible soils have been identified during the geotechnical investigations performed on site to date. Construction of proposed facilities will involve excavation and backfilling, however, proper design and construction practices should prevent any subsidence. Expansive soils are not known to occur at the VWRP site. Therefore, this impact is considered less than significant.

Mitigation: No mitigation is required.

Impact: *Potential for Loss of Mineral Resources Resulting from the VWRP Expansion.* Loss of mineral resources may result from a loss of access, deposits covered by changed land use conditions, or zoning restrictions. The size of the proposed expansion facilities area is insignificant when compared to the total area of potential aggregate resources, estimated to be 10 square miles. Therefore, it is believed that the loss of mineral resources, if any, due to the expansion of the VWRP would be less than significant.

Mitigation: No mitigation is required.

Impact: *Potential for Exposure to Tsunami, Seiche, or Volcanic Activity.* Due to the 35-mile distance between the plant and the ocean as well as the significant plant elevation above sea level, there is no potential hazard from Tsunamis. There are no large bodies of standing water in the immediate vicinity which could have seiches develop and cause failure of a structure and/or water damage. Within the watershed of the Santa Clara River there are two reservoirs, which are part of the Los Angeles Aqueduct System, Bouquet Canyon Reservoir, capacity 36,505 AF, and Dry Canyon Reservoir, capacity 751 AF. Should either of these structures fail as a result of an earthquake, or other causes, flooding could occur at the site. St. Francis Dam (capacity 38,000 AF), that failed in 1928, is within the same watershed area. Castaic Reservoir, capacity 350,000 AF, is located on Castaic Creek, which is tributary to the Santa Clara River. They join about 1.5 miles down stream of the plant property. In the event of a catastrophic failure of Castaic Dam a back water surge could impact the site. The plant is not located near an area of potential volcanic hazard (CDMG, 1973). Volcanic ash, from prehistoric volcanic activity in the Mono-Bishop area, has been identified in Ventura County, some 30 to 40 miles west of the site. Due to the low likelihood of these events occurring, this impact is considered less than significant.

Mitigation: No mitigation is required.

SWRP and VWRP Upgrade Construction Impacts

Impact: *Potential for Increased Short-Term Erosion During Construction at the SWRP and VWRP.* During modification of existing facilities at the SWRP and VWRP, minor grading may be necessary, increasing the potential for short-term erosion. Although the SWRP and VWRP sites are nearly level, there could be an increase in short-term wind and water erosion and an increase in sedimentation rates associated with construction. Construction of proposed facilities could cause minor changes to topography. However, proper design and precautions taken during construction and operation of facilities will prevent any potential impacts. Therefore, this impact is considered less than significant.

Mitigation: No mitigation is required.

SWRP and VWRP Upgrade Operations Impacts

Impact: *Potential for Structural Damage and Injury Resulting from Siting the SWRP and VWRP in Seismic Risk Zone IV.* Movement on the Holser Fault could cause extensive damage via ground rupture and ground shaking. Displacement on nearby faults, such as the San Gabriel Fault, could also cause extensive ground shaking.

Mitigation Measure 10-2: *Implement Appropriate Seismic Engineering Considerations for Facilities.* This mitigation measure is described previously under *§VWRP Expansion Operations Impacts.*

Impact: *Potential for Structural Damage Resulting from Siting the SWRP and VWRP on Ground Subject to Liquefaction.* The phenomenon of liquefaction occurs when the depth to groundwater is less than 30 feet, and fine-grained non-cohesive materials are subjected to strong earthquake excitation. These conditions are present at the SWRP and VWRP properties. Sand filled dikes, observed within the Pacoima Formation, suggest that historically, the WRP site may have experienced at least low level liquefaction.

Mitigation Measure 10-3: *Implement Appropriate Liquefaction Engineering Considerations for Facilities.* This mitigation measure is described previously under §*VWRP Expansion Operations Impacts*.

Impact: *Potential for Structural Damage Resulting from Siting the SWRP and the VWRP on Ground Subject to Subsidence or on Expansive Soils.* The extraction of groundwater, gas, oil, or geothermal energy has not caused land subsidence in the vicinity of the SWRP and VWRP. The oxidation of peat observed in the Post-Saugus Paleosol has not caused measurable settlements. Hydro-compaction problems are common within the watershed of the upper Santa Clara River, however, no collapsible soils have been identified during the geotechnical investigations performed on site to date. Construction of proposed facilities will involve excavation and backfilling, however, proper design and construction practices should prevent any subsidence. Expansive soils are not known to occur at the SWRP and VWRP sites. Therefore, this impact is considered less than significant.

Mitigation: No mitigation is required.

Impact: *Potential for Exposure to Tsunami, Seiche, or Volcanic Activity.* Due to the 35-mile distance between the plant and the ocean as well as the significant plant elevation above sea level, there is no potential hazard from Tsunamis. There are no large bodies of standing water in the immediate vicinity which could have seiches develop and cause failure of a structure and/or water damage. Within the watershed of the Santa Clara River there are two reservoirs, which are part of the Los Angeles Aqueduct System: Bouquet Canyon Reservoir (capacity 36,505 AF) and Dry Canyon Reservoir (capacity 751 AF). Should either of these reservoirs fail as a result of an earthquake, or other causes, flooding could occur at the sites. St. Francis Dam (capacity 38,000 AF), which failed in 1928, is within the same watershed area. Castaic Reservoir (capacity 350,000 AF) is located on Castaic Creek, which is tributary to the Santa Clara River. In the event of a catastrophic failure of Castaic Dam a back water surge could impact the sites. The plants are not located near an area of potential volcanic hazard (CDMG, 1973). Volcanic ash, from prehistoric volcanic activity in the Mono-Bishop area, has been identified in Ventura County, some 30 to 40 miles west of the sites. Due to the low likelihood of these events occurring, this impact is considered less than significant.

Mitigation: No mitigation is required.

No Project Alternative

No geologic or soils impacts would occur under the No Project Alternative.