CHAPTER 10 – GEOLOGY, SEISMICITY AND SOILS

INTRODUCTION

This chapter describes the environmental setting (existing conditions and regulatory setting) for regional geology, topography, and seismic hazards, as well as current soil conditions in the MTP Plan Area. This chapter also presents the federal, state, and local policies and regulations that determine mitigation requirements and identifies impacts on geologic and soil resources, and seismic hazards that may result from implementation of the proposed MTP 2035 projects, and mitigation measures to reduce these impacts where necessary.

The study area consists of transportation routes, including highways, rail alignments, bicycle trails, state routes, roads, and Caltrans rights-of-way in the MTP Plan Area. The key sources of data and information used in the preparation of this section are listed below:

- Guidelines for Evaluating and Mitigating Seismic Hazards in California published by the California Division of Mines and Geology
- Fault-Rupture Hazard Zones in California: Alquist-Priolo Earthquake Fault Zoning Act with index to Earthquake Fault Zone Maps published by the California Division of Mines and Geology
- Fault Activity Map of California and Adjacent Areas published by the California Division of Mines and Geology
- Seismic Shaking Hazards in California published by the California Geological Survey

The information presented in this chapter is based on a review of existing and available information and is regional in scope. Data provided in this section should be considered preliminary and appropriate for general policy planning and tiering of subsequent environmental documents. Site-specific evaluations will be necessary to determine future project-level environmental effects and appropriate mitigation.

SETTING

Environmental Setting

Geology and Topography

This section addresses the geology and topography of the MTP Plan Area. Quaternary sediments and geologic hazards pertaining to the MTP Plan Area are emphasized. The project area is located in six separate counties within the Great Valley geomorphic province and the Sierra Nevada geomorphic province. Both geomorphic provinces are discussed below.

Regional Physiographic Setting of the MTP Plan Area

The Great Valley of California, also called the Central Valley of California, is a nearly flat alluvial plain extending from the Tehachapi Mountains at the south to the Klamath Mountains at the north, and from the Sierra Nevada on the east to the Coast Ranges on the west. The valley is about 450 miles long and has an average width of about 50 miles. Elevations of the alluvial plain are generally just a few hundred feet above mean sea level (MSL), with extremes ranging from a few feet below MSL to about 1,000 feet above MSL (Hackel 1966).

The Sierra Nevada is a strongly asymmetric mountain range with a long gentle western slope and a high and steep eastern escarpment. It averages 50 to 80 miles wide, and it runs west of north through eastern California for more than 400 miles – from the Mojave Desert on the south to the Cascade Range and the Modoc Plateau on the north (Bateman and Wahrhaftig 1966).

Geology and Topography of the MTP Plan Area

Geologically, the Great Valley geomorphic province is a large, elongate, northwest-trending asymmetric structural trough that has been filled with an extremely thick sequence of predominantly alluvial sediments ranging in age from Jurassic to Recent. This asymmetric geosyncline has a long stable eastern shelf supported by the subsurface continuation of the granitic Sierran slope and a short western flank expressed by the upturned edges of the basin sediments (Hackel 1966).

The Sierra Nevada is a huge block of the earth's crust that has broken free on the east along the Sierra Nevada fault system and has been tilted westward. It is overlapped on the west by sedimentary rocks of the Great Valley geomorphic province and on the north by volcanic sheets extending south from the Cascade Range. A blanket of volcanic material caps large areas in the north part of the range (Bateman and Wahrhaftig 1966).

Most of the south half of the Sierra Nevada and the eastern part of the north half are composed of plutonic (chiefly granitic) rocks of Mesozoic age. These rocks constitute the Sierra Nevada batholith. In the north half of the range, the batholith is flanked on the west by the western metamorphic belt, a terrane of strongly deformed, but weakly metamorphosed sedimentary and volcanic rocks of Paleozoic and Mesozoic age. The batholith extends eastward to the east edge of the range (Bateman and Wahrhaftig 1966).

The topographic features of the MTP Plan Area vary, depending upon physiography. The topography of the western MTP Plan Area is generally typical of an alluvial valley influenced by sediment introduction from the Sierra Nevada and its foothills. From southwest to northeast, topographic features consist of the Sacramento-San Joaquin Delta (Delta), flat alluvial valleys, river floodplains and channels, low alluvial plains and fans, and dissected uplands. The eastern portion of the MTP Plan Area generally consists of rocky foothills that increase in elevation to the east to become the Sierra Nevada crest. Elevations in the MTP Plan Area presently range from approximately below sea level on the western edge of the MTP Plan Area to over 10,000 feet on the Sierra Nevada crest of eastern edge of the MTP Plan Area.

Seismicity

Seismic hazards are earthquake fault ground rupture and ground shaking (primary hazards) and liquefaction and earthquake-induced slope failure (secondary hazards). When compared to other areas of the State (e.g. the San Francisco Bay Region), the MTP Plan Area is not located in a very seismically active region. However, with respect to fault rupture, earthquakes have occurred in the vicinity of the MTP Plan Area in the past and can be expected to occur again in the future. Accordingly, ground shaking and liquefaction are the most critical seismic hazards in the MTP Plan Area.

Surface Rupture and Faulting

The purpose of the Alquist-Priolo Earthquake Fault Zoning Act (Alquist-Priolo Act) is to regulate development near active faults to mitigate the hazard of surface rupture. Faults in an Alquist-Priolo Earthquake Fault Zone are typically active faults. As defined under the Alquist-Priolo Act, an active fault is one that has had surface displacement within Holocene time (about the last 11,000 years). An early Quaternary fault is one that has had surface displacement during Quaternary time (the last 1.6 million years). A pre-Quaternary fault is one that has had surface displacement before the Quaternary period. Only faults officially recognized by the State of California under the Alquist-Priolo Act or faults recognized by the Uniform Building Code (UBC) are subject to mitigation (Hart and Bryant 1997).

Only two active faults occur within the MTP Plan Area, the Dunnigan Hills fault in Yolo County (Jennings 1994) and the Hunting Creek fault (Hart and Bryant 1997; International Conference of Building Officials 1994; Jennings 1994). The Dunnigan Hills fault is not within an Alquist-Priolo Earthquake Fault Zone (Hart and Bryant 1997) nor mapped by the UBC (International Conference of Building Officials 1994). The Hunting Creek fault is within an Alquist-Priolo Earthquake Fault Zone (Hart and Bryant 1997) and is mapped by the UBC as a Type B seismic source (International Conference of Building Officials 1994). The Hunting Creek fault is located in the western-most portion of Yolo County in remote topography.

However, there are numerous early Quaternary and pre-Quaternary faults within the MTP Plan Area, as shown in Figure 10-1. In brief, most fault activity is centered on the western margins of El Dorado and Placer counties. These faults and fault complexes are associated with the Foothills Fault System. Most of these faults are early Quaternary in nature and have not recorded significant movement during the last 10,000 years. However, recent evidence suggests that buried thrust faults and inferred faults are located in the boundaries of the MTP Plan Area. These faults are not officially recognized yet by the State of California or the UBC, but they are potential seismic sources. The buried thrust faults and inferred thrust faults are not listed in Alquist-Priolo Earthquake Fault Zones because they do not have surface ruptures and are not officially recognized.

Ground-Shaking Hazard

The MTP Plan Area is located in UBC Seismic Hazard Zone 3. Structures must be designed to meet the regulations and standards associated with Zone 3 hazards. As mentioned above, the MTP Plan Area is located in a region of California characterized by historically low seismic activity. Additionally, the UBC recognizes no active seismic sources in the MTP Plan Area vicinity (International Conference of Building Officials 1994).

The measurement of the energy released at the point of origin, or epicenter, of an earthquake is referred to as the magnitude, which is generally expressed in the Richter Magnitude Scale or as moment magnitude. The scale used in the Richter Magnitude Scale is logarithmic so that each successively higher Richter magnitude reflects an increase in the energy of an earthquake of about 31.5 times. Moment magnitude is the estimation of an earthquake magnitude by using seismic moment, which is a measure of an earthquake size utilizing rock rigidity, amount of slip, and area of rupture.

The greater the energy released from the fault rupture, the higher the magnitude of the earthquake. Earthquake energy is most intense at the fault epicenter; the farther an area from an earthquake epicenter, the less likely that ground shaking will occur there. Geologic and soil units comprising unconsolidated, clay-free sands and silts can reach unstable conditions during ground shaking, which can result in extensive damage to structures built on them (see “Liquefaction and Related Hazards” below).

Ground shaking is described by two methods: ground acceleration as a fraction of the acceleration of gravity (g) or the Modified Mercalli scale, which is a more descriptive method involving 12 levels of intensity denoted by Roman numerals. Modified Mercalli intensities range from I (shaking that is not felt) to XII (total damage).

The intensity of ground shaking that would occur in the MTP Plan Area as a result of an earthquake is partly related to the size of the earthquake, its distance from the MTP Plan Area, and the response of the geologic materials within the MTP Plan Area. As a rule, the greater earthquake magnitude and the closer the fault rupture to the site, the greater the intensity of ground shaking. When various earthquake scenarios are considered, ground-shaking intensities will reflect both the effects of strong ground accelerations and the consequences of ground failure.

