

3.11 Geology/Soils/Seismic/Topography

3.11.1 Regulatory Setting

For geologic and topographic features, the key federal law is the Historic Sites Act of 1935, which establishes a national registry of natural landmarks and protects “outstanding examples of major geological features.” Topographic and geologic features are also protected under the California Environmental Quality Act.

This section also discusses geology, soils, and seismic concerns as they relate to public safety and project design. Earthquakes are prime considerations in the design and retrofit of structures. Caltrans’ Office of Earthquake Engineering is responsible for assessing the seismic hazard for Caltrans projects. The current policy is to use the anticipated Maximum Credible Earthquake (MCE), from young faults in and near California. The MCE is defined as the largest earthquake that can be expected to occur on a fault over a particular period of time.

The Alquist-Priolo Earthquake Fault Zoning Act was passed by the State of California in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. The Alquist-Priolo Earthquake Fault Zoning Act’s main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. The Act only addresses the hazard of surface fault rupture and is not directed toward other earthquake hazards. The Seismic Hazards Mapping Act, passed in 1990, addresses nonsurface fault rupture earthquake hazards, including liquefaction and seismically induced landslides.

The law requires the State Geologist to establish regulatory zones (known as Earthquake Fault Zones¹) around the surface traces of active faults and to issue appropriate maps. The maps are distributed to all affected cities and counties and state agencies for their use in planning and controlling new or renewed construction.

3.11.2 Affected Environment

The information in this section is based on the *Preliminary Geotechnical Design Report* (March 2008.)

California comprises 11 geomorphic provinces as defined by the California Department of Mining. The MCP study area is located within the Peninsular Ranges

¹ “Earthquake Fault Zones” were called “Special Studies Zones” prior to January 1, 1994.

Geomorphic Province. The Peninsular Range province is a series of mountain ranges separated by northwest-trending valleys running parallel to faults branching from the San Andreas fault. The Peninsular Ranges extend south to Mexico and are bordered by the Transverse Ranges on the north, the Colorado Desert on the east, and the Pacific Ocean on the west.

3.11.2.1 Local Geology/Topography

There are no designated national natural landmarks within the MCP study area.

As shown in Figure 3.11.1, the Bernasconi Hills are a distinct natural landmark in the Lake Perris area. Trending northeast and located approximately 6 miles (mi) northeast of Perris, the elevation of the Bernasconi Hills is approximately 2,647 feet (ft) above sea level.

The McCanna Hills lie south of Lake Perris, directly south of the Ramona Expressway. These are relatively low-lying hills with an elevation of approximately 1,700 ft above sea level.

The northern portion of the Lakeview Mountains is one of the most distinctive topographic features in the MCP study area. Mount Rudolph, a prominent feature at the northerly end of the range, rises to an elevation of 2,595 ft above sea level.

Perris Valley is a 4 to 5 mi wide, alluvial-filled basin that extends from Moreno Valley on the north to Menifee Valley on the south. The Bernasconi Hills define the eastern border of the Perris Valley, separating it from the San Jacinto Valley.

The San Jacinto River floodplain is located within a northeast-trending valley between Perris Valley and the San Jacinto Valley, bordered by the Bernasconi Hills on the west and the Lakeview Mountains on the southeast. The San Jacinto River flows toward the Elsinore Valley approximately 20 mi to the southwest.

The eastern end of the MCP study area is within the San Jacinto Valley. The San Jacinto Valley is an alluvial valley along the San Jacinto fault zone.

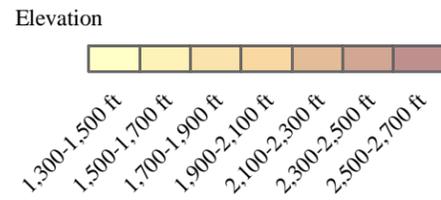
3.11.2.2 Faulting/Seismicity

The entire southern California region is seismically active due to the influence of several earthquake fault systems resulting from interaction between the Pacific and North American crustal plates. An active fault is defined by the State of California as a “sufficiently active and well-defined fault that has exhibited surface displacement within the last 11,000 years.” A potentially active fault is defined by the State as a



LEGEND

- Mid County Parkway Study Area
- Limits of Proposed Improvements (All Alternatives and Design Variