3.9 Geology and Soils

3.9.1 Introduction

This section provides an overview of the geology and soils within the study area and an analysis of impacts to geology and soils associated with each of the components. Geology and soils includes seismic hazards (and related issues, such as subsidence, liquefaction, and tsunamis), grading, and erosion/sedimentation and slope stability. The significance of potential geologic impacts is analyzed for each of the four Alternatives and the No Project Alternative. Where applicable, mitigation measures to reduce the impacts associated with each Alternative are provided.

3.9.2 Environmental Setting

The following sections describe existing geologic conditions for the overall area of the Alternatives, as well as site-specific geology and soil information for the components.

3.9.2.1 General Setting

This section describes the geology of the HSA and the geological hazards that have the potential to occur in the area.

Geology

The area in which the Alternatives would be implemented extends over widely varying physiographic and geologic terrains throughout the City and County of Los Angeles. The northern and central portions of the City of Los Angeles lie within the Transverse Ranges Geomorphic Province, so named because the mountains in the area, and geologic structures that define them, have an east-west orientation. This east-west orientation is transverse to the generally dominant northwestern orientation of most of the mountains and valleys within Southern California. The northern portion of the City of Los Angeles includes the San Fernando Valley and portions of the surrounding Santa Susana Mountains, San Gabriel Mountains and Verdugo Mountains. The San Fernando Valley contains thick deposits of alluvium from the surrounding mountains. The southern boundary of the Transverse Ranges Geomorphic Province trends along the south side of the Santa Monica Mountains.

The Los Angeles Basin and downtown Los Angeles are south of the Santa Monica Mountains and within the Peninsular Range Geomorphic Province. This province trends northward along the southern portion of California and is characterized by northwest trending faults and other geologic structures. The province contains late Paleozoic to Recent formations and Mesozoic-age intrusive rocks.

Soil and bedrock deposits generally are grouped in accordance with age, composition, and other geologic characteristics. These groups of deposits are referred to as geologic units, or more formally as geologic formations. The Los Angeles area has very diverse geology, which includes many informal geologic units and geologic formations. Some of these units have been grouped in different ways by different geologists working in the area over the years and this has led to varying depictions of the units on geologic maps. For the purpose of this EIR, some of the more prevalent geologic units and formations that occur in the HSA are described below.

Artificial Fill. The Los Angeles area has undergone extensive development and urbanization and, as a result, many areas exist where the soil has been cut and filled. Areas that have received significant (generally greater than 5 vertical feet) amounts of fill soil can be shown on geologic maps as fill deposits. These deposits, especially older, pregrading code fill deposits, can commonly be relatively loose and subject to consolidation and settlement.

Numerous distinct deposits of artificial fill are present along the banks of the major stream and river channels, along the shoulders of roadways, and in various isolated areas where soil was placed to raise the grade. As shown by older topographic maps (dating back to 1906) and aerial photographs (dating back to 1928), fill was placed in low-lying areas to level the land during construction of streets, bridges, railroad crossings and buildings. For the most part, fill was typically placed in areas, such as along the banks of the Los Angeles River and secondary drainages for road and building construction.

Much of this grading and fill placement predates modern methods of fill placement, certification and documentation. These older fill deposits might not have been compacted at the time of placement. Record review at the City of Los Angeles Department of Building and Safety reveals that fill placement from structures constructed after 1964 was sometimes documented. Other fill deposits that lie within street rights-of-way, such as at various points along San Fernando Road, predate modern grading practices and were likely not compacted during placement. In general, fill deposits along the alignment were generated at different times and from different sources, and are, therefore, variable in soil type. In general, fill soils are brownish in color and consist of silty sands with gravel. However, fill soils in the area range from clayey silt and silty clay, to angular gravel with sand.

Recent Alluvium. Holocene (or Recent) alluvial deposits of the modern stream channels, such as along the Los Angeles and San Gabriel Rivers, and on the alluvial fans and floodplains, are among the youngest surficial deposits in the Los Angeles area. Recent alluvial deposits as used here describe those stream and river deposits that are less than about 10,000 years old. The Recent alluvium encountered in the San Fernando Valley and Los Angeles Basin areas can be generally characterized as moderately dense mixtures of silt, sand and gravel with lesser amounts of clay. Alluvial deposits along the north side of the Santa Monica Mountains, the Los Angeles Narrows, Ballona Gap, and across the Los Angeles Basin toward the Los Angeles Harbor were deposited by Los Angeles River fluvial system. Second order stream deposits occur throughout the area in the upper reaches of coalescing alluvial fans and along the flanks of the hills and mountains. Subsurface exploration data generally reveal that the alluvial deposits consist predominantly of silty sands, poorly graded to well-graded sands, and gravelly sands. These granular sediments were mostly deposited in the channels and along the banks of streams and rivers that feed into the alluvial basins. Lesser deposits of silt and clayey silt can be found in floodplain areas, in low areas subject to ponding, and as the upper part of fining upward granular deposits.

Previous subsurface exploration and laboratory testing in the Los Angeles Narrows areas provides specific sedimentary information. These studies show the alluvial sands typically consist of mixtures of silt, sand, gravel, cobbles/boulders, and/or clay, and occasional organic fragments. The gravels are described as very dense with varying amounts of sand, silt, and/or cobbles/boulders. At various locations, the coarse-grained soil is interlayered with fine-grained soils categorized as silts and clays. The silts are generally described as loose to very dense with varying amounts of sand and/or clay, and occasional organic fragments.

Older Alluvium. The older (generally late Quaternary age) alluvial soils are similar to the overlying younger alluvial soils described above. Older alluvial deposits, including nonmarine terrace deposits, are exposed in uplifted areas around the margins of the San Fernando Valley and Los Angeles Basin. Boulders of hard intrusive rock are present in the young and older alluvial soils. Boulders are present especially near drainage headland areas near exposures of intrusive rocks, such as along the toe of the Verdugo and San Gabriel Mountains, and in some of the major stream and river channels such as in the Los Angeles Narrows. Generally, such boulders would occur within the gravel beds but, in rare cases, isolated boulders have been observed.

Lakewood Formation and San Pedro Formation. The Lakewood Formation of upper Pleistocene age and the San Pedro Formation of lower Pleistocene age are widely exposed around the margins of the Los Angeles Basin. The San Pedro Formation is generally better defined in the subsurface on the basis of its importance as a source of fresh water. The San Pedro Formation in the Los Angeles Basin reaches thicknesses of several thousand feet (Yerkes et al., 1965) and includes many of the major groundwater aquifers in the basin (such as the Lynwood, Silverado, Sunnyside, Exposition, and Gage aquifers) (Thomas et al., 1961).

Much of the late Quaternary deposits present in the Los Angeles Basin have been grouped together and mapped as the Lakewood Formation. The formation includes "terrace deposits," Palos Verdes Sand, Sunny Hills Formation, and other unnamed upper-Pleistocene deposits (both marine and continental). The grouping of deposits within the Lakewood Formation served to help define the hydrogeology of the Los Angeles Basin. The Lakewood Formation designation is now outdated and the U.S.

The Lakewood Formation deposits along the NEIS alignment are generally nonmarine and similar to the overlying alluvial deposits. The upper Pleistocene alluvial deposits in the lower reach of the NEIS tunnel, as defined by subsurface exploration thorough drilling, consists predominantly of silty sands, poorly graded to well-graded sands, and lesser gravelly sands and gravel. Granular soils within the Lakewood Formation commonly have a greenish gray or olive color.

Along the north margin of the Los Angeles Basin, a distinct sequence of fine-grained deposits of silt, clay and silty clay exists below the typical granular older alluvium in the exploratory borings. These fine-grained deposits are gray to blue gray and contain low-angle laminations.

Fernando Formation. The Fernando Formation underlies the fluvial deposits of the Los Angeles River and alluvial fan deposits along the southern foothills of the Elysian Park and Repetto Hills. This formation is inclusive in upper Pliocene marine strata exposed in many areas around the margins of the Los Angeles Basin.

The unit, as encountered in exploratory borings drilled in the southernmost portion of the NEIS tunnel alignment, is soil-like in consistency. The formation consists of stiff olive-colored silt and clay. Fragments of thin broken shells several millimeters across were observed in some of the olive silt samples. The observed shell debris was generally poorly organized and bedding was difficult to discern.

Puente Formation. The Miocene-age Puente Formation underlies the Elysian Park Hills and the western Repetto Hills in the area of the NEIS alignment. The middle member is 750 to 1,500 meters (m) thick and is thicker in the north. It is a medium- to coarse-grained, feldspathic sandstone interbedded with sandy siltstone and diatomaceous siltstone with lenses of pebble conglomerate (Dibblee, 1989).

Topanga Formation. Bedrock of the Topanga Formation has been mapped at many locations within the Santa Monica Mountains and in the northern portion of the Verdugo Mountains. The formation consists mostly of interbedded gray to tan sandstone and gray micaceous claystone. Locally, it contains lenses of pebbly sandstone and pebble-cobble conglomerate. A more significant conglomerate unit is present in the hills in the northern portion of the NEIS II corridor area near the Los Angeles Zoo. The formation locally contains basaltic volcanic rocks.

Intrusive Rocks. Mesozoic-age igneous intrusive rocks are exposed in the hillside areas on both the east and west sides of the Los Angeles Narrows along the NEIS II corridor. Igneous rocks form from the solidification of molten material that originates in or below the crust of the earth. The composition depends on the kind of molten material (magma) from which it crystallizes, and its texture depends on the rate at which the material cools. Slow rates of cooling promote larger crystal-sized rock (granodiorite, quartzdiorite), whereas fast-cooling rates produce fine crystallized rock (basalt).

Santa Monica Slate. The Jurassic-age Santa Monica Slate, which underlies a great portion of the eastern Santa Monica Mountains, is a low-grade metamorphosed slate. The deep marine deposit formed within a subduction zone. Having a much longer and more complex structural history than the overlying Tertiary deposits, it is highly fractured and sheared. The slate is distinctly foliated with foliation parting surfaces at an orientation commonly subparallel to relict bedding. This structural character leads to unpredictable slope stability. Landslides can occur along shears, joints, foliation, or a combination of these.

Chico Formation Chatsworth Formation. The Chico Formation (Chatsworth Formation of the Simi Hills) is an Upper Cretaceous, mostly marine clastic sedimentary sequence that occurs in the Santa Monica Mountains and Simi Hills. The deposits consists largely of well-sorted sandstone and interbedded shale with less abundant sandy conglomerate and poorly sorted pebble and cobble conglomerate.

Seismic Faults and Other Geological Hazards

The City of Los Angeles lies relatively close to the San Andreas fault, a transform fault boundary that marks the juncture between the North America Tectonic Plate and the Pacific Tectonic Plate. Movement on the San Andreas fault has created a complex geologic terrain over the 20 to 30 million years since it has been active Figure 3.9-1 illustrates active and potentially active faults in the Los Angeles area.

The San Andreas fault is also the boundary between the oceanic plate on the west and the continental plate on the east. The section of the San Andreas fault nearest Los Angeles trends at an angle to that of the fault to the north and south and has been termed "The Big Bend" that causes a component of north-south convergence in the Southern California area. Numerous geologic units have been faulted against each other, forming mountains and valleys. Many faults in the Southern California area trend northerly, similar to the San Andreas fault; others within the Transverse Ranges Geomorphic Province trend east-west. It is generally accepted that the Transverse Range fault system was formed as a result of transpressional forces (both lateral and compressional) along the "Big Bend."

The seismicity of Southern California is dominated by movements on the intersecting northwest-southeast trending San Andreas fault system and the east-west trending faults of the Transverse Ranges fault system. The Los Angeles Basin is located south of the intersection of these two systems. Both fault systems respond to strain by fault movement and deformation of the rocks. This fault movement is driven by the relative motions of the Pacific and North American Tectonic Plates. The strain is relieved by faulting on the San Andreas and related faults and by displacement on faults in the Transverse Ranges. Geologically young faults are present in the Transverse Ranges and the Los Angeles Basin and are classified as historically active, active, potentially active, or inactive, based on the following criteria:

- *Historically Active:* Faults that have generated earthquakes accompanied by evidence of movement during historic time (approximately the last 200 years), and faults that exhibit creep.

- *Active:* Faults that show geologic evidence of movement within Holocene time (approximately the last 11,000 years).
- *Potentially Active:* Faults that show geologic evidence of movement during the Quaternary period (approximately the last 2,000,000 years). Such faults might have remained active during Holocene time, but direct evidence for continued activity is not available.
- *Inactive:* Faults that do not show evidence of movement during all of Quaternary time or longer.

Active faults within the HSA include the Elysian Park thrust fault, Raymond Hills fault and the Hollywood fault, the Northridge Hills fault, the Newport-Inglewood fault, and the San Fernando fault.

An earthquake is classified by the amount of energy released, which traditionally has been quantified using the Richter scale. This is a logarithmic scale wherein each whole number increase in Richter Magnitude represents a tenfold increase in the wave magnitude generated by an earthquake. Earthquakes of Richter Magnitude 6.0 to 6.9 are classified as moderate, those between 7.0 and 7.9 as major, and those of 8.0 or higher as great.

Active and Potentially Active Faults in the Los Angeles Basin

Elysian Park Fold and Thrust Belt. The Elysian Park and Repetto Hills have been interpreted as a fault propagated fold associated with a seismically active blind thrust fault, the Elysian Park thrust (Davis et al., 1989; Hauksson and Jones, 1989). The axial trace of this fold structure extends approximately 12 miles through the Elysian Park-Repetto Hills from about Silverlake on the west to the Whittier Narrows on the east. The fold and thrust belt is expressed at the ground surface by elongate low-lying bedrock ridges protruding through the basin sediments.

The subsurface faults that create the structure are not exposed at the surface. Such faults are termed "blind thrust faults," which are faults that do not, and never have, extended upward to the surface of the earth. These faults usually are associated with axial regions of folds. At the core of these folds are low-angle, blind thrust faults rising off a basal detachment surface. The regional detachment surface coincides with the observed base of seismicity at a depth 10 to 13 km (7 to 8 miles) below the basin (Hauksson, 1990). Because the fault is buried, it is not considered a hazard in terms of surface fault rupture. However, it can generate moderate to strong ground motion, as evidenced by the 1987 Whittier Narrows earthquake, as well as ground surface deformation.

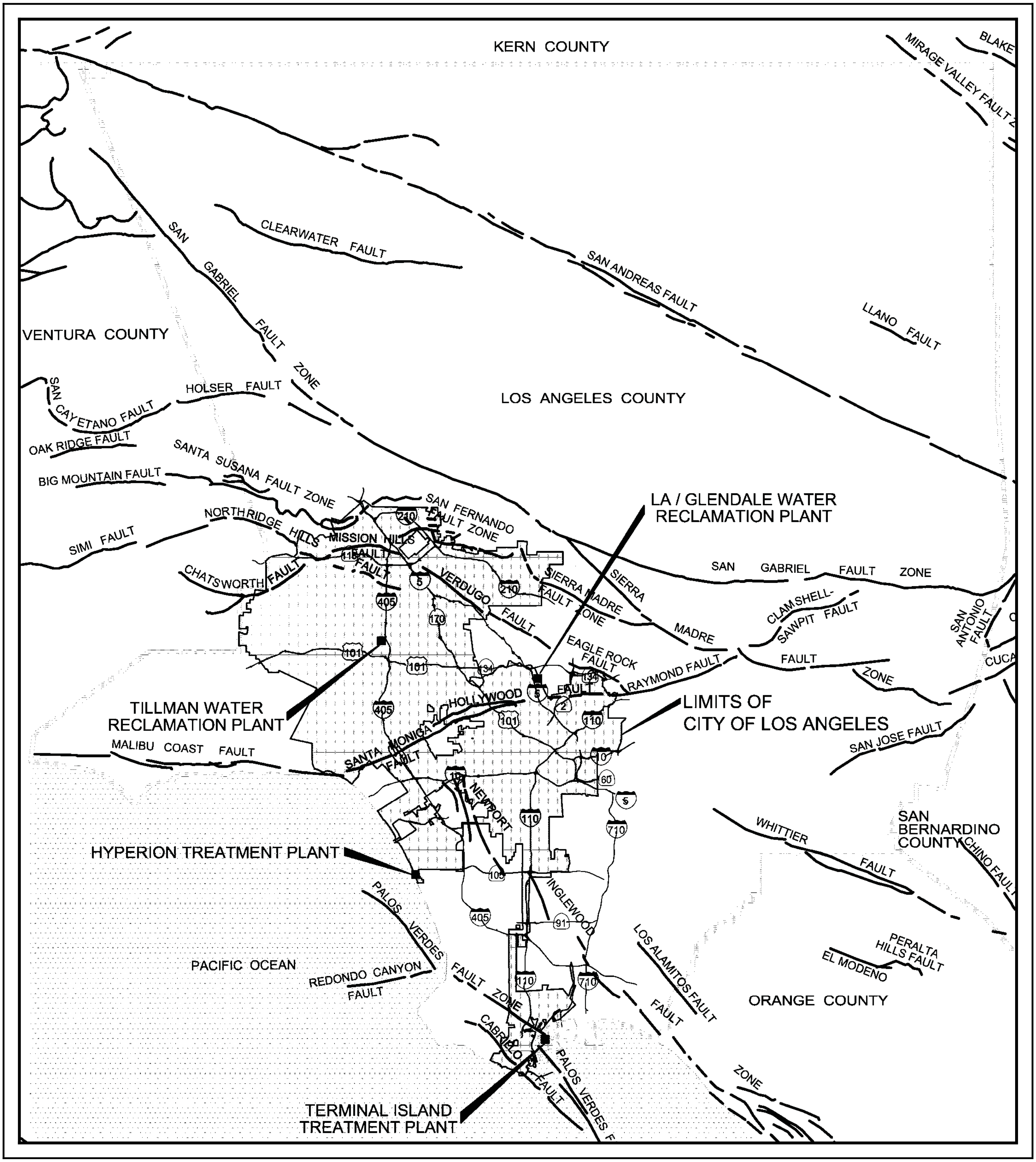

Figure 3.9-1
Faults in the Los Angeles Area

Source: City of Los Angeles
Bureau of Engineering

Integrated Resources Plan
Environmental Impact Report

Hollywood-Raymond Fault. The Hollywood-Raymond fault comprises the eastern extent of the Santa Monica Mountains Frontal Fault System and extends from the area of western Hollywood eastward to the City of Pasadena. The fault trends east-west across the Los Angeles Narrows where it crosses the various proposed alignments of the NEIS II. These faults are part of the Raymond-Hollywood-Santa Monica fault system postulated to have mechanical connections, thus providing for a greater potential fault rupture plane and associated large magnitude earthquake (Dolan, 2004).

The eastern part of the Hollywood fault zone extends along the base of the Santa Monica Mountains, near Los Feliz Boulevard. From there, the fault trends eastward across the alluvial deposits of the Los Angeles River in the Atwater area. The fault continues across the alluvial deposits of the Los Angeles River in the Atwater area. The geomorphic expression of the Hollywood fault cannot be traced across the floodplain of the Los Angeles River and into the hills northeast of the River. Subtle linear ridges on the floodplain east of the river might be fault related in origin (Weber et al., 1980). Gravity data also indicate that the bedrock expression of the fault extends eastward across the river toward the Raymond fault (Chapman and Chase, 1979).

The Raymond Hills fault zone is located east of the Los Angeles Narrows and is generally considered an extension of the Hollywood fault. The Raymond fault is a high-angle reverse fault, which within the Eagle Rock area forms a subsurface barrier restricting groundwater movement and trapping artesian water north of the fault and beneath alluvial sediments.

If the Hollywood fault alone were to rupture, it could generate a moment magnitude (Mw) 6.6 earthquake (Dolan, 2004). This moderate magnitude earthquake could generate surface displacement with an average slip of 0.4 m and an average maximum slip 0.75 m (approximately). It is concluded that potential larger magnitude earthquakes, which would be generated if more of the fault system were to rupture, must be considered (Dolan, 2004). If for example, the Hollywood and Santa Monica faults ruptured together, a Mw 7.0 earthquake could be generated. The probability of such a large event is difficult to determine because of the lack of field evidence. Dr. Dolan indicates that large earthquake events would likely occur on the order of only once every 1,000 years. The last known surface-rupture event of the Raymond fault was about 2,000 years ago. Other small earthquake events without accompanying surface rupture could be attributed to the Raymond fault. One larger earthquake event in 1855 (see Table 3.9-1) could be attributed to the Raymond fault; however, it was poorly documented by historical notes and could have resulted from movement of an offshore fault.

These estimated maximum ground displacement values are deterministic in nature; they are determined in consideration of maximum earthquake magnitudes without consideration of the likelihood of the earthquake event. Thus, these values are based on conservative (i.e., worst-case) scenarios that contrast with the seismic design practice of today, which relies on probabilistic evaluations for ground motions.

Benedict Canyon Fault. The Benedict Canyon fault strikes northeast across the Santa Monica Mountains from the area of Sepulveda Boulevard at Sunset Boulevard, where it is exposed in Cretaceous-age sandstone, to the foothills along the north flank of the Santa Monica mountains area, east of Universal Studios. The fault varies from very sharp and well defined where it clearly offset Miocene sedimentary and volcanic units, to more broad and diffuse where it trends through the Jurassic-age Santa Monica Slate. The mapped trace of the Benedict Canyon fault extends northward from the Santa Monica Mountains into the southeastern San Fernando Valley. This fault is considered inactive (Jennings, 1994).

San Fernando Fault. The San Fernando fault was mapped from surface rupture following the 6.6 M 1971 earthquake and has been zoned as an Alquist-Priolo fault by the CGS. The fault has many steps and has been delineated into several segments. It trends from the area of Big Tujunga Canyon northward around the edge of the San Fernando Valley. The San Fernando fault has a left lateral/reverse sense of movement and forms frontal faults bounding the southern margin of the Santa Susana Mountains and the portion of the San Gabriel Mountains west of Big Tujunga Canyon. Surface rupture occurred along the Tujunga, Sylmar, and Mission Wells segments of the San Fernando fault zone during the 1971 earthquake.

Verdugo Fault. The Verdugo fault trends along the west side of the Verdugo Mountains and has been recognized by the occurrence of groundwater barriers. The fault forms a groundwater cascade where it separates the Sylmar Basin from the San Fernando Valley. A series of sharp photo lineaments is in the gentle alluvial apron along the west flank of the Verdugo Mountains (Weber et al, 1980). These lineaments indicate potential Holocene movement on the fault, but this is inconclusive and the fault has not yet been zoned as an active fault by the state. The fault is classified as a potentially active fault. A fault rupture hazard zone has been designated by the City of Burbank for the Verdugo fault.

Ground Shaking

Table 3.9-1 lists major historic earthquakes that have affected the Los Angeles area and the known or probable causative fault. Potentially damaging earthquakes could also occur on other known or unknown faults in the Southern California area. It is important to note that earthquake activity from unmapped subsurface faults is a distinct possibility. The 1987 Whittier Narrows magnitude 5.9 earthquake and the 1994 Northridge earthquake are examples of such events.

Table 3.9-1. Historic Earthquakes
Integrated Resources Plan EIR

Regional Location	Date	Earthquake Magnitude (Richter)	Modified Mercalli Intensity	Causative Fault	Aftershocks Reported
Offshore Orange County	Dec. 8, 1812	6.9	VIII-IX	Newport-Inglewood	--
Los Angeles	July 11, 1855	6	VIII	Raymond	--
Fort Tejon	Jan. 9, 1857	8+	X-XI	San Andreas	--
Newport-Inglewood	Mar. 11, 1933	6.3	IX	Newport-Inglewood	Yes
Newport-Inglewood	Nov. 14, 1941	5.4	VII+	Newport-Inglewood	--
San Jacinto	Oct. 21, 1942	6.6	VII	San Jacinto	--
Bakersfield	July 21, 1952	7+	XI	White Wolf	--
San Fernando	Feb. 9, 1971	6.6	IX	San Fernando	Yes
Whittier Narrows	Oct. 1, 1987	5.9	VIII	Elysian Park	Yes
Sierra Madre	June 28, 1991	5.8	VII(?)	Sierra Madre	--
Northridge	Jan. 17, 1994	6.8	IX	Previously Unknown	Yes

Source: Yerkes, 1985

The intensity of earthquake-induced ground motion is a function of the magnitude of the earthquake, distance from the epicenter, and the materials through which the earthquake waves travel. The intensity of earthquake-induced ground motion can be described using the Modified Mercalli Scale, which is a subjective numerical index describing the severity of an earthquake in terms of its observed effects upon humans, man-made structures, and on the surface of the earth surface. Based on past studies, it is reasonable to expect that Modified Mercalli Intensities of about VII to VIII can be expected in the vicinity of the HSA.

The computer program EQFault (Version 3.0) was used to create a listing of earthquake faults in the vicinity of the HSA, as shown in Table 3.9-2.

Table 3.9-2. Maximum Moment Magnitudes of Earthquakes on Local Faults in Southern California
Integrated Resources Plan EIR

Fault Name	Maximum Earthquake Magnitude (Mw)
Hollywood	6.4
Verdugo	6.7
Raymond	6.5
Sierra Madre	7
Santa Monica	6.6
Sierra Madre (San Fernando)	6.7
Northridge (E. Oak Ridge)	6.9
Newport-Inglewood (L.A. Basin)	6.9
Elysian Park Thrust	6.7
Compton Thrust	6.8
San Gabriel	7
Malibu Coast	6.7
Santa Susana	6.6
Clamshell-Sawpit	6.5
Palos Verdes	7.1
Whittier	6.8
Holser	6.5
Anacapa-Dume	7.3
San Jose	6.5
Oak Ridge (Onshore)	6.9
Simi-Santa Rosa	6.7
San Andreas – Mojave	7.1
San Andreas – 1857 Rupture	7.8
Cucamonga	7
Chino-Central Avenue (Elsinore)	6.7
San Cayetano	6.8
San Andreas – Carrizo	7.2
Santa Ynez (East)	7
Elsinore-Glen Ivy	6.8
Newport-Inglewood (offshore)	6.9
San Andreas – San Bernardino	7.3
San Andreas – Southern	7.4
San Jacinto-San Bernardino	6.7
Ventura – Pitas Point	6.8
Cleghorn	6.5

Liquefaction

Liquefaction is a phenomenon in which sediments below groundwater temporarily lose their shear strength during periods of strong, earthquake-induced, ground shaking. Saturated loose sands and silty sands within 50 feet of the ground surface are most susceptible to liquefaction. Liquefaction-related phenomena include subsidence, lateral spreading, and sand boils.

The California Department of Conservation, Division of Mines and Geology (CDMG), now referred to as the California Geological Survey (CGS) Seismic Hazard Maps of the Los Angeles area indicate that many areas are potentially subject to liquefaction. These areas are located predominantly in the valleys where relatively high groundwater has been reported. The locations of these seismic hazard zones within the City of Los Angeles are shown in Figure 3.9-2.

The potential for liquefaction is dependent on the groundwater levels. Groundwater levels in alluvial valley areas of Los Angeles are an important source of drinking water and are both raised by natural and controlled recharge from rainwater runoff and lowered by pumping from groundwater drinking wells. Liquefaction sometimes occurs during a large earthquake, usually when the water table is within about 30 feet of the ground surface. Strong ground shaking causes the saturated soil to temporarily behave as a thick liquid, which removes support for foundations and can damage overlying structures.

Lateral Spreading

Seismically induced lateral spreading involves primarily lateral movement of earth materials from ground shaking. Lateral spreading occurs in conjunction with liquefaction and loss of soil strength in near-level topography. It differs from slope failure because complete ground failure involving large movement does not occur, based on the relatively smaller gradient of the initial ground surface. Lateral spreading is demonstrated by near-vertical cracks with predominantly horizontal movement of the soil mass involved.

Such phenomena can occur widely across the Los Angeles area, with a location depending on the source of the earthquake and the nature of the generated seismic ground motions. Lateral spreading in conjunction with liquefaction was observed in the Northridge area during the Northridge earthquake and in the Sylmar area during the San Fernando Earthquake.

Ground Lurching

Ground lurching is essentially a dynamic phenomenon where the sudden shift of the ground during an earthquake causes sudden, high, ground velocities and concomitant accelerations. The ground can lurch a meter or more unidirectionally within 1 to 3 seconds. It can also occur on slopes and ridge tops where seismic shaking can cause lateral movement of the ground and result in rock or soil fracturing. Ridge-top lurching was observed in the hills and mountain slopes in Los Angeles in the 1971 San Fernando Earthquake and the 1994 Northridge Earthquake.

Subsidence

In Southern California, subsidence (lowering of ground surface elevation) has been generally attributable to four major causes: tectonic activity, groundwater extraction, hydroconsolidation, and oil and gas withdrawal. Subsidence attributable to tectonic activity is a geologic phenomenon occurring in areas of active seismicity, such as where down warping is caused by progressive bending of earth strata. Groundwater extraction in Los Angeles was at its peak in the 1930s and 1940s when much of the San Fernando Valley and Los Angeles Basin were used for agriculture. Reports of subsidence from agriculture water-well pumping were documented in scattered areas. Groundwater dewatering for construction purposes, such as in the Los Angeles Harbor area, can result in subsidence (Curtain, 1973). In contrast, hydroconsolidation caused by infiltration of surface water to the ground can occur in areas of ponding or water spilling. Alluvial deposits in the headward, proximal areas, of alluvial fans might be more susceptible to hydroconsolidation.

Settlement

Settlement under load is the total vertical movement of the soil column caused by the application of a load. Settlement of an engineered structure attributable to compression of soil below the foundation can occur in certain circumstances on the basis of building loads. Settlement occurs as a natural process in certain soils that were deposited in a loose state, such as landslide deposits and some alluvial deposits laid down rapidly during a storm event. Such natural settlement occurs over time as the loose soils naturally consolidate either due to load application or time dependent pore drainage. Natural consolidation can be accelerated by the addition of overburden soils deposited above or by infiltration of water causing hydroconsolidation.

Some man-made conditions that might lead to settlement include the addition of weight to the soil column, such as by the construction of a large sewage holding tank or the addition of fill soils.

Landslides

Landslides occur in the City of Los Angeles and slope failures were instrumental in Los Angeles being one of the first municipalities in the nation to adopt hillside-grading ordinances. Rapid uplift of the mountainous areas of Los Angeles from past and ongoing tectonic movements gives rise to a geologic setting conducive to mass wasting. The variable nature of sediments and rocks exposed throughout Los Angeles, and the slope conditions created by uncontrolled grading, have led to frequent landslides of a variety of types.

Rotational and translational landslides are common, as are debris flows of surficial deposits, such as topsoil and colluvium. Beginning at the turn of the century, uncontrolled grading in the hillside areas of Los Angeles created innumerable situations where uncompacted fill soils were placed over surficial soil deposits, or adversely oriented bedrock, in a way that loads a natural slope that previously had a near equilibrium slope stability.

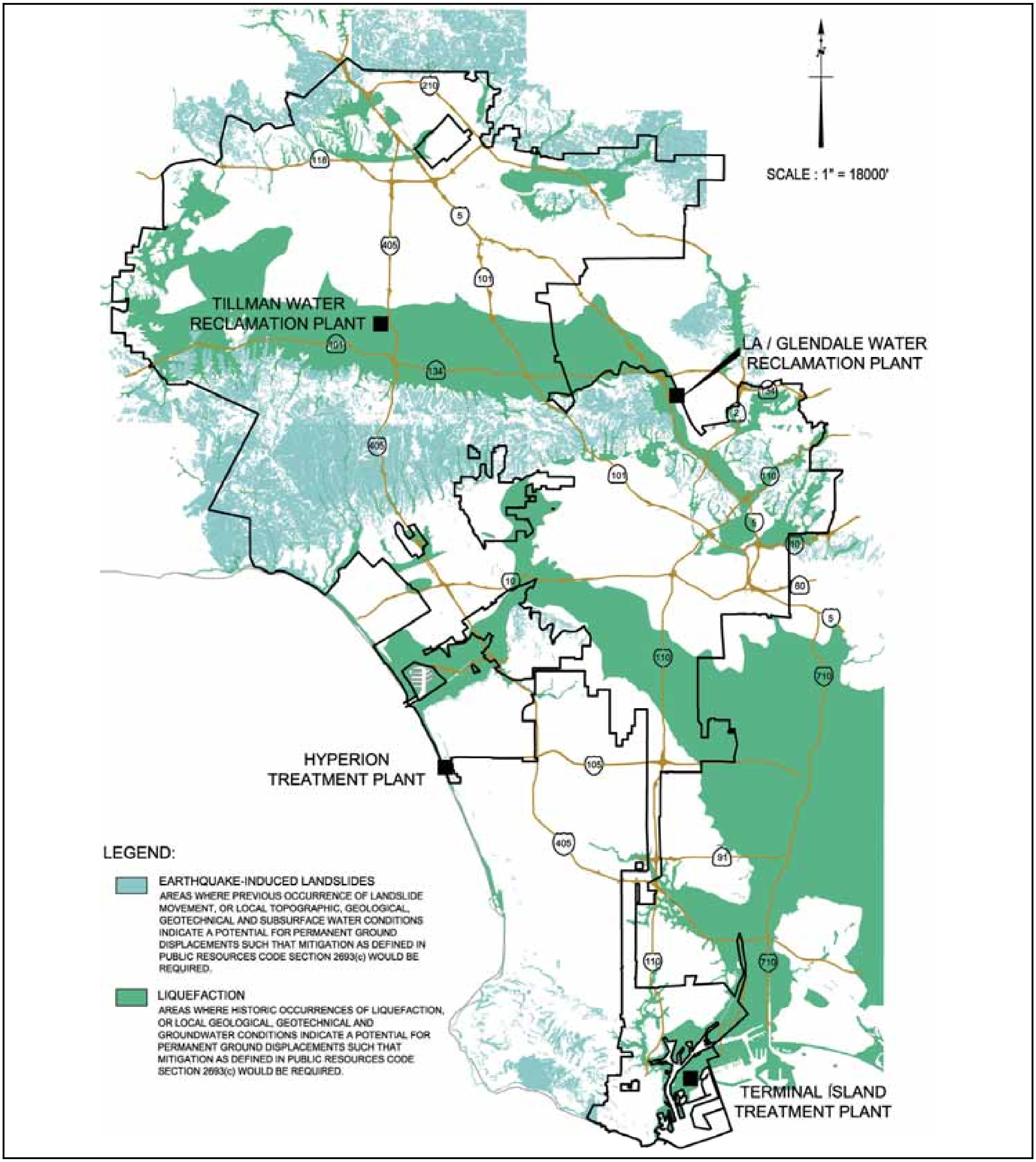

Figure 3.9-2
Seismic Hazard Zones in the Los Angeles Area

CH:CDM

State of California Seismic Hazard Zones of Required Investigation for Liquefaction and Earthquake Induced Landslides

Integrated Resources Plan
Environmental Impact Report

Source:
City of Los Angeles Bureau of Engineering

Landslides on the hills and bluffs of the coastal areas of Los Angeles are common and have posed a hazard for many years.

Other hillside areas of Los Angeles, especially the central and eastern Santa Monica Mountains, have geologic and topographic conditions that are conducive to the development of surficial and gross landslides. The City of Los Angeles Department of Building and Safety regulates construction and development in hillside areas of Los Angeles. As part of the City of Los Angeles Building Code, and review process, the City has established a Hillside Ordinance, which specifies that a geologic report is required for proposed construction within hillside areas. The areas to which the Los Angeles Hillside Ordinance applies are shown in Figure 3.9-3.

Tsunami Hazard

Tsunamis are long-period sea waves generated by a large-scale movement of the sea floor. Volcanic eruption, submarine earthquake or landslides can cause sea floor movement of this scale. The coastal areas of the City of Los Angeles are at risk of inundation by tsunamis, largely from those that might be generated from earthquakes. Tsunamis can travel over long distances at high velocities, as much as 460 miles per hour, and, thus, can strike the coast unexpectedly. The maximum expected run-up from a tsunami wave varies depending on coastline geomorphology and sea bottom topography, as well as by the direction of the source.

Low-lying coastal areas, harbor inlets and at the mouths of moderate-sized drainages are locations particularly at risk to the hazard of tsunami wave run-up. Such areas in Los Angeles include Belmont Shores, Seal Beach, Long Beach and Los Angeles Harbors, and the Marina del Rey and Ballona Creek.

Design criteria for coastal development are provided in the City of Los Angeles Flood Hazard Specific Plan (City of Los Angeles Safety Element). The Flood Hazard Management Specific Plan Guidelines by City of Los Angeles Department of Building and Safety stipulate development requirement for construction within flood risk zones. Potential flood zones are delineated in the Los Angeles Flood Hazard Map. The City of Los Angeles Safety Element Exhibit "Inundation & Tsunami Hazard Areas" illustrates the Hyperion Treatment Plant to be outside of the coastal area of potential Tsunami impact.

Mineral Resources

Southern California, and particularly the Los Angeles Basin, has historically been a productive source of petroleum. Development of this resource began in the late 1800s and continues today. Oil in the Los Angeles area occurs in a variety of geologic formations with Pliocene- and Miocene-age deposits being the most common. Oil fields have been identified and developed across much of Los Angeles including areas in the San Fernando Valley, Santa Susana Mountains, Santa Monica Mountains, coastal areas, and especially along the north margin of the Los Angeles Basin (see Figure 3.10-1).

Although much of the oil reserves have been depleted over the last century and exploration and production have slowed markedly in the last three decades, many pumping wells remain in the area. With urban development of the City of Los Angeles, exploration and development have become less likely based on economic and environmental constraints.

A second significant mineral resource of the Los Angeles area is aggregate sand and gravel. The term aggregate includes materials composed of natural or crushed, hard, sound and durable particles of unreactive minerals (sand, gravel, and crushed rock). Aggregate is used to make concrete and the proximity of these quarry sites in Los Angeles has been important to the development of the City. Aggregate is a bulk commodity with a low unit value at the quarry site. The cost of aggregate is primarily dependent on transportation costs.

Sand and gravel washed out of the local San Gabriel Mountains form most of the quarry deposits. The larger quarries are located east of Los Angeles in the San Gabriel Basin, but some were located in the alluvial deposits in the eastern San Fernando Valley.

3.9.2.2 Components

Project-Level Components

Hyperion

Hyperion is situated on the older sand dune deposits of the El Segundo Sandhills, which comprise a belt of recent and older sand dune deposits that parallel the coast from Ballona Creek south to the Palos Verdes Hills. This belt extends 3 to 4 miles inland from the Pacific coast. The recent sand dune deposits immediately adjacent to the coast are approximately 0.5-mile wide with crests ranging from 85 to 185 feet above sea level, while the older dune sand deposits comprise the remainder of the belt. The older sand dune deposits are composed almost entirely of fine- to medium-grained sand and silty sand. Locally, these sands are dense to very dense and slightly cemented.

A portion of the El Segundo Sandhills was excavated to create the building site for Hyperion. These sand dunes once paralleled the coast from Ballona Creek to the Palos Verdes Hills. The dune system is comprised of a belt of recent and older sand deposits that parallel the coast from Ballona Creek to the Palos Verdes Hills. This belt extends 3 to 4 miles inland from the Pacific coast. The recent sand deposits immediately adjacent to the coast are approximately 0.5-mile wide, with crests ranging from 85 to 185 feet above sea level, while the older sand deposits comprise the remainder of the belt. The older sand deposits are formed almost entirely of fine- to medium-grained sands and silty sands that are dense to very dense and slightly cemented. Underlying these deposits is the Lakewood Formation, which subsequently is underlain by Tertiary sediments.

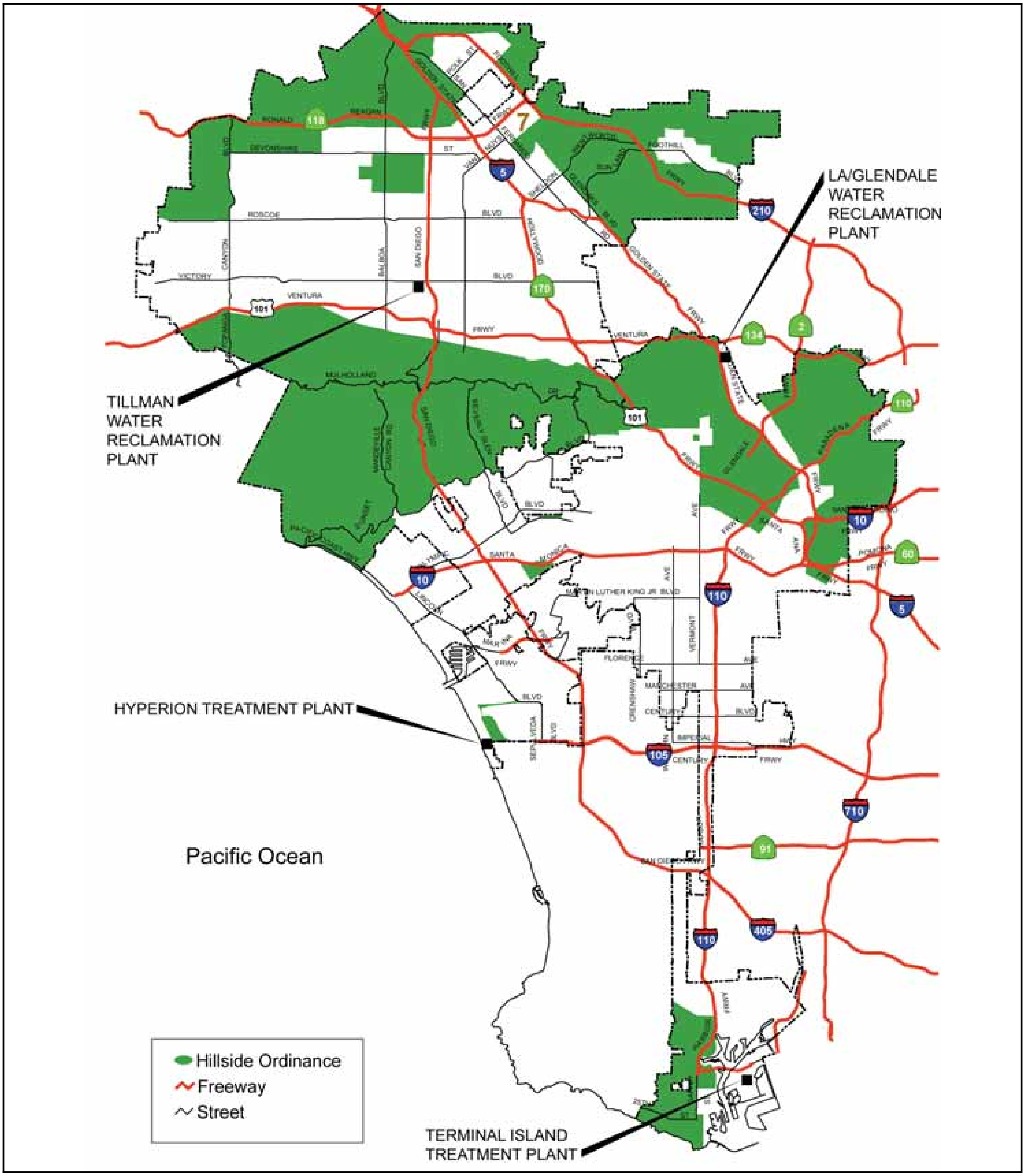

Figure 3.9-3
City of Los Angeles Hillside Ordinance

CH:CDM

Source:
City of Los Angeles Bureau of Engineering

The nearest active faults delineated on the State of California Special Studies Zones maps are in the Newport Inglewood fault zone. These are about 7 miles north east of the facility. The potentially active Palos Verdes fault is about 3 miles west of Hyperion under the Santa Monica Bay (see Fault Activity Map of Southern California, Figure 3.9-1). On the basis of the lack of consolidation of the sediments on which Hyperion was constructed, and the major faults that are near the site, it is anticipated that the area would be subject to ground shaking during its lifetime. The state has zoned the land west of Hyperion as a seismic hazard zone for liquefaction; however, the land upon which Hyperion is built is not zoned as a potential liquefaction area (Figure 3.9-4). Portions of the ascending hills east and south of Hyperion are zoned by the State of California as having the potential for earthquake-induced landsliding.