Estimates of Earthquake Shaking

The MTP Plan Area is located in a region of California characterized by a generally low ground-shaking hazard. Based on a probabilistic seismic hazard map that depicts the peak horizontal ground acceleration values exceeded at a 10% probability in 50 years (Cao et al. 2003; California Geological Survey 2006), the probabilistic peak horizontal ground acceleration values in the MTP Plan Area range from less than 0.1 to 0.3g, where one *g* equals the force of gravity, thus indicating that the ground-shaking hazard in the MTP Plan Area is low (Figure 10-1). The highest *g* values occur in the extreme western portions of Sacramento and Yolo counties. Farther to the east (i.e., the majority of the MTP Plan Area), the ground-shaking hazard decreases, coinciding with the decrease in abundance of associated faults and fault complexes. Ground-shaking hazard then increases toward the easternmost portions of the MTP Plan Area, specifically the eastern portions of Placer and El Dorado counties.

Liquefaction and Related Hazards

Liquefaction is a phenomenon in which the strength and stiffness of unconsolidated sediments are reduced by earthquake shaking or other rapid loading. Poorly consolidated, water-saturated fine sands and silts having low plasticity and located within 50 feet of the ground surface are typically considered to be the most susceptible to liquefaction. Soils and sediments that are not water-saturated and that consist of coarser or finer materials are generally less susceptible to liquefaction (California Division of Mines and Geology 1997). Based on the sedimentological characteristics of the soils and the depth to groundwater, liquefaction hazard is expected to be moderate for the portion of the MTP Plan Area within the Great Valley geomorphic province and low for the portion of the MTP Plan Area within the Sierra Nevada geomorphic province.

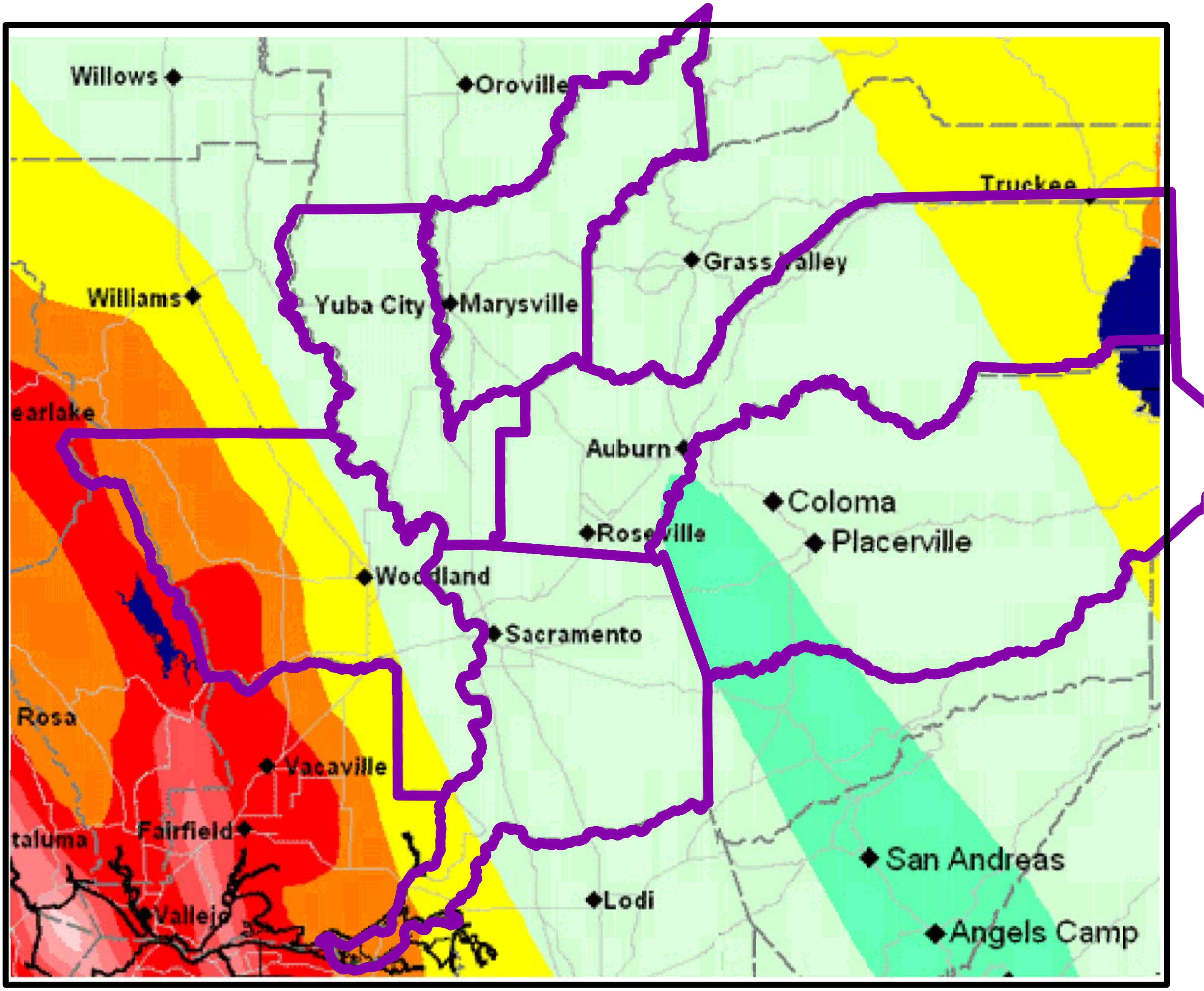
Two potential ground failure types associated with liquefaction in the Great Valley geomorphic province are lateral spreading and differential settlement (Association of Bay Area Governments 2001). Lateral spreading involves a layer of ground at the surface being carried on an underlying layer of liquefied material over a gently sloping surface toward a river channel or other open face. Lateral spreading is common in the Great Valley geomorphic province (especially in the Delta) and poses a moderate to significant hazard (Association of Bay Area Governments 2001).