Seismic events that occur near coastal areas can generate seismic sea waves, commonly known as tsunamis, which can inundate low-lying coastal areas. Hyperion is outside the coastal area of potential Tsunami impact.

Tillman

Soils beneath Tillman are mapped as Quaternary alluvium, composed of alluvial gravel, sand, and silty clay, derived mostly from the Santa Monica Mountains.

Previous subsurface investigations indicate that primarily silty clays and clayey silts with interlayered sands underlie the Tillman facility. Tests in the area indicate that the soils are typically firm and dense.

Groundwater data reported by the California Department of Water Resources indicate that groundwater in the area is present at a depth of about 20 feet below ground surface.

The nearest active faults to the Tillman site are faults related to the 1971 San Fernando (or Sylmar) earthquake. These faults are approximately 8 miles north of Tillman. It is important to note that the epicenter of the 1994 Northridge earthquake is north of Tillman, which is located within a State of California Seismic Hazard Zone for earthquake-induced liquefaction.

LAG

LAG lies just east of the Los Angeles River channel in a transitional area between the Los Angeles Narrows and the Glendale/Verdugo Narrows. This area is underlain by deep, predominantly granular, alluvial sediments that form a significant unconfined groundwater aquifer. Alluvial soils that fill the Los Angeles Narrows occur within a linear valley that connects the alluvial San Fernando Groundwater Basin with alluvial and shallow marine aquifers of the Los Angeles Basin. Regionally, groundwater within the alluvial fill of the San Fernando Basin flows southeast toward the Glendale/Verdugo Narrows and then joins other southward flowing alluvial aquifers from the east and flows southward through the Los Angeles Narrows.

LAG lies on the east bank of the Los Angeles River, near the east end of the east-west trending Santa Monica Mountains. North of LAG is the San Fernando Valley. The course of the Los Angeles River turns from flowing eastward to southward a short distance north of the LAG site. Elevations at LAG are approximately 400 feet above sea level. Soils beneath the site are mapped as recent to late Quaternary age sand, clay, silt and gravel.

The nearest active faults delineated on the State of California Special Studies Zones maps are faults related to the 1971 San Fernando (or Sylmar) earthquake. However; these faults are located on the other side of the Verdugo Mountains, approximately 7 miles north of LAG. It is important to note that the epicenter of the 1994 Northridge earthquake is west of LAG, which is also located approximately 3 miles northwest of the Hollywood Raymond fault. This fault is generally recognized as active, but is not yet designated with Alquist-Priolo Special Studies Zone by the State of California. The site is located within a State of California Seismic Hazard Zone for earthquake induced liquefaction.

NEIS II

The NEIS II alignments are located in the Transverse Range Province at the east end of the Santa Monica Mountains. The proposed NEIS II Alignments begin within the Los Angeles Narrows in a transitional area between the northern margin of the Los Angeles Basin and the San Fernando Valley Basin. The Los Angeles Narrows is a well-defined canyon eroded by the Los Angeles River, which connects the San Fernando Valley drainage basin to the Los Angeles Basin. The Los Angeles River incised an antecedent course through bedrock over geologic time to create a narrow valley bounded on the west by the Santa Monica Mountains and Elysian Park Hills and on the east by the Repetto Hills. The narrow river valley is approximately 1,500 feet wide with varying widths of river floodplain adjacent to the active river channel. A steep, natural slope up to 60 m high bounds the west side of the narrows where the river has eroded the east flank of the Elysian Hills and eastern Santa Monica Mountains. The eastern margin of the narrows has a more gentle topography of rolling hills cut by numerous drainages.

The NEIS II alignments fall in an area of complex geologic structure where several regional faults, including the Hollywood-Raymond fault, the Verdugo fault and the York Boulevard fault, all come together. How these faults come together and which ones are geologically active are being studied at this time in the scientific community. Faults in the vicinity of the NEIS II alignment are shown in Figure 3.9-1. The Los Angeles Narrows area lies in a compressional area between the eastern Transverse Ranges and the northern Peninsular Range.

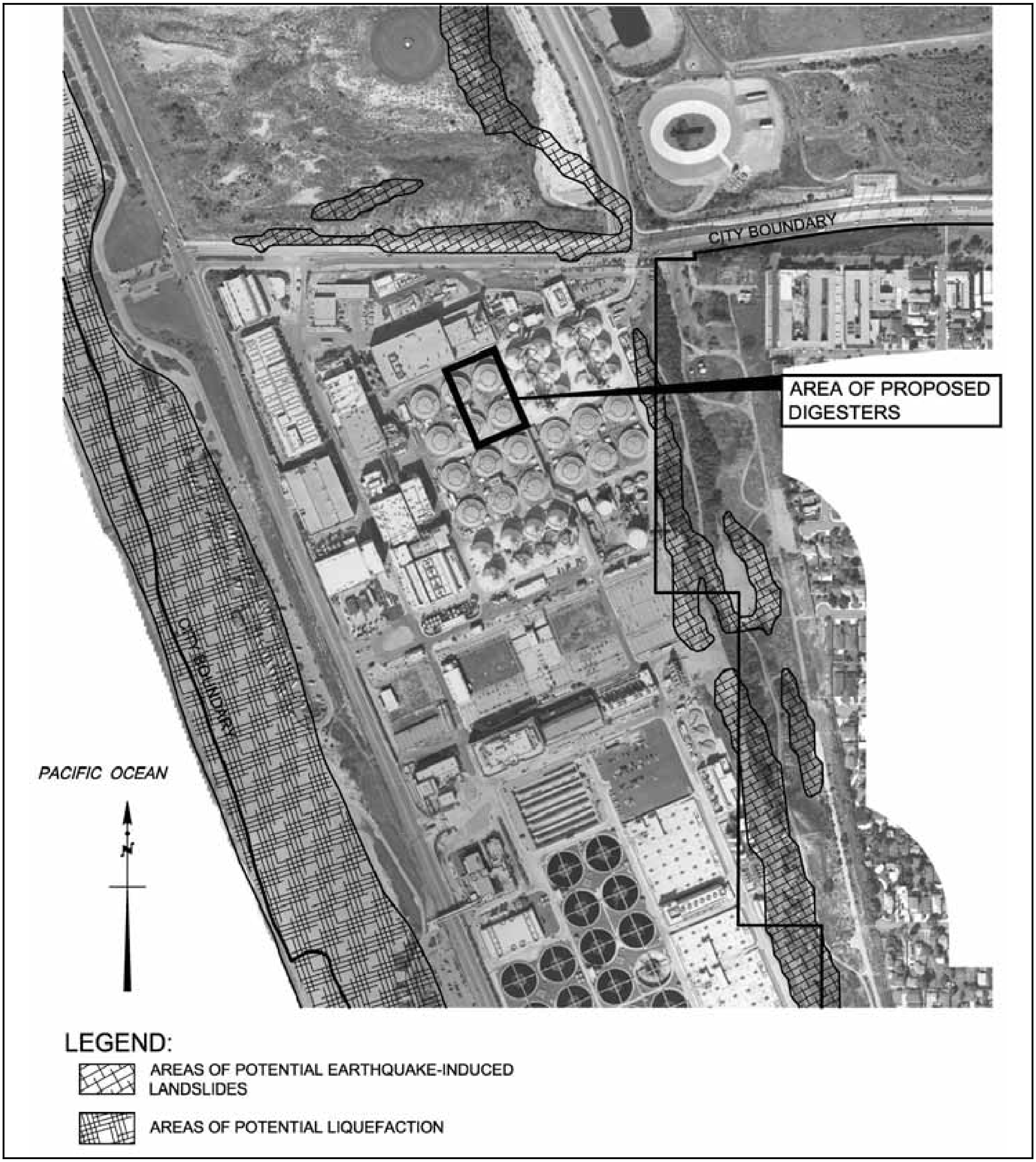

Figure 3.9-4
Seismic Hazard Zones at Hyperion

Orthophoto of Hyperion Treatment Plant showing State of California Seismic Hazard Zones of Required Investigation for Liquefaction and Earthquake Induced Landslides

CH:CDM

Source:
City of Los Angeles Bureau of Engineering

Integrated Resources Plan
Environmental Impact Report

The NEIS II tunnel alternatives consist of one along the east side of the Los Angeles River and one along the west side of the Los Angeles River. The tunnel alternatives traverse across a variety of geologic formations and structures. The tunnel alignments begin in the south at the Division Street shaft site where Holocene and late Quaternary alluvium overlies the Miocene-age Puente Formation bedrock. From there, the alignments extend outward into the deep alluvial soils of the Los Angeles River. Both alignments cross the trace of the Hollywood-Raymond fault. The eastern alignment crosses the fault trace within alluvial soils whereas the west alignment might cross the fault within relatively shallow bedrock along the west side of the river at the foot of the mountains.

The alignments begin in the south at the Division Street shaft site where Holocene and late Quaternary alluvium overlies the Miocene-age Puente Formation bedrock. From there, the alignments extend outward into the deep alluvial soils of the Los Angeles River. Both alignments cross the trace of the Hollywood-Raymond fault. The eastern alignment crosses the fault trace within alluvial soils; whereas, the west alignment might cross the fault within relatively shallow bedrock along the west side of the river at the foot of the mountains.

The two alignment alternatives cross the Hollywood-Raymond fault at different locations and depths. The characters of the crossings are of three basic potential conditions: 1) the pipe crosses the fault totally within bedrock, 2) the pipe crosses the fault totally within alluvium, or 3) the pipe crosses the fault at a location where bedrock is juxtaposed against alluvium. Each of these conditions has different implications as to the anticipated fault width and possibly the displacement amount. Where alluvial soils are present at the crossing, the fault might develop into a “flower structure” that involves the breaking of the fault rupture plane near the ground surface into the several rupture surfaces with incremental slip on each plane. Thus, the amount of slip on the rupture plane is spread out over a larger area laterally and the amount of slip on a discrete plane is reduced. In addition, the alluvial soils could compress internally so that less slip actually occurs across the fault plane.

Where the fault rupture is totally within bedrock, the displacement is more likely to be concentrated on a discrete plane, thus, the width of the fault zone would be narrower and the actual displacement could be relatively greater.

NEIS II is located within the liquefaction and potential seismic slope instability areas shown on the State of California Seismic Hazard Zones for the Los Angeles, Hollywood, and Burbank Quadrangles (Figure 3.9-2). Liquefaction typically occurs when near surface (usually upper 15 meters), saturated, clean, fine-grained loose sands are subject to intense ground shaking. Generally, groundwater in the NEIS Phase II study area occurs at a depth of 10 to 16 m below ground surface. Liquefaction-related phenomena include subsidence, lateral spreading and sand boils. Portions of the alignment have been identified as being in liquefaction zones (see Figure 3.9-2).

GBIS

The two proposed GBIS alignments turn westward from the northern shaft sites of the NEIS II alignments and trend along the north flank of the Santa Monica Mountains, along the south side of the San Fernando Valley. The San Fernando Valley is an east-trending structural trough, or basin, that has filled with alluvial sediments derived from the surrounding mountains. Much of the alluvial sediment is derived from Pacoima and Tujunga watersheds, which have their source in the San Gabriel Mountains. This source area contributes cobbles and boulders of hard crystalline bedrock. In the southern area, however, more sedimentary material is contributed from the Santa Monica Mountains.

As with the proposed NEIS II Alignments, the currently proposed GBIS alignments cross a geologic terrain that includes several distinctly different geologic units ranging widely in age. Both GBIS alignments extend through alluvial soils associated with the Los Angeles River and other less prominent fluvial and alluvial depositional systems, such as the Tujunga Fan. Proposed upgradient extension of the GBIS north alignment might stay entirely within alluvial soils, whereas the GBIS south alignment would traverse through Mesozoic-age intrusive rocks on the west end of the Santa Monica Mountains. Following a relatively short westward traverse through these harder granitic-type rocks, the northern GBIS alignment trends close to the lined channel of the Los Angeles River and, depending on its proposed depth, would keep within alluvial soils. In contrast, the southern GBIS alignment hugs closer to the foothills and traverses areas of alluvial sediments and Tertiary-age sedimentary rocks.

Geologic structural features in the area of GBIS include northwest-trending faults and folds, including the Benedict Canyon fault (inactive), the Hollister fault, the Griffith fault, and several unnamed folds that have been mapped in the bedrock exposed in the Santa Monica Mountains to the south of the alignment.

The nearest active faults delineated on the State of California Special Studies Zones maps are faults related to the 1971 San Fernando (or Sylmar) earthquake. These faults are approximately 10 miles north of the GBIS corridor. Importantly, the epicenter of the 1994 Northridge earthquake is north of the GBIS corridor. The GBIS corridor is located within a State of California Seismic Hazard Zone for earthquake induced liquefaction.

Portions of the GBIS alignment corridor lie within areas with potential for liquefaction and seismic slope (Figure 3.9-2). Liquefaction typically occurs when near surface (usually upper 15 m), saturated, clean, fine-grained loose sands are subject to intense ground shaking. Liquefaction-related phenomena include subsidence, lateral spreading and sand boils.

Program-Level Components

VSLIS

The San Fernando Valley is an east-trending structural trough, or basin, that has filled with alluvial sediments from the surrounding mountains. Much of the alluvial sediment is derived from Pacoima and Tujunga watersheds, which have their source in the San Gabriel Mountains. This source area contributes cobbles and boulders of hard crystalline bedrock. In the southern area, however, more sedimentary material could be contributed from the Santa Monica Mountains.

The nearest active faults delineated on the State of California Special Studies Zones maps are faults related to the 1971 San Fernando (or Sylmar) earthquake. These faults are approximately 10 miles north of VSLIS. Importantly, the epicenter of the 1994 Northridge earthquake is north of the VSLIS corridor.

Portions of the VSLIS alignment corridor lie within areas with potential for liquefaction (Figure 3.9-2). Liquefaction typically occurs when near-surface (usually upper 15 m), saturated, clean, fine-grained loose sands are subject to intense ground shaking. Liquefaction related phenomena include subsidence, lateral spreading and sand boils.

Recycled Water

Central and Eastern Portions of the San Fernando Valley (Tillman). The valley contains thick sequences of alluvial sediments that contain fresh-water bearing. Large areas of the valley are subject to earthquake-induced liquefaction (Figure 3.9-2). The epicenter of the very damaging 1994 Northridge earthquake is in the San Fernando Valley.