Another common hazard in the Great Valley geomorphic province (specifically the Delta) is differential settlement (also called ground settlement and, in extreme cases, ground collapse) as soil compacts and consolidates after the ground shaking ceases. Differential settlement occurs when the layers that liquefy are not of uniform thickness, a common problem when the liquefaction occurs in artificial fills. Settlement can range from 1% to 5%, depending on the cohesiveness of the sediments (Tokimatsu and Seed 1984).

Other Geologic Conditions

Land Subsidence

Portions of the MTP Plan Area are located in the Sacramento-San Joaquin Delta, including the southwestern portion of Sacramento County. Land subsidence is a decrease in land-surface elevation and



Shaking (%g*)

PGA (Peak Ground Acceleration)

Firm Rock

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

*The unit 'g' is acceleration of gravity.

Source: California Department of Conservation, California Geological Survey
http://www.consrv.ca.gov/CGS/rghm/pshamap/psha12239.html

Figure 10-1: 1996 Faults Shaking Hazard Map is a significant concern within this region of the Delta, referred to as the north Delta . Land subsidence occurs in three ways in the entire Delta region: as a result of compaction and oxidation of peat soils, hydrocompaction, and groundwater overdraft. In the portion of the Sacramento-San Joaquin Delta within the MTP Plan Area (i.e., the north Delta), compaction and aerobic decomposition (oxidation) of peat soils is the most relevant. Historically (i.e., in the past 200 years), land subsidence has been a significant problem in the south Delta. However, it is also a concern in the north Delta (Figure 10-2)

Compaction and Oxidation of Peat Soils
Land subsidence can occur as a result of farming and cessation of flooding. Most of the north Delta islands and tracts in the MTP Plan Area are covered in thick layers of peat, a highly organic soil. Tillage of the peat soil, combined with removal of flooding from the islands and tracts and construction of drainage ditches, exposes the peat soils to oxygen. This creates a chemical reaction that causes the soil to oxidize and consolidate, lowering the land level. Wind erosion further exacerbates this condition. Subsidence of this type is a major concern in the MTP Plan Area (Figure 10-2).

Hydrocompaction
Hydrocompaction, as it relates to the MTP Plan Area, is the loss of water between peat particles as a result of compaction from farming practices. The loss of water helps to lower the land level.

Subsidence of this type is not well documented in the MTP Plan Area; however, because this process is closely related to compaction of peat soils and associated chemical reactions, it is assumed that it is a significant concern.

Groundwater Overdraft
Groundwater overdraft occurs when groundwater extraction results in so much compression of a clay bed in an aquifer that it no longer expands to its original thickness after groundwater recharge. Clay beds often compress when wells pump groundwater and expand after pumping stops. Clay beds contain individual clay particles and small pores that fill with groundwater in saturated conditions. Groundwater maintains the pore space, expands the clay particles, and helps the bed maintain its thickness. A clay bed will yield a certain volume of groundwater (i.e., safe yield) without losing storage capacity. If safe yield is not exceeded, the clay bed will compress and expand as the pores shrink and swell. This can lead to elastic land subsidence at the ground surface, where elevation decreases when water is extracted then increases when water is recharged. If the safe yield of a clay bed is exceeded, however, its pores collapse and the surrounding clay particles settle in their place. When the clay particles settle, the clay bed is effectively thinned, resulting in permanent land subsidence at the ground surface.

Subsidence caused by groundwater pumping for agriculture is a common problem throughout the entire Delta region; however, it is more common upstream in the San Joaquin River hydrologic region and is not a major concern in the MTP Plan Area (see Figure 10-2).

Volcanic Activity

There are no volcanoes located within the MTP Plan Area, and volcanic activity is not a local concern. The nearest notable volcanic activity is in Mono County, in the Mammoth Lakes/Long Valley area, and Lassen Peak in Shasta County.

Landslides

Within the limits of the MTP Plan Area, the risk of naturally occurring large landslides varies depending upon slope. Localized landsliding as a result of project activities is discussed in the Impacts and Mitigation Measures section.

Soils

The soils in the MTP Plan Area have been extensively mapped by the Natural Resources Conservation Service and are described in the following soil surveys:

- El Dorado Area (1974)
- El Dorado County, Western Part (1968)
- El Dorado National Forest Area (1984)
- Placer County, Western Part (1980)
- Placerville Area (1932)
- Sacramento and San Joaquin Delta Area (1941)
- Sacramento Area (1904) (map only)
- Sacramento Area (1954)
- Sacramento County (1993)
- Sacramento Valley Reconnaissance (1913)
- Sutter County (1988)
- Yolo County (1972)
- Yuba County (1998)

National Soil Survey Geographic (SSURGO) Database and State Soil Geographic (STATSGO) database information is also available.

Geographic Relationships and Distribution of Soils in Major Land Resource Areas

Due to the large size of the MTP Plan Area, characterization of soils has been inferred using major land resource area (MLRA) information.

An MLRA is a geographically associated land resource unit (LRU). An LRU is a geographic area, usually several thousand acres in extent that is characterized by a particular pattern of soils, climate, water resources, and land uses. A unit can be one continuous area or several separate nearby areas.

An LRU is the basic unit from which an MLRA is determined. It is also the basic unit for state land resource maps. It is coextensive with state general soil map units, but some general soil map units are subdivided into land resource units because of significant geographic differences in climate, water resources, and land use (U.S. Department of Agriculture, Natural Resources Conservation Service 2005).

The MTP Plan Area falls within two MLRAs identified by the USDA (Earth System Science Center 1998). Most of the plan area is located within MLRA 17, the Sacramento and San Joaquin Valleys.

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Descriptions of soil texture and erosion, runoff, and expansion hazards are described for the surface horizon of the soils only.

Sacramento Valley
The western portion of the MTP Plan Area is located within MLRA 17, the Sacramento and San Joaquin Valleys. The soils are nearly level, and are alluvial, occurring on low terraces, fans, floodplains, and basins. Soil textures are generally clayey to loamy sand. Soils in the northern portion of the plan area are organic. Soils are very deep.

Erosion hazard is slight to none, runoff is very slow, and soil expansiveness is low to high, depending on geographic location and texture.

Sierra Nevada Foothills
The eastern portion of the MTP Plan Area is located within MLRA 18, the Sierra Nevada Foothills. The soils are nearly level to moderately sloping, and are primarily alluvial, although soils are residual at the highest elevations. Soil textures are generally loamy to sandy-textured and some soils are gravelly and cobbly. Soils are shallow to deep.

The erosion hazard is moderate due to the presence of poorly aggregated volcanic and igneous rocks. Runoff is moderate to rapid, and soil expansiveness is low moderate.

Regulatory Setting

Federal Regulations

Clean Water Act 402/National Pollutant Discharge Elimination System

The Clean Water Act (CWA) is discussed in detail in the Hydrology and Water Quality chapter. However, because CWA 402 is directly relevant to excavation and grading, additional information is provided below.

Amendments in 1987 to the CWA added Section 402p, which establishes a framework for regulating municipal and industrial stormwater discharges under the National Pollutant Discharge Elimination System (NPDES) program. The Environmental Protection Agency (EPA) has delegated to the State Water Resources Control Board (SWRCB) the authority for the NPDES program in California, which is implemented by the state's nine Regional Water Quality Control Boards (RWQCBs). Under the NPDES Phase II Rule, construction activity disturbing 1 acre or more must obtain coverage under the state's General Permit for Discharges of Storm Water Associated with Construction Activity (General Construction Permit). Proponents of specific projects under the MTP 2035 that would disturb one or more acres will be required to obtain a General Construction Permit, prepare a Notice of Intent and a Storm Water Pollution Prevention Plan (SWPPP), and implement and maintain Best Management Practices (BMPs) to avoid adverse effects on water quality as a result of construction activities, including earthwork.

State Regulations

Alquist-Priolo Earthquake Fault Zoning Act

California's Alquist-Priolo Act (PRC 2621 et seq.), originally enacted in 1972 as the Alquist-Priolo Special Studies Zones Act and renamed in 1994, is intended to reduce the risk to life and property from surface fault rupture during earthquakes. The Alquist-Priolo Act prohibits the location of most types of structures intended for human occupancy across the traces of active faults and strictly regulates construction in the corridors along active faults (Earthquake Fault Zones). It also defines criteria for identifying active faults, giving legal weight to terms such as "active," and establishes a process for reviewing building proposals in and adjacent to Earthquake Fault Zones.