Pipelines for carrying recycled water would likely be installed in artificial fill or alluvium in the City of Los Angeles rights-of-way. Water tanks could be installed in upland areas on the perimeter of the valley underlain either by alluvial materials or possibly directly on bedrock. Some of these upland areas could be subject to earthquake-induced landslides, as shown on CGS maps.

Northeast and Downtown Portions of Los Angeles. Several oil fields are present in this area, including the Los Angeles City Oil Field and Union Station oil field. Oil seeps are present in local areas generally around these oil fields, and shallow methane gas has been encountered in numerous borings drilled in the area. Portions of the area lie within the City of Los Angeles Methane Zone.

This area is located along the Elysian Park fold and thrust belt and is subject to significant ground shaking in the event of an earthquake on one of the nearby faults, including the Elysian Park Blind Thrust. The CGS Seismic Hazards maps indicate that much of the low-lying alluvial valleys have the potential for liquefaction and that steeper slopes in the local hills have the potential for seismically induced landslides.

West Los Angeles Area, Upstream from Hyperion and West Basin Municipal Water District. This area is in the Los Angeles Coastal Plain, which is south of the Santa Monica Mountains. Aquifers within the Coastal Plain are important groundwater resources for Los Angeles. The location of pipelines in this general Project area has not been finalized, but some would be in and around Hyperion Treatment Plant. It is also possible that water tanks for storing recycled water would be located at Hyperion. Most of the earth units in this area are sedimentary bedrock of varying hardness and Quaternary alluvium.

Harbor Area Upstream from Terminal Island. Surface water and groundwater underflow from as far north as the San Fernando Valley discharge to the Pacific Ocean in this area. Groundwater elevations are generally shallow in the low-lying areas, and much of the area is subject to seismically induced liquefaction and landslides, in part from large amounts of artificial fill being placed to reclaim land. Oil was produced in this area from some of the oldest oil fields in Los Angeles, such as the Wilmington oil field. Topography is variable with low-lying hills composed of sedimentary bedrock and lower lying alluvium filled areas near the Los Angeles River. The active Newport-Inglewood fault zone trends to the northwest in the area, and is within about 5 miles of Terminal Island. The potentially active Palos Verdes fault trends northwest across the Harbor onshore along the north flank of the Palos Verdes Hills.

Some distribution system components might also be placed in the southeast Los Angeles area near Compton Creek. This area lies on the Downey Plain in the central portion of the Los Angeles Basin. Deep alluvial sediments and Pleistocene-age deposits of San Pedro Formation underlie this area. The Rosecrans, East Rosecrans, South Rosecrans, and Howard Townsite oil fields lie West of Compton Creek. This oil field area is largely contained within the City of Los Angeles Methane Ordinance Zone.

Dry Weather Runoff – Low-Flow Diversions

Coastal areas along the Santa Monica Bay have widely varying topography. For instance, topography along Pacific Coast Highway is relatively flat through much of the area; however, it is adjacent to coastal bluffs that rise steeply. Geologic and soil-related issues in the flatter areas are not numerous, but do include seismically related liquefaction hazards. The flat coastal areas are relatively narrow with the beach on one side and coastal bluffs on the other. Coastal bluffs are prone to landslides and a careful evaluation of the landslide potential would need to be made if locating infrastructure near bluffs is considered.

In inland areas such as the San Fernando Valley, one key geologic consideration is the risk of seismically induced liquefaction. Liquefaction in the valley was documented after the 1971 San Fernando and the 1994 Northridge earthquakes. The risk of liquefaction would need to be investigated prior to placing infrastructure.

Wet Weather Runoff – Onsite Management

Onsite percolation can cause settlement of the soils; therefore, soil testing is needed to determine this risk. Geologic and soil-related issues for onsite percolation and cistern use are complex. Generally, sites chosen for onsite percolation should be underlain by permeable granular soils, such as alluvium near the base of the San Gabriel Mountains. These proximal alluvial soils are well suited for rapid percolation and have internal stratigraphy that lends itself to groundwater basin recharge. Loose, unconsolidated alluvial soils might be subject to hydroconsolidation (leading to settlement). To determine whether a specific site is suited for construction of a groundwater recharge basin, it would be necessary to perform soil testing such as moisture density tests and consolidation tests.

Dry Weather Runoff – Urban Runoff Plants or Treatment Wetlands
Dry weather runoff from Compton Creek and Ballona Creek could be diverted to URPs. Runoff at inland drainages would be diverted to URPs or Treatment Wetlands, which could be constructed near diversion locations placed along these creeks. The subject portion of Compton Creek flows over an area generally underlain by alluvial surficial soils and at greater depth by nonmarine and marine clastic sedimentary deposits of the Lakewood and San Pedro Formations. The near-surface sediments in which proposed structures would likely be founded reportedly have the potential for liquefaction in the event of an earthquake. The deposits are generally fine-grained and can vary from loose to dense.

Near-surface sediments along Ballona Creek, a historic and prehistoric former course of the Los Angeles River, generally consist of alluvial sands and sandy gravels. Pleistocene-age freshwater aquifers are present at shallow depths along the stream course. The area along the creek has been mapped as a potential liquefaction zone by the CGS.

Wet Weather Runoff – Urban Runoff Plants
Three wet weather URPs would be constructed along the coast. As described under the Hyperion project- level component above, this coastal area lies within the El Segundo Sandhills. These hills consist of older dune sands composed largely of fine- to medium-grained sand and silty sand. The dune deposits are generally consolidated and are locally dense.

As shown in Figure 3.9-2, a thin band of coastal sediments in the area has liquefaction potential. The risk of liquefaction would need to be investigated prior to placing infrastructure.

The Newport-Inglewood fault lies about 7 miles to the east and has the potential to generate significant ground shaking at the site.

Dry Weather Runoff – Smart Irrigation
Dry weather runoff can be greatly minimized by smart irrigation. These devises would be installed at residential, commercial, and industrial properties throughout the City of Los Angeles. The geology for this component would be the same as described under General Setting (Section 3.9.2.1). For instance, landscape irrigation can contribute to subsurface water to slopes possibly reducing their stability.

Wet Weather Runoff – Non-Urban Regional Recharge
The San Fernando Valley contains abundant granular soils and is a key groundwater basin in the Los Angeles Area. Non-urban wet weather runoff captured in the San Fernando Valley would be used to recharge groundwater

basins used by the City of Los Angeles. Rainfall would be collected in a new pipeline and conveyed to spreading grounds in the East Valley such as Hansen and Pacoima Spreading Grounds. Fault surface rupture occurred north of here during the 1971 San Fernando earthquake. The pipeline would likely be placed in City rights-of-way and oriented in an east west direction, be about 10 miles long and 100 inches in diameter. Although the location and alignment have not been determined, certain areas of the valley have soils subject to liquefaction.

3.9.3 Environmental Impacts

3.9.3.1 Background

Presented below are brief discussions of the regulatory framework, methodology, and thresholds of significance used to analyze each Alternative and program-level component.

Regulatory Framework

Federal

The federal government role in geology and soils for the projects appears limited. For example, the federal government does not have regulations regarding liquefaction, landslide, and earthquake zones. The Occupational Safety and Health Administration (OSHA) requirements of the federal government appear to be implemented, or superseded, by state requirements.

State

The State of California promulgates a number of regulations regarding geology and soils. The State of California has adopted the International Building Code (IBC), which is based in large part on the older Uniform Building Code (UBC). These codes of regulation for construction practice include sections pertinent to design and construction to avoid geotechnical hazards such as expansive soil, settlement, and slope instability. The codes are inclusive of design standards and general design parameters for seismic design.

In addition to the guidance provided by these codes, various laws have been enacted, which direct the California Geologic Survey (formerly the California Division of Mines and Geology [CDMG]) to prepare guidance documents and define zones in which special engineering geologic studies are required. The State of California Alquist-Priolo Act of 1972 was enacted to address the hazard and damage caused by surface fault rupture during an earthquake. The Act requires the State Geologist to identify and map the trace of active faults in California and to establish "earthquake fault zones" along these faults. Proposed development/construction projects that fall within one of these state-defined AP-Special-Studies Zones must address the potential for surface rupture from earthquake faulting. At the local level, cities and counties are required to regulate development projects within these zones.

The Northridge earthquake brought attention to the fact that landslides can account for a significant percentage of the economic losses caused by an earthquake. In recognition of this, the state legislature passed the Seismic

Hazards Mapping Act, which required the CGS to prepare guidelines and maps for evaluation of seismic hazards other than surface fault-rupture, and to recommend mitigation measures. In response, the CGS published Special Publication 117, which provides guidelines to practicing geologists and engineers for evaluation of seismic hazards, especially liquefaction and landslides. CGS created a statewide seismic hazard mapping and technical advisory program to assist cities and counties in fulfilling their responsibilities for protecting the public health and safety from the effects of seismic hazards caused by earthquakes, including landslides. Liquefaction and landslide susceptibility maps prepared by the CGS were used for this study to aid in identification of the geologic hazards as they relate to the Project.

The California Department of Occupation and Health promulgates regulations regarding earthwork safety, such as shoring in trenches, height and gradient of temporary excavation slopes, tunnel construction safety procedures

Local

The City of Los Angeles has adopted with some modifications the UBC and regulates compliance with the City of Los Angeles Building Code. Some infrastructure components of the various Alternatives would require design and construction in compliance with the City of Los Angeles Building Code as enforced by the City of Los Angeles Department of Building and Safety.

For sewer line construction and other Public Works construction, the City of Los Angeles has adopted the "Standard Specifications for Public Works Construction" (popularly known as the Green Book). These specifications have general applicability to public works projects and provide a basis for uniformity of design and construction. They are regularly updated to reflect changing technology of the construction industry.

Methodology

Geology and soil-related issues for the IRP included liquefaction, landslides, active faults, and workplace safety. All routine scenarios regarding the projects relating to geology and soils appear to be under the umbrella of the federal, state, and local governments.

Thresholds of Significance

The Proposed Project would have a significant impact to geology and soils if it would:

GEO-1: Cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.

GEO-2: Cause or accelerate instability from erosion, expansion or settlement, or if it would result in offsite sediment runoff or deposition.

GEO-3: Result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

3.9.3.2 Component Impacts

This subsection describes the project- level and program-level component impacts related to geology and soils.

Project-Level Impacts

Hyperion Expansion to 500 mgd

Construction would not take place within CGS earthquake-induced liquefaction and landslide hazard zones. Additionally, no faults are known to exist in the area of construction. Prior to earthwork, a geotechnical study would be needed to evaluate geology and soil conditions and concerns. BMPs would minimize any concerns for offsite sediment runoff. Known mineral resources would not be depleted during earthwork. As part of standard practice and the predesign process, a geotechnical study would be prepared to identify geotechnical conditions and design features (such as foundation requirements and the maximum credible design earthquake) that would have to be included as part of the component design.

The City of Los Angeles Safety Element Exhibit "Inundation & Tsunami Hazard Areas" in the City's General Plan illustrates Hyperion to be outside the coastal area of potential tsunami impact (City of Los Angeles, 1996).

Neither the construction nor the operation of the Hyperion Expansion to 500 mgd would cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards. Construction and operation would not cause or accelerate instability from erosion, expansion or settlement or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Hyperion Process Upgrades

The impacts described in the Hyperion Expansion to 500 mgd above also apply to this component. No geology and soils impacts are anticipated.

Tillman Expansion to 100 mgd

Earthwork for the clarifiers and basins requires excavation into the alluvial soils. The Tillman site lies within an area identified by the state as having the potential for seismically induced liquefaction; however, previous tests indicate that the underlying soil is firm and dense and might not be subject to liquefaction. However, a geotechnical investigation, including subsurface exploration, soil sampling, and laboratory testing, would be required to ascertain the project- level soil conditions to develop appropriate geotechnical design parameters. With knowledge of site information, design and construction in accordance with existing regulations, applicable standard specifications, and compliance with the recommendations in the project-level geotechnical studies that are prepared as a standard practice during the predesign process, potential risks of damage as a result of liquefaction would be reduced to an acceptable level.

Design and construction in compliance with regulations, standard specifications, and project-level geotechnical studies would also reduce the risk of damage from lateral spreading, settlement, expansive soils, and ground shaking from an earthquake to professionally acceptable levels. As a result, construction and operation of this component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards. Construction and operation would not cause or accelerate instability from erosion, expansion or settlement or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Tillman Expansion to 80 mgd

Construction and operation of this component is a smaller subset of the Tillman Expansion to 100 mgd. As a result, the analysis of impacts described above for the Tillman Expansion to 100 mgd also would apply to this component. No geology and soils impacts would be anticipated.

Tillman Process Upgrades

Construction and operation of this component is a smaller subset of the Tillman Expansion to 100 mgd and includes only installation of microfiltration and reverse osmosis units. As a result, the analysis of impacts described in the Tillman Expansion to 100 mgd above also applies to this component. No geology and soils impacts are anticipated.

Tillman Wastewater Storage

The Tillman site lies within an area identified by the state as having the potential for seismically induced liquefaction; however, previous tests indicate that the underlying soil is firm and dense and might not be subject to liquefaction. A geotechnical investigation, including subsurface exploration, soil sampling, and laboratory testing would be required to ascertain the site-specific soil conditions to develop appropriate geotechnical design parameters. Knowledge of site information, design, and construction in accordance with existing regulations, applicable standard specifications, and compliance with the recommendations in the project-level geotechnical studies prepared as a standard practice during the predesign process, would reduce potential risks of damage from liquefaction to an acceptable level. Design and construction in compliance with regulations, standard specifications, and project-level geotechnical studies would also reduce the risk of damage from lateral spreading, settlement, expansive soils, and ground shaking from an earthquake. As a result, construction and operation of this component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards. Construction and operation would not cause or accelerate instability from erosion, expansion, settlement, or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

LAG Expansion to 30 mgd

Under the LAG Expansion to 30 mgd option, earthwork for the clarifiers and aeration basins would require excavation into the alluvial soils. The LAG site lies within an area identified by the state as having the potential for seismically induced liquefaction. A geotechnical investigation, including subsurface exploration, soil sampling, and laboratory testing, would occur as a standard practice during the predesign process to ascertain the site-specific soil conditions to develop appropriate geotechnical design parameters. With knowledge of the site-specific information, design and construction in accordance with existing regulations and other applicable standard specifications would reduce the risk of damage from liquefaction. Design and construction in compliance with regulations and standard specifications would also reduce the risk of damage from lateral spreading, settlement, expansive soils, and ground shaking from an earthquake.

As a result, construction and operation of is component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards. Construction and operation would not cause or accelerate instability from erosion, expansion or settlement or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

LAG Operational Storage Only

This component includes construction of a 5-million-gallon buried wastewater storage tank and a 5-million-gallon buried recycled water storage tank. Earthwork for the buried wastewater and recycled water storage tanks requires excavation into the alluvial soils. The LAG site lies within an area identified by the state as having the potential for seismically induced liquefaction. A geotechnical investigation, including subsurface exploration, soil sampling, and laboratory testing, would occur as a standard practice during the predesign process to ascertain the site-specific soil conditions to develop appropriate geotechnical design parameters. With knowledge of the site-specific information, design and construction in accordance with existing regulations and other applicable standard specifications would reduce the risk of damage from liquefaction to professionally acceptable levels. Design and construction in compliance with regulations and standard specifications would also reduce the risk of damage due to lateral spreading, settlement, expansive soils, and ground shaking from an earthquake.

As a result, construction and operation of this component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards. Construction and operation would not cause or accelerate instability from erosion, expansion or settlement or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

NEIS II West Alignment

Construction of the tunnel would require that several shaft sites be constructed, which would be as deep as the tunnel. The tunnel would cross the Los Angeles River, freeways, and abandoned LADWP infiltration galleries.

The northern and southern portions of the proposed NEIS II West Alignment and the majority of the NEIS II East Alignment fall within the CGS-defined zone of potentially liquefiable alluvial soils. However, the eastern alignment would be deeper than the liquefaction zone and the western alignment likely would be deeper than the liquefaction zone and possibly within bedrock. Therefore, the risk of damage from the hazard of liquefaction is very low to nonexistent. This also applies to connector tunnels given similar design depths. However, if pipes or accessory structures are considered at depths less than 50 feet, a geotechnical investigation would occur as a standard practice during the predesign process to ascertain the soil properties to formulate appropriate design and construction recommendations.

Portions of the western NEIS II West Alignment would trend near the toe of the Elysian Hills, which have some potential for landslides. The proposed sewer pipe would be below the depth of potential landslide slip planes; therefore, the risk of damage to the pipe from landslides is very low to nonexistent.

The potential for geology and soil impacts exists along the NEIS II West Alignment.

NEIS II West Alignment would cross the Hollywood-Raymond fault, which trends generally east-west across the southern portion of the alignment corridor. Preliminary information indicates that the western alignment would likely cross the fault within the bedrock, which lies at a shallower depth on the west side of the Los Angeles Narrows valley. This fault is active and capable of generating several meters of ground displacement and, therefore, could break or deform the proposed sewer pipe at the crossing. Mitigative design and/or construction measures to address the risk of pipe breakage in the event of movement on the fault are presented in Section 3.9.3.3 below.

It is possible that settlement of soils above the new sewer alignment could take place during tunnel construction. The NEIS II West Alignment also crosses the active Hollywood Raymond fault. However, installation of the sewer across the fault would not cause or accelerate geologic hazards. Fault rupture could damage the sewer and create localized subsidence in the area of a damaged sewer.

Construction and operation could cause or accelerate settlement resulting from ground loss during tunneling or fault rupture of the tunnel. Construction and operation, however, would not cause or accelerate instability from erosion, expansion, or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

NEIS II East Alignment

The NEIS II east Alignment would cross the Hollywood-Raymond fault, and the design considerations as described above for the NEIS II West Alignment 1 would apply.

It is possible that settlement of soils above the new sewer could occur during construction. The NEIS II East Alignment would cross the active Hollywood Raymond fault. Installation of the sewer across the fault, however, would not cause or accelerate geologic hazards. Fault rupture could damage the sewer, and create localized subsidence in the area of a damaged sewer. Recent tunnel designs, such as the NEIS I tunnel, are constructed using state-of-the-art tunneling technologies and consist of three layers of lining protection. The NEIS I exterior lining consists of 8- to 12-inch-thick precast concrete. This type of lining design adds strength to resist damage from earthquake shaking.

The shafts constructed for NEIS I were constructed in such a way to minimize the need to dewater.

In summary, construction of the sewer tunnel could cause settlement of the ground surface. Construction and operation could cause or accelerate settlement resulting from ground loss during tunneling or fault rupture of the tunnel. Construction and operation, however, would not cause or accelerate instability from erosion, expansion, or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

GBIS South Alignment

Construction of the tunnel would require that several shaft sites be constructed, which would be as deep as the tunnel. The GBIS South Alignment would result in the potential for ground settlement to occur above the alignment during construction.

In addition, much of the GBIS South Alignment falls within liquefaction overlay zones established by the state; however, GBIS would be located at depths below the actual liquefaction zones. Therefore, the potential of impacts from liquefaction hazards is very low to nonexistent. Furthermore, compliance with design and/or construction recommendations in the project-level geotechnical studies that would be prepared as a standard practice during the predesign process would ensure that potential liquefaction-related impacts are kept at acceptable levels.

The GBIS alignment would cross the inactive Benedict Canyon fault. Current geologic information indicates the fault trends along north side of the Santa Monica Mountains near the Los Angeles River. Installation of the sewer across the fault would not cause or accelerate the potential for fault rupture geologic hazard.

Construction and operation could cause or accelerate settlement resulting from ground loss during tunneling. However, construction and operation would not cause or accelerate instability from erosion, expansion or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

GBIS North Alignment

Construction of the tunnel would require that several shaft sites be constructed, which would be as deep as the tunnel. The GBIS North Alignment would result in the potential for geology and soil impacts. Specifically, the potential exists for ground settlement to occur above the alignment during construction.

The potential for impacts from liquefaction hazards is the same as discussed above for the GBIS South Alignment.

The GBIS alignment would cross the inactive Benedict Canyon fault. The exact location of this fault crossing is not presently known; however, current geologic information indicates the fault trends along the north side of the Santa Monica Mountains near the Los Angeles River. Installation of the sewer across the fault would not cause or accelerate the potential for fault rupture geologic hazard.

Construction and operation could cause or accelerate settlement resulting from ground loss during tunneling. However, construction and operation would not cause or accelerate instability from erosion, expansion or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Program-Level Impacts

VSLIS

It is expected that some of the construction could be by trenching and other parts by tunneling. It is possible that settlement of soils above the new sewer alignment could occur during tunneling construction. However, a tunnel that is constructed within the bedrock, or below the groundwater table in earth-pressure-balance (EPB) mode, would be less likely to cause ground loss and associated ground settlement at the surface. Nonetheless, a potential exists for significant settlement impact. Substantial settlement impacts are not anticipated with open-trench construction based on the use of established backfilling and compaction methods (mechanical compaction in layers or water jetting).

VSLIS would potentially be constructed in liquefaction overlay zones. If VSLIS were constructed using tunneling methods, it would likely be located beneath the actual liquefaction zone, in which case, minimal liquefaction impacts would occur. If constructed using open trench methods, a potential exists for VSLIS to be installed within soils prone to liquefaction. However, compliance with design and/or construction recommendations in the project-level geotechnical studies that would be prepared as a standard practice during the predesign process would ensure that potential liquefaction-related impacts are kept at acceptable levels.

Construction and operation could cause or accelerate settlement resulting from ground loss during tunneling. However, construction and operation would not cause or accelerate instability from erosion, expansion or offsite sediment runoff. Construction and operation would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Recycled Water
Because the recycled water pipelines would be constructed primarily by trenching, it is possible that settlement of soils above the new pipelines could occur. However, established backfilling and compaction methods, such as mechanical compaction in layers or water jetting (where appropriate), would be employed to keep potential post construction settlement to acceptable levels.

Geotechnical studies would be prepared during the predesign process for recycled water distribution components such as tanks or underground pump stations, and the appropriate recommendations would be incorporated into the component design. Consequently, the water storage tanks and pump stations are not expected to result in geology-related impacts or cause or accelerate geologic hazards.

Under the Groundwater Recharge option, advance-treated recycled water from Tillman would be pumped through an existing pipeline to the Hansen Spreading Grounds (or possibly the Pacoima Spreading Grounds). A second pipeline from the Pacoima Spreading Grounds has been cleared in a previous environmental document. The pumping of recycled water under this component option would not result in geology impacts.

Dry Weather Runoff – Smart Irrigation
Geology and soil-related impacts would not occur from implementation of smart irrigation because the smart irrigation devices would be installed at the ground surface and would not affect underlying soil conditions. Erosion as a result of runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water.

Dry Weather Runoff – Low-Flow Diversions
This component includes relatively shallow earthwork where dry weather runoff could be directed into the sanitary sewer system. The low flow diversions in coastal and inland areas could result in geology and soils impacts because they could occur in liquefaction overlay zones at depths prone to liquefaction. However, compliance with design and/or construction recommendations in the project-level geotechnical studies that would be prepared as a standard practice during the predesign process would keep potential liquefaction-related impacts within acceptable levels. Erosion as a result of runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water.

Dry Weather Runoff – Urban Runoff Plants or Treatment Wetlands
A potential exists for liquefaction and seismic-related impacts from the placement of URPs in liquefaction overlay zones or in areas subject to ground shaking. However, design and construction in compliance with regulations, standard specifications, and project-level geotechnical studies would reduce

the risk of damage from liquefaction and ground shaking from an earthquake. Treatment wetlands would be subject to cyclical and intentional inundation, which could result in potential offsite sediment transport. However, sediment management features such as settling basins would be incorporated into the wetland designs to minimize the potential for offsite sediment transport.

Wet Weather Runoff – Onsite Management

Settlement of the ground surface can occur when groundwater recharge is accomplished by spreading the water over an area. However, design and construction in compliance with regulations, standard specifications, and recommendations in project-level geotechnical studies would reduce the risk of damage from settlement. Erosion as a result of runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water.

Wet Weather Runoff – Urban Runoff Plants

Geology and soils impacts could occur from potential liquefaction and substantial ground shaking if the URPs are located in liquefaction overlay zones or are in proximity to active faults. However, design and construction in compliance with regulations, standard specifications, and recommendations in project-level geotechnical studies would reduce the risk of damage from liquefaction or ground shaking from an earthquake. Erosion from runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water.

Wet Weather Runoff – Non-Urban Regional Recharge

Construction would be with open trench methods. A potential exists for geology and soil impacts related to liquefaction and potential hydroconsolidation and postconstruction settlement from trenching construction. The non-urban regional recharge pipeline would likely be located within liquefaction overlay zones at shallow depths that would be prone to liquefaction. However, compliance with design and/or construction recommendations in the project-level geotechnical studies that would be prepared as a standard practice during the predesign process would ensure that potential liquefaction-related impacts are kept at acceptable levels.

Substantial settlement impacts are not anticipated with open-trench construction using established backfilling and compaction methods (mechanical compaction in layers or water jetting as appropriate). Erosion from runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water.