Under the Alquist-Priolo Act, faults are zoned, and construction along or across them is strictly regulated if they are "sufficiently active" and "well-defined." A fault is considered sufficiently active if one or more of its segments or strands shows evidence of surface displacement during Holocene time (defined for the purposes of the act as within the last 11,000 years). A fault is considered well-defined if its trace can be clearly identified by a trained geologist at the ground surface or in the shallow subsurface, using standard professional techniques, criteria, and judgment (Hart and Bryant 1997).

Seismic Hazards Mapping Act

Like the Alquist-Priolo Act, the Seismic Hazards Mapping Act of 1990 (PRC 2690–2699.6) is intended to reduce damage resulting from earthquakes. While the Alquist-Priolo Act addresses surface fault rupture, the Seismic Hazards Mapping Act addresses other earthquake-related hazards, including strong ground shaking, liquefaction, and seismically induced landslides. Its provisions are similar in concept to those of the Alquist-Priolo Act: The state is charged with identifying and mapping areas at risk of strong ground shaking, liquefaction, landslides, and other corollary hazards, and cities and counties are required to regulate development within mapped Seismic Hazard Zones. At the present time, the State has mapped only Alameda, Los Angeles, Orange, San Francisco, and Ventura counties.

California Building Standards Code

The State of California's minimum standards for structural design and construction are given in the California Building Standards Code (CBSC) (CCR Title 24). The CBSC is based on the UBC (International Code Council 1997), which is used widely throughout United States (generally adopted on a state-by-state or district-by-district basis) and has been modified for California conditions with numerous, more detailed or more stringent regulations. The CBSC provides standards for various aspects of construction, including (i.e., not limited to) excavation, grading, and earthwork construction; fills and embankments; expansive soils; foundation investigations; and liquefaction potential and soil strength loss. In accordance with California law, proponents of specific projects would be required to comply with all provisions of the CBSC for certain aspects of design and construction.

Caltrans Seismic Design Criteria

The California Department of Transportation (Caltrans) has Seismic Design Criteria (SDC), which is an encyclopedia of new and currently practiced seismic design and analysis methodologies for the design of new bridges in California. The SDC adopts a performance-based approach specifying minimum levels of structural system performance, component performance, analysis, and design practices for ordinary standard bridges. The SDC has been developed with input from the Caltrans Offices of Structure Design, Earthquake Engineering and Design Support, and Materials and Foundations. Memo20-1 outlines the bridge category and classification, seismic performance criteria, seismic design philosophy and approach, seismic demands and capacities on structural components and seismic design practices that collectively make up Caltrans' seismic design methodology.

Local Regulations

Geotechnical Investigations

Local jurisdictions in the MTP Plan Area typically regulate construction activities through a process that may require the preparation of a site-specific geotechnical investigation. The purpose of a site-specific geotechnical investigation is to provide a geologic basis for the development of appropriate construction design. Geotechnical investigations typically assess bedrock and Quaternary geology, geologic structure, soils, and the previous history of excavation and fill placement. Proponents of specific projects in the MTP 2035 that require design of earthworks and foundations for proposed structures will need to prepare geotechnical investigations on the physical properties of soil and rock at the site prior to project design.

Local Grading and Erosion Control Ordinances

Many counties and cities in the MTP Plan Area have grading and erosion control ordinances. These ordinances are intended to control erosion and sedimentation caused by construction activities. A grading permit is typically required for construction-related projects. As part of the permit, project applicants usually must submit a grading and erosion control plan, vicinity and site maps, and other supplemental information. Standard conditions in the grading permit include a description of BMPs similar to those contained in a SWPPP.

County and City General Plans

The seismic elements of the various County and City General Plans of the MTP Plan Area contain goals, objectives, and policies aimed at reducing the seismic risk to people and property. Proponents of specific projects in the MTP Plan Area would be required to consult the applicable general plans and design the projects consistent with the applicable guidelines of the jurisdictions in which the projects are located.

IMPACTS AND MITIGATION MEASURES

Methods and Assumptions

The evaluation of the geology, seismicity, and soils impacts in this section assumes that the proponents of site-specific projects included in the MTP 2035 will conform to the latest UBC standards, CBSC standards, Caltrans Seismic Design Criteria, County general plan seismic standards, County and City grading ordinances, and NPDES requirements, as appropriate for individual projects.

Criteria for Determining Significance

The standards of significance described in CEQA, and the seismic elements of County General Plans in the MTP Plan Area were used in this analysis. Appendix G of the State CEQA Guidelines provides guidance for evaluation of project effects on geologic resources. Based on these guidelines, the proposed project would have a significant impact on geologic resources if it would:

- expose people or structures to rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault;

- expose people or structures to major geologic hazards that could result in loss, injury, or death related to strong seismic ground shaking or seismic-related ground failure, including liquefaction or landslides;
- result in development on a geologic unit or soil that is unstable or that would become unstable as a result of the Project and potentially result in an on-site or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse;
- result in substantial soil erosion or the loss of topsoil; or
- result in development on expansive soil, as defined in the UBC (International Conference of Building Officials 1997), creating substantial risks to life or property.