Summary of Component Impacts

Table 3.9-3 presents a summary of the component impacts to geology and soils relative to the three significance thresholds.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
Site Specific			
Hyperion Expansion to 500 mgd	No impact is anticipated. No geologic conditions such as faults, seismically induced liquefaction areas, or landslides exist in the area of the proposed expansion. Nevertheless, to protect against causing or exacerbating geologic hazards that could damage structures or expose people to increased risks of hazards prior to earthwork, a geotechnical study would be prepared during the design process to evaluate geology and soil conditions and concerns.	No impact is anticipated. Best management practices would be used during construction and operation to minimize erosion. The presence of expansive soils is not anticipated nor are settlement impacts. Nevertheless, to protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during the design process to evaluate geology and soil conditions and concerns.	No impact is anticipated. No known mineral resource of value to the region would be depleted during construction or operation of this component.
Hyperion Process Upgrades	No impact is anticipated. Analysis of this component is already included in the Hyperion Expansion to 500 mgd component.	No impact is anticipated. Analysis of this component is already included in the Hyperion Expansion to 500 mgd component.	No impact is anticipated. Analysis of this component is already included in the Hyperion Expansion to 500 mgd component.
Tillman Expansion to 100 mgd	No impact is anticipated although the site lies in an area designated as a seismically induced liquefaction area. Note that this designation is generalized and requires that a site-specific liquefaction analysis be completed. Existing data indicate that the soils at the site are firm and dense. No other geologic hazards are known to exist at the site. Nevertheless, to protect against causing or exacerbating geologic hazards that could damage structures or expose people to increased risks of hazards prior to earthwork, a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. The soils beneath the site are not understood to be expansive or prone to settlement and best management practices would be used during construction and operation to minimize offsite sediment runoff or deposition. Nevertheless, to protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. No known mineral resource of value to the region would be depleted during construction or operation of this component.
Tillman Expansion to 80 mgd	No impact is anticipated. Analysis of this component is already included in the Tillman Expansion to 100 mgd component.	No impact is anticipated. Analysis of this component is already included in the Tillman Expansion to 100 mgd component.	No impact is anticipated. Analysis of this component is already included in the Tillman Expansion to 100 mgd component.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
Tillman Process Upgrade	No impact is anticipated. Analysis of this component is already included in the Tillman Expansion to100 mgd component.	No impact is anticipated. Analysis of this component is already included in the Tillman Expansion to 100 mgd component.	No impact is anticipated. Analysis of this component is already included in the Tillman Expansion to 100 mgd component.
Tillman Oper. Storage	No impact is anticipated although the site lies in an area designated as a seismically induced liquefaction area. However, existing data indicate that the soils at the site are firm and dense. No other geologic hazards are known to exist at the site. Nevertheless, to protect against causing or exacerbating geologic hazards that could damage structures or expose people to increased risks of hazards prior to earthwork, a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. The soils beneath the site are not understood to be expansive or prone to settlement and best management practices would be used during construction and operation to minimize offsite sediment runoff or deposition. Nevertheless, to protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. No known mineral resource of value to the region would be depleted during construction or operation of this component.
LAG Expansion to 30 mgd	No impact is anticipated although the site lies in an area designated as a seismically induced liquefaction area. Note that this designation is generalized and requires that a site-specific liquefaction analysis be completed. No other geologic hazards are known to exist at the site. Nevertheless, to protect against causing or exacerbating geologic hazards that could damage structures or expose people to increased risks of hazards prior to earthwork, a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. The soils beneath the site are not understood to be expansive or prone to settlement and best management practices would be used during construction and operation to minimize offsite sediment runoff or deposition. Nevertheless, to protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. No known mineral resource of value to the region would be depleted during construction or operation of this component.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
LAG Oper. Storage	No impact is anticipated although the site lies in an area designated as a seismically induced liquefaction area. Note that this designation is generalized and require that a site-specific liquefaction analysis be completed. No other geologic hazards are known to exist at the site. Nevertheless, to protect against causing or exacerbating geologic hazards that could damage structures or expose people to increased risks of hazards prior to earthwork, a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. The soils beneath the site are not understood to be expansive or prone to settlement and best management practices would be used during construction and operation to minimize offsite sediment runoff or deposition. Nevertheless, to protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. No known mineral resource of value to the region would be depleted during construction or operation of this component.
NEIS II West Alignment	Potential impact exists. Although no construction impacts are anticipated, the proposed tunnel crosses the active Hollywood-Raymond fault. If the fault ruptures, the sewer could be damaged. This damage to the sewer would create an operational impact. Otherwise, construction and operation of the sewer and its associated structures would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	Potential impact exists. Tunnel construction would be performed by a tunnel boring machine or earth pressure balance tunneling machine. During tunneling, ground loss can occur that could lead to ground surface settlement. Possible pipe breakage in the event of ground surface rupture from an earthquake on Hollywood-Raymond fault. This could allow ground loss that could lead to ground surface settlement. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the tunnel and its associated structures would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
NEIS II East Alignment	Potential impact exists. Although no construction impacts are anticipated, the proposed tunnel crosses the active Hollywood-Raymond fault. If the fault ruptures, the sewer could be damaged. This damage to the sewer would create an operational impact. Otherwise, construction and operation of the sewer and its associated structures would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	Potential impact exists It is likely that tunnel construction would be performed by a tunnel boring machine or earth pressure balance tunneling machine. During tunneling ground loss can occur that could lead to ground surface settlement. Possible pipe breakage in the event of ground surface rupture with earthquake on Hollywood-Raymond fault. This could allow ground loss that could lead to ground surface settlement. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the tunnel and its associated structures would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.
GBIS South Alignment	No impact is anticipated. Although some of the tunnel is located within an area subject to liquefaction, the structures would either be below the liquefiable depth, or designed to take into account effects of liquefaction. Construction and operation of the tunnel and its associated structures would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	Potential impact exists. It is likely that tunnel construction would be performed by a tunnel boring machine or earth pressure balance tunneling machine. During tunneling ground loss can occur that could lead to ground surface settlement. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the tunnel and its associated structures would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
GBIS North Alignment	No impact is anticipated. Although some of the tunnel is located within an area subject to liquefaction, the structures would either be below the liquefiable depth, or designed to take into account effects of liquefaction. Construction and operation of the tunnel and its associated structures would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	Potential impact exists. It is likely that tunnel construction would be performed by a tunnel boring machine or earth pressure balance tunneling machine. During tunneling, ground loss can occur that could lead to ground surface settlement. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the tunnel and its associated structures would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.
Program-Level			
VSLIS	No impact is anticipated. Although some of the tunnel is located within an area subject to liquefaction, the structures would either be below the liquefiable depth, or designed to take into account effects of liquefaction. Construction and operation of the tunnel and its associated structures would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	Potential impact exists. It is likely that tunnel construction would be performed by a tunnel boring machine or earth pressure balance tunneling machine. During tunneling, ground loss can occur that could lead to ground surface settlement. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the tunnel and its associated structures would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
Recycled Water	No impact is anticipated. Although some of these components could be in areas subject to geologic hazards, such as liquefaction, geotechnical studies would be prepared to incorporate concerns regarding geologic hazards. Construction and operation of the component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	No impact is anticipated. Settlement of trench back fill is a concern; However, established backfilling and compaction methods would be employed to keep potential post construction settlement to acceptable levels. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the component would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.
DWR – Smart Irrigation	No impact is anticipated. Smart irrigation components would be of small scale, involving very limited earthwork, if any. Therefore, construction and operation of the component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	No impact is anticipated. Earthwork would be minor and erosion from runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water.	No impact is anticipated. Construction and operation of the component would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
DWR – LF Divisions	No impact is anticipated. Low flow diversions require fairly shallow earthwork and are not of a large aerial extent. Therefore, construction and operation of the component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	No impact is anticipated. The low flow diversions in coastal and inland areas could settle or be damaged if they could occur in areas subject to liquefaction. However, compliance with design and/or construction recommendations in the project-level geotechnical studies that would be prepared as a standard practice during the predesign process would keep potential liquefaction-related impacts within acceptable levels. Erosion from runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the component would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
DWR – URP or TW	No impact is anticipated. Although some of these components could be in areas subject to geologic hazards, such as liquefaction, geotechnical studies would be prepared to incorporate concerns regarding geologic hazards. Construction and operation of the component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	No impact is anticipated. If an URP is placed in an area subject to liquefaction or strong ground shaking it could settle or become damaged. However, design and construction in compliance with regulations, standard specifications, and project-level geotechnical studies would reduce the risk of damage from liquefaction and ground shaking to professionally acceptable levels. Treatment wetlands would be subject to cyclical and intentional inundation, which could result in potential offsite sediment transport. However, sediment management features such as settling basins would be incorporated into the wetland designs to minimize the potential for offsite sediment transport. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the component would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
WWR – Onsite Management	No impact is anticipated. Although some of these components could be in areas subject to geologic hazards, such as liquefaction, geotechnical studies would be prepared to incorporate concerns regarding geologic hazards. Construction and operation of the component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	No impact is anticipated. Settlement of the ground surface can occur when groundwater recharge is accomplished by spreading the water over an area. However, design and construction in compliance with regulations, standard specifications, and recommendations in project-level geotechnical studies would reduce the risk of damage from settlement. Erosion from runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the component would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
WWR – Urban Treatment Plants	No impact is anticipated. Although some of these components could be in areas subject to geologic hazards, such as liquefaction, geotechnical studies would be prepared to incorporate concerns regarding geologic hazards. Construction and operation of the component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	No impact is anticipated. If an Urban Treatment Plant is placed in an area subject to liquefaction and ground shaking it could settle or become damaged. However, design and construction in compliance with regulations, standard specifications, and recommendations in project-level geotechnical studies would reduce the risk of damage from liquefaction or ground shaking from an earthquake to professionally acceptable levels. Erosion from runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the component would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

Table 3.9-3. Geology and Soils Component Impact Summary Table
Integrated Resources Plan EIR

Component	Significance Threshold		
	Geologic Hazards	**Instability from Erosion, Expansion, or Settlement**	**Mineral Resources**
WWR – Non-Urban Recharge	No impact is anticipated. Although some of these components could be in areas subject to geologic hazards, such as liquefaction, geotechnical studies would be prepared to incorporate concerns regarding geologic hazards. Construction and operation of the component would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.	No impact is anticipated. If this component were located in an area where hydroconsolidation or liquefaction was a concern, it could settle or become damaged. However, compliance with design and/or construction recommendations in the project-level geotechnical studies would ensure that potential liquefaction-related impacts are kept at acceptable levels. Substantial settlement impacts are not anticipated with open-trench construction from established backfilling and compaction methods (mechanical compaction in layers or water jetting as appropriate). Erosion from runoff would be prevented by design and construction of nonerosive drainage devices to control and properly direct runoff water. To protect against instability from erosion, expansion or settlement, and offsite sediment runoff or deposition prior to earthwork a geotechnical study would be prepared during design to evaluate geology and soil conditions and concerns.	No impact is anticipated. Construction and operation of the component would not result in the loss of availability of a known mineral resource that is of value to the region and the residents of the state.

3.9.3.3 Alternative Impacts

Alternative 1

Potential primary and secondary geologic and soils impacts from Alternative 1 are discussed below.

Impact GEO-1

Primary Impacts. Under Alternative 1, the construction of treatment plant improvements would occur. Improvements at Hyperion would not cause or accelerate geologic hazards because existing hazardous geologic conditions do not exist on. For Tillman and LAG, which are within a potential liquefaction zone, compliance with standard specifications and recommendations in project-level geotechnical studies would keep potential liquefaction impacts and related risks of hazards or damage to acceptable levels. The proposed treatment plant projects are not within a currently established Alquist-Priolo Earthquake Fault Zone for surface fault rupture hazards. Based on the available geologic data, active or potentially active faults with the potential for surface fault rupture are not known to be located directly beneath or projecting toward the other existing projects. Therefore, the potential for ground-surface rupture from fault movement caused by an earthquake at the site during the design life of the Project is considered low. Consequently, the treatment plant improvements under Alternative 1 would not result in significant impacts related to the potential to accelerate or exacerbate geologic hazards that could result in damage or hazard risks.

The City of Los Angeles Safety Element Exhibit "Inundation & Tsunami Hazard Areas" illustrates Hyperion to be outside the coastal area of potential tsunami impact (City of Los Angeles, 1996). Therefore, the proposed Hyperion expansion construction is not considered at risk of damage in the event of a tsunami.

The NEIS II alignments and the GBIS alignments under Alternative 1 lie partially or wholly within a state-defined potential liquefaction zone. However, current design information indicates these pipe alignments would be located at depths beneath the susceptible soils. Therefore, these project components would not result in damage or substantial increase in hazard risks. In situations where NEIS II and GBIS accessory structures would be constructed in areas of potential liquefaction, compliance with the recommendations in the project-level geotechnical studies, prepared as a standard practice during the predesign process, would keep potential risks of damage from liquefaction to an acceptable level.

Also the NEIS II West Alignment would be located along the toe of the Elysian Hills, which has experienced landslides in the past; however, the alignment would be located below the depth of potential slip planes. Therefore the NEIS II West Alignment would not cause or accelerate landslides in the Elysian Hills, and significant impacts are not anticipated.

Dewatering activities could be necessary for construction of infrastructure facilities and shallow pipe installation for various components of

Alternative 1. Construction works that require such dewatering likely would take place in areas of alluvial soil, which generally have high transmissivity rates. In such cases, for measurable ground settlement to occur as a result of dewatering, the dewatering activities would have to be long term and of withdrawal quantities that would substantially lower the regional water table. Some dewatering would be necessary but construction techniques being considered would not allow the overall regional water table to be lowered. Therefore, significant impacts are not expected.

The NEIS II sewer alignment crosses the Hollywood-Raymond fault, which is considered to be active, and the GBIS sewer alignment crosses the Benedict Canyon fault, which is considered to be inactive. The Hollywood-Raymond fault has the potential to cause several meters of ground-surface displacement in the event of an earthquake. The Benedict Canyon fault is considered inactive; therefore, its crossing is not expected to result in impacts.

In summary, tunneling operations for the NEIS II, GBIS, and VSLIS alignments might, depending on construction practice, result in ground-loss propagation to the surface resulting in substantial ground settlement. Potential ground-surface settlement associated with ground loss during the tunneling operation is addressed under the Impact GEO-2 section. Additionally, the potential exists for pipe breakage as a result of ground-surface rupture where the NEIS II alignment crosses the Hollywood-Raymond fault.

Although the program-level components of Alternative 1 would be constructed in potential liquefaction zones, none is expected to result in or exacerbate geologic hazards. The components would be located at depths below soils prone to liquefaction, be subject to standard design specifications, and/or they would comply with the design recommendations and measures in the component-level geotechnical studies that would be prepared during the predesign process, to keep the potential risks of damage from liquefaction to an acceptable level.

With the exception of potential sewer pipe breakage at the Hollywood-Raymond fault crossing for NEIS II, construction and operation of Alternative 1 would not cause, accelerate, or exacerbate geologic hazards that would result in substantial damage to structures or infrastructure, or that would expose people to increased risk of hazards.

Secondary Impacts. Catastrophic break of the NEIS II sewer from rupture during an earthquake event on the Hollywood-Raymond fault could result in sewage spillage into the groundwater aquifer. This could adversely affect groundwater quality. A discussion of this potential impact is presented in Section 3.4 – Hydrology and Water Quality.

Mitigation. The following mitigation measures would be implemented during the design and/or construction phase of the Project.

GEO-MM-1
For the potential of sewer pipe breakage at the Hollywood-Raymond fault crossing for NEIS II, the City of Los Angeles will reroute flows to the maximum extent, and then repair the break as soon as possible. The City of Los Angeles also will conduct a detailed subsurface investigation for NEIS II, including drilling borings and soil sample collection, to more accurately locate the trace of the Hollywood-Raymond fault and to analyze soil/bedrock conditions in the area of where the pipelines cross the faults.

The geotechnical investigation will identify design recommendations and options for addressing the fault crossings, including the following:

- Consider the recent study by Jacobs Associates (Jacobs) of NEIS II design alternatives at the Hollywood-Raymond fault crossing that give consideration to several construction design features to mitigate and/or minimize the potential damage to the pipe in the event the fault moves (Jacobs, 2005). Two linings could be used for the pipe along with short pipe segments to spread the offset over a larger number of joints. Another alternative would be to use a welded-steel lining and cement grout to enhance the structural capacity and ductility.
- Consider a vault reach, where an enlarged cavern would be constructed to allow the carrier pipe to deform across the zone of offset in a controlled manner. With the addition of maintenance shafts, this vault could allow for inspection and repair of the pipeline at the fault crossing. Vault construction is dependent on the soil/bedrock conditions to be determined in future investigations.
- Consider a design option that provides a larger tunnel and lining diameter for the reach that crosses the fault zone. This option is advantageous if the location of the fault offset is uncertain and if ground conditions are not favorable for vault construction.

Impacts after Mitigation. After incorporation of mitigation measure GEO-MM-1, the potential for a break in the NEIS II sewer pipe at the location of the Hollywood-Raymond fault crossing still would exist in the event of ground-surface rupture on the fault during an earthquake. Although remote, this would be considered a significant and unavoidable impact.

The potential for seismic activity on the Benedict Canyon fault is so low that the risk of breakage of the GBIS at the fault crossing would be considered insignificant.

Impact GEO-2
Primary Impacts. The NEIS II, GBIS, and VSLIS alignments pass through areas that have near-surface soils with a potential for settlement in the event that ground loss occurs during the tunneling operation. However, a tunnel that would be constructed within the bedrock, or below the groundwater table in

earth-pressure-balance mode, would be less likely to cause ground loss and associated ground settlement at the surface. Nonetheless, the potential exists for significant settlement impact.

Secondary Impacts. Potential ground loss associated with the tunneling operations for NEIS II, GBIS, and VSLIS could result in settlement at the ground surface. Such settlement could adversely affect structures, such as buildings, located over the distressed area.

Mitigation

GEO-MM-2

- Require the construction contractor to limit settlement to less than 0.75-inch (19 mm) in the public right-of-way as a performance standard. Require additional preconstruction geotechnical studies to define the nature of the soils and to refine the means of achieving the performance specification.
- Require the use of compaction grouting or other method to fill voids where appropriate and offset potential settlement when excess material has been removed during excavation.
- Grout the tunnel in advance to provide adequate soil support and minimize settlement as geotechnical conditions require. This will be required in cases where major structures need more stringent settlement criteria than the 0.75-inch (19 mm) specified earlier.
- Monitor settlement along the Project alignment using a series of settlement monuments and other measuring devices above the route of the selected alignment. Leveling surveys will be conducted before tunneling reaches a given area when the heading is in the immediate vicinity, to monitor possible ground movements.
- Conduct a preconstruction survey of buildings, including dwellings, to establish a baseline against which potential construction-induced damage would be measured.
- Describe and define in the contract specifications for tunnel construction the monitoring requirements for the tunneling operation with regard to performance criteria. During the tunneling operation, the soils encountered will be monitored relative to the anticipated soil conditions as described in the Geotechnical Baseline Report.
- Specify the capability of the earth pressure balance or slurry shield tunneling machines to process large cobbles and boulders to minimize settlement. Tunnel machine selection and method of operation will be based on anticipated ground conditions.
- Consult and coordinate with the USACE prior to the start of construction regarding construction methods and performance criteria in the Los Angeles River crossings.