Environmental Impacts of the Proposed Project

This section describes the impacts to geology, soils and seismicity that would result from the proposed project, including their significance. This section describes potential impacts related to geology, seismicity, and soils that could result from the MTP 2035. Some projects within the MTP 2035 could significantly affect geology, seismicity, and soil issues. However, prior to final approval of each project considered in the MTP 2035, the implementing agency will conduct the appropriate project-specific environmental review. Significant impacts and mitigation measures will be considered during that project-level review.

Impact GEO - 1: Potential Structural Damage and Injury Caused by Fault Rupture

Fault rupture has the potential to compromise the structural integrity of proposed new facilities (including roadways, rail lines, streetcars, bridges, and other associated features) and cause injury to construction workers and users of project facilities, depending on the design of such facilities. However, based on available knowledge of fault locations and locations of earthquake epicenters, the risk of surface fault rupture in the MTP Plan Area is generally low because of the scarcity of active faults. Based upon the general planning nature of the MTP 2035, development of detailed, site-specific information on this impact at the program level is not feasible. As a result, SACOG does not have sufficient reliable data to permit preparation of a meaningful and accurate report on the impact and no significance determination can be reasonably made. The implementing agency will conduct appropriate project-level environmental review and will be responsible for consideration of mitigation measures for significant effects on the environment. The following mitigation measure could be used by implementing agencies to address potential impacts during project-level review:

Mitigation Measure GEO - 1: Implement Seismic Design Standards into Site-Specific Project Design

Implement UBC Seismic Hazard Zone 4, CBSC, Caltrans Seismic Design Criteria, and County and City General Plan standards, as appropriate, in project design to minimize the potential for fault rupture hazards.

Impact GEO - 2: Potential Structural Damage and Injury from Ground Shaking

Because the MTP Plan Area is not located in a very seismically active region, the potential for ground-shaking hazards in the MTP Plan Area is low. A large earthquake on a fault in either the extreme western portions of Sacramento and Yolo counties or the eastern portions of Placer and El Dorado counties, however, could cause strong ground shaking, potentially resulting in liquefaction and associated ground failure, such as lateral spreading or differential settlement, which in turn could increase the risk of structural loss, injury, or death to construction workers and users of project facilities. Based upon the general planning nature of the MTP 2035, development of detailed, site-specific information on this impact at the program level is not feasible. As a result, SACOG does not have sufficient reliable data to permit preparation of a meaningful and accurate report on the impact and no significance determination can be reasonably made. The implementing agency will conduct appropriate project-level environmental review and will be responsible for consideration of mitigation measures for significant effects on the environment. To mitigate this impact, implementing agencies should consider Mitigation Measure GEO-1, described above,

Impact GEO - 3: Potential Structural Damage and Injury from Development on Materials Subject to Liquefaction

Based on existing ground-shaking hazard and the sedimentological characteristics of the soils and the depth to groundwater, the liquefaction hazard to construction workers and users of project facilities is expected to be moderate for the portion of the MTP Plan Area within the Great Valley geomorphic province and low for the portion of the MTP Plan Area within the Sierra Nevada geomorphic province. Implementation of Mitigation Measure GEO-1 to implement seismic design standards into project design would minimize the potential for liquefaction hazards. Furthermore, as required by the County and cities within the MTP Plan Area, proponents of specific projects in the MTP 2035 that require design of earthworks and foundations for proposed structures will need to prepare geotechnical investigations on the physical properties of soil and rock at the site as described in Mitigation Measure GEO-2 below. The proponents of such projects, in conjunction with soil scientists and/or engineers, will be responsible for determining whether the substrate at particular sites is susceptible to liquefaction. Based upon the general planning nature of the MTP 2035, development of detailed, site-specific information on this impact at the program level is not feasible. As a result, SACOG does not have sufficient reliable data to permit preparation of a meaningful and accurate report on the impact and no significance determination can be reasonably made. The implementing agency will conduct appropriate project-level environmental review and will be responsible for consideration of mitigation measures for significant effects on the environment. The following mitigation measure could be used by implementing agencies to address potential impacts during project-level review:

Mitigation Measure GEO - 2: Conduct Site-Specific Geotechnical Evaluations for Projects that Require Design of Earthworks and Foundations and Implement the Recommendations

Based on the subsurface conditions expressed through geotechnical inquiry and in conjunction with soil scientists and/or engineers, ensure that specific project elements are designed so to accommodate the effects of liquefaction. For roadways and bridges, subsurface borings at regular intervals along proposed roadways and in the vicinity of proposed bridges are recommended as part of the geotechnical evaluations.

If liquefiable soils or soils susceptible to seismically induced settlement are determined to be present at any location where project activities would occur, corrective actions shall be taken, including removal and replacement of soils; on-site densification; grouting; and design of special foundations or other similar measures, depending on the extent and depth of susceptible soils and the findings of the geotechnical evaluations.

All of these measures reduce pore water pressure during ground shaking by densifying the soil or improving its drainage capacity (Johansson 2000).

Impact GEO - 4: Potential Structural Damage as a Result of Development on Expansive Soils

Shrink-swell potential (i.e., soil expansiveness) in the MTP Plan Area is variable, ranging from low to high. Expansive soils have the potential to compromise the structural integrity of proposed new facilities (including roadways, rail lines, streetcars, bridges, and other associated features). Based upon the general planning nature of the MTP 2035, development of detailed, site-specific information on this impact at the program level is not feasible. As a result, SACOG does not have sufficient reliable data to permit preparation of a meaningful and accurate report on the impact and no significance determination can be reasonably made. The implementing agency will conduct appropriate project-level environmental review and will be responsible for consideration of mitigation measures for significant effects on the environment. Implementing agencies should consider Mitigation Measure GEO-1 to implement seismic design standards into project design and Mitigation Measure GEO-2 to conduct a site-specific geotechnical evaluation.

Impact GEO - 5: Potential Accelerated Runoff, Erosion, and Sedimentation from Construction Activities

Grading, excavation, removal of vegetation cover, and loading activities associated with construction activities could temporarily increase runoff, erosion, and sedimentation. Construction activities also could result in soil compaction and wind erosion effects that could adversely affect soils and reduce the revegetation potential at construction sites and staging areas. Based upon the general planning nature of the MTP 2035, development of detailed, site-specific information on this impact at the program level is not feasible. As a result, SACOG does not have sufficient reliable data to permit preparation of a meaningful and accurate report on the impact and no significance determination can be reasonably made. The implementing agency will conduct appropriate project-level environmental review and will be responsible for consideration of mitigation measures for significant effects on the environment. The following mitigation measure could be used by implementing agencies to address potential impacts during project-level review:

Mitigation Measure GEO - 3: Obtain and Implement the Requirements of the NPDES Permit into the Design of Site-Specific Projects that Would Disturb 1 or More Acres

If the project would disturb 1 or more acres will be required to obtain a General Construction Permit, prepare a Notice of Intent and a SWPPP, and implement and maintain BMPs to avoid adverse effects on water quality as a result of construction activities, including earthwork. The SWPPP will be developed by a qualified engineer or erosion control specialist and implemented before construction. The SWPPP will be kept onsite during construction activity and will be made available on request to representatives of the RWQCB. The objectives of the SWPPP would be to: (1) identify pollutant sources that may affect the quality of stormwater associated with construction activity; and (2) identify, construct, and implement stormwater pollution prevention measures to reduce pollutants in stormwater discharges during and after construction. Therefore, the SWPPP would include a description of potential pollutants, the management of dredged sediments, and hazardous materials present on the site during construction (including vehicle and equipment fuels). The SWPPP also would include details of how the sediment and erosion control practices, referred to as BMPs, would be implemented. Implementation of the SWPPP would comply with state and federal water quality regulations.

Mitigation Measure GEO - 4: Comply with County and City Grading Ordinances

Ensure that construction contracts will comply with the county and/or city grading ordinances so as to minimize any negative effects associated with erosion and sedimentation. County and/or city grading ordinances typically outline regulations and practices relevant to construction and grading activities and typically are required for all construction and grading activities within a county or city.

Mitigation Measure GEO - 5: Implement the Geotechnical Report Recommendations

Ensure that their contractor implements the recommendations in site-specific geotechnical reports pertaining to site clearing and preparation, organic removal, engineered fill placement, trench backfilling, foundation design, sound wall systems, exterior flatwork, pavement design, and site drainage so as to minimize any negative effects associated with runoff, erosion, and sedimentation.

Impact GEO - 6: Inconsistency of Project with County and City Policies for Development in Geologically Hazardous Areas

The proposed project is consistent with County and City policies described in the "Regulatory Setting" section of this chapter. Project included in the MTP 2035 must reach the design stage before consistency with such policies can be determined. Based upon the general planning nature of the MTP 2035, development of detailed, site-specific information on this impact at the program level is not feasible. As a result, SACOG does not have sufficient reliable data to permit preparation of a meaningful and accurate report on the impact and no significance determination can be reasonably made. The implementing agency will conduct appropriate project-level environmental review and will be responsible for consideration of mitigation measures for significant effects on the environment. Implementing agencies should consider Mitigation Measures GEO-1, GEO-2, GEO-3, GEO-4, and GEO-5 to address potential impacts during project-level review.