Areas of potential ground loss from tunnel operations for NEIS II, GBIS, and VSLIS will be identified during and immediately after tunneling, and mitigation measures will be implemented. However, settlement associated with the tunneling operation could occur within days and months of construction.

Impacts after Mitigation. After incorporation of mitigation measure GEO-MM-2, a risk of ground loss and associated ground-surface settlement from the tunneling operations would exist for NEIS II, GBIS, and VSLIS.

Impact GEO-3
Primary Impacts. No significant impact would result from construction and operation of Alternative 1 from the loss of availability of a known mineral resource that is of value to the region and residents of the state.

Secondary Impacts. Because no impacts would be anticipated from the loss of availability of a known mineral resource that is of value to the region and residents of the state, no secondary impacts would be anticipated.

Mitigation. No mitigation is required.

Impacts after Mitigation. No impact is anticipated.

Alternative 2

Impact GEO-1
Potential primary and secondary geologic and soils impacts from Alternative 2 are discussed below.

Primary Impacts. Primary GEO-1 impacts associated with Alternative 2 generally are identical to those of Alternative 1 for the following components: Tillman wastewater storage, NEIS II, GBIS, VSLIS, Dry Weather Smart Irrigation, Dry Weather Low-Flow Diversions, Wet Weather Onsite Management (capture/percolation and cisterns), Wet Weather Non-Urban Recharge, and Wet Weather URPs.

Alternative 2 includes more upgrades to the Tillman and LAG wastewater treatment plants than Alternative 1. Alternative 2 also includes creation of URPs and treatment wetlands in the San Fernando Valley. However, no additional primary GEO-1 impacts have been identified.

Secondary Impacts. Secondary impacts are limited to those previously identified under Alternative 1. No additional secondary impacts have been identified.

Mitigation. The mitigation measure (GEO-MM-1) under Alternative 1 is the same for Alternative 2.

Impacts after Mitigation. As with Alternative 1, after the incorporation of GEO-MM-1, a break in the NEIS II sewer at the location of the Hollywood-Raymond fault crossing still exists; therefore, this would be considered a significant and unavoidable impact.

Impact GEO-2

Primary Impacts. Primary GEO-2 impacts associated with Alternative 2 are identical to those of Alternative 1 for the following components: Tillman wastewater storage, NEIS II, GBIS, VSLIS, Dry Weather Smart Irrigation, Dry Weather Low-Flow Diversions, Wet Weather Onsite Management (capture/percolation and cisterns), Wet Weather Non-Urban Recharge, and Wet Weather URPs.

Additional Primary GEO-2 impacts are identified for the Dry Weather Runoff – Urban Runoff Plants or Treatment Wetlands. A potential exists for hazard from liquefaction- and seismic-related impacts to these proposed components in state-identified potential liquefaction areas subject to ground shaking. However, design and construction in compliance with regulations, standard specifications, and project-level geotechnical studies would reduce the risk of damage from liquefaction and ground shaking from an earthquake. Also, treatment wetlands would be subject to cyclical and intentional inundation, which could result in potential offsite sediment transport. However, sediment management features such as settling basins would be incorporated into the wetland designs to minimize the potential for offsite sediment transport.

Secondary Impacts. No secondary GEO-2 impacts would be associated with Alternative 2.

Mitigation. The mitigation measures (GEO-MM-2) under Alternative 1 is the same for Alternative 2.

Impacts after Mitigation. As with Alternative 1, after incorporation of mitigation, a risk of ground loss and associated ground surface settlement from the tunneling operations would exist for NEIS II, GBIS, and VSLIS.

Impact GEO-3

Primary Impacts. No significant impact would result from Alternative 2 from the loss of availability of a known mineral resource that is of value to the region and residents of the state.

Secondary Impacts. No secondary GEO-3 impacts would be associated with Alternative 2.

Mitigation. No mitigation is required.

Impacts after Mitigation. No impacts are anticipated.

Alternative 3

Potential primary and secondary geologic and soils impacts from Alternative 3 are discussed below.

Impact GEO-1

Primary Impacts. Primary GEO-1 impacts associated with Alternative 3 are identical to those of Alternative 1 for the following components: Tillman wastewater storage, NEIS II, GBIS, VSLIS, Dry Weather Smart Irrigation, Dry

Weather Low-Flow Diversions, Wet Weather Onsite Management (capture and percolation), and Wet Weather URPs.

Primary GEO-1 impacts associated with Alternative 3 would be similar to those of Alternatives 1 and 2 described above.

Note that Alternative 3 differs from Alternatives 1 and 2 in that it would include an expansion of Tillman to 100 mgd. Although the expansion of Tillman under Alternative 3 would include more buried tanks and other infrastructure, no new GEO-1 impacts are identified because earthwork for tank construction would be included in the Alternative 1 and 2 analyses. No new primary impacts have been identified.

Secondary Impacts. Secondary impacts are limited to those previously identified under Alternatives 1 and 2. No additional secondary impacts have been identified.

Mitigation. The mitigation measure (GEO-MM-1) under Alternative 1 is the same for Alternative 3.

Impacts after Mitigation. As with Alternative 1, after the incorporation of mitigation, a break in the NEIS II sewer at the location of the Hollywood-Raymond fault crossing still exists; therefore, this would be considered a significant and unavoidable impact.

Impact GEO-2

Primary Impacts. Primary GEO-2 impacts associated with Alternative 2 would be identical to those of Alternative 1 for the following components: Tillman wastewater storage, NEIS II, GBIS, VSLIS, Dry Weather Smart Irrigation, Wet Weather Onsite Management (capture and percolation), Wet Weather Cisterns, Wet Weather Non-Urban Recharge, and Wet Weather URPs.

Primary GEO-2 impacts associated with Alternative 3 would be identical to those of Alternatives 1 and 2 for the following components: Tillman wastewater storage, NEIS II, GBIS, VSLIS, Dry Weather Smart Irrigation, Wet Weather Onsite Management (capture and percolation), Wet Weather Non-Urban Recharge, and Wet Weather URPs.

Settlement and erosion related impacts associated with program-level component impacts (see 3.9.4.3) for Dry Weather Runoff – Urban Runoff Plants or Treatment Wetlands would be similar to those described under Primary GEO-1 Impacts.

Secondary Impacts. No secondary GEO-2 impacts would be associated with Alternative 3.

Mitigation. The mitigation measure (GEO-MM-2) under Alternative 1 is the same for Alternative 3.

Impacts after Mitigation. As with Alternative 1, after incorporation of mitigation, a risk of ground loss and associated ground-surface settlement from the tunneling operations would exist for NEIS II, GBIS, and VSLIS.

Impact GEO-3
Primary Impacts. No significant impact would result from Alternative 3 from the loss of availability of a known mineral resource that is of value to the region and residents of the state.

Secondary Impacts. No secondary GEO-3 impacts are associated with Alternative 3.

Mitigation. No mitigation is required.

Impacts after Mitigation. No impacts are anticipated.

Alternative 4

Potential primary and secondary geologic and soils impacts from Alternative 4 are discussed below.

Impact GEO-1
Primary Impacts. Primary GEO-1 impacts associated with Alternative 4 would be similar to those of Alternatives 1, 2, and 3 described above. No components in Alternative 4 would be different than those previously discussed in Alternatives 1, 2, and 3.

Secondary Impacts. Secondary impacts would be limited to those previously identified with Alternatives 1, 2, and 3.

Mitigation. The mitigation measure (GEO-MM-1) under Alternative 1 is the same for Alternative 4.

Impacts after Mitigation. As with Alternative 1, after the incorporation of mitigation, a break in the NEIS II sewer at the location of the Hollywood-Raymond fault crossing still exists; therefore, it would be considered a significant and unavoidable impact.

Impact GEO-2
Primary Impacts. Settlement and erosion-related impacts associated with program-level component impacts (see 3.9.4.3) for Dry Weather Runoff – Urban Runoff Plants or Treatment Wetlands would be similar to those described under Primary GEO-1 Impacts.

Secondary Impacts. No secondary GEO-2 impacts would be associated with Alternative 4.

Mitigation. The mitigation measure (GEO-MM-2) under Alternative 1 is the same under Alternative 4.

Impacts after Mitigation. As with Alternative 1, after incorporation of mitigation, a risk of ground loss and associated ground-surface settlement from the tunneling operations would exist for NEIS II, GBIS, and VSLIS.

Impact GEO-3
Primary Impacts. No significant impact would result from Alternative 4 from the loss of availability of a known mineral resource that is of value to the region and residents of the state.

Secondary Impacts. No secondary GEO-3 impacts would be associated with Alternative 4.

Mitigation. No mitigation is required.

Impacts after Mitigation. No impacts are anticipated.

No Project Alternative

The No Project Alternative, for purposes of this EIR, is no action. Under this Alternative, integrated improvements to the wastewater treatment and collection system, recycled water system, or runoff system will not occur.

However, individual wastewater, recycled water, or runoff projects will still likely be necessary to meet regulatory requirements and future demands, but such individual projects will be designed and constructed as the needs arise rather than being planned in a systemwide integrated manner. In this case, each individual project will be subject to its own environmental clearance in the future.

Impact GEO-1
Potential primary and secondary impacts resulting from the No Project Alternative are discussed below.

Primary Impacts. Under the No Project Alternative, no impacts will occur to the geologic conditions because none of the proposed integrated wastewater, recycled water, or runoff improvements throughout the City of Los Angeles will be constructed. Biosolids will continue to be generated at Hyperion and sent to the Green Acres Farm in Kern County for land application under the existing contract. The planning, design, and implementation of wastewater, recycled water, and runoff improvements will continue to be pursued on an individual project basis by the various departments and bureaus of the City of Los Angeles as demand requires and resources become available.

In the long term, however, various wastewater, recycled water, and runoff projects would be necessary to protect public health and safety or to meet regulatory requirements, as defined in the objectives for the IRP (see Section 1.3). In the absence of an integrated resources planning process for the City of Los Angeles wastewater system, projects would continue to be implemented individually. The individual projects, however, would be constructed at unknown future dates and would not benefit from incremental consideration of various trigger mechanisms (discussed in Sections 2.4.1, 2.4.2, and 2.4.3) for maximizing efficiencies based on objectives of the IRP.

Secondary Impacts. The No Project Alternative is void of components that will result in physical changes to the environment, which, in turn, could have secondary impacts to the geologic conditions or surrounding infrastructure. Consequently, significant secondary geotechnical impacts would not occur.

Mitigation. No mitigation is required.

Impacts after Mitigation. No impacts are anticipated.

Impact GEO-2
Potential primary and secondary impacts resulting from the No Project Alternative are discussed below.

Primary Impacts. Under the No Project Alternative, no impacts will occur to the geologic conditions because none of the proposed integrated wastewater, recycled water, or runoff improvements throughout the City of Los Angeles would be constructed. Biosolids will continue to be generated at Hyperion and sent to the Green Acres Farm in Kern County for land application under the existing contract. The planning, design, and implementation of wastewater, recycled water, and runoff improvements will continue to be pursued on an individual project basis by the various City departments and bureaus as demand requires and resources become available.

In the long term, however, various wastewater, recycled water, and runoff projects will be necessary to protect public health and safety or to meet regulatory requirements, as defined in the objectives for the IRP (see Section 1.3). In the absence of an integrated resources planning process for the City of Los Angeles wastewater system, projects will continue to be implemented individually. The individual projects, however, will be constructed at unknown future dates and will not benefit from incremental consideration of various trigger mechanisms (discussed in Sections 2.4.1, 2.4.2, and 2.4.3) for maximizing efficiencies based on objectives of the IRP.

Secondary Impacts. The No Project Alternative is void of components that will result in physical changes to the environment, which, in turn, could have secondary impacts to the geologic conditions or surrounding infrastructure. Consequently, significant secondary geotechnical impacts will not occur.

Mitigation. No mitigation is required.

Impacts after Mitigation. No impacts are anticipated.

Impact GEO-3
Potential primary and secondary impacts resulting from the No Project Alternative are discussed below.

Primary Impacts. Under the No Project Alternative, no impacts will occur to the geologic conditions because none of the proposed integrated wastewater, recycled water or runoff improvements throughout the City of Los Angeles would be constructed. Biosolids will continue to be generated at Hyperion and sent to the Green Acres Farm in Kern County for land application under the existing contract. The planning, design, and implementation of wastewater, recycled water and runoff improvements will continue to be pursued on an individual project basis by the various departments and bureaus of the City of Los Angeles as demand requires and resources become available.

In the long term, however, various wastewater, recycled water, and runoff projects will be necessary to protect public health and safety or to meet regulatory requirements, as defined in the objectives for the IRP (see Section 1.3). In the absence of an integrated resources planning process for the City of Los Angeles wastewater system, projects will continue to be implemented individually. The individual projects, however, will be constructed at unknown future dates and will not benefit from incremental consideration of various trigger mechanisms (discussed in Sections 2.4.1, 2.4.2, and 2.4.3) for maximizing efficiencies based on objectives of the IRP.

Secondary Impacts. The No Project Alternative is void of components that will result in physical changes to the environment, which, in turn, could have secondary impacts to the geologic conditions or surrounding infrastructure. Consequently, significant secondary geotechnical impacts will not occur.

Mitigation. No mitigation is required.

Impacts after Mitigation. No impacts are anticipated.

3.9.3.4 Cumulative Impacts

With the exception of the NEIS II crossing of the Hollywood-Raymond fault, none of the Proposed Project Alternatives would result in causing or exacerbating geologic hazards. None of the related plans or projects is expected to cause or result in geologic hazards. Although a possibility exists that NEIS II could break from fault rupture, such a break would occur up to 180 feet below the ground surface and would not accelerate other geologic hazards. As a consequence, none of the Project Alternatives would result in significant cumulative impacts related to geologic hazards.

During construction of the NEIS II, GBIS, and VSLIS, soil instability associated with potential ground loss at the tunneling face and subsequent settlement of soil could result for any of the Project Alternatives. This is a project-level impact that is unique to tunneling projects. None of the other related projects is expected to result in soil instability at or near the NEIS II, GBIS, or VSLIS alignments because they are not located near the component alignments or confined to the surface or near surface. Consequently, the construction and operation of the Alternatives in conjunction with the associated projects would not result in significant cumulative impacts related to instability from settlement.

None of the Alternatives would result in impacts to mineral resources; therefore, the Alternatives would not contribute to a cumulatively considerable impact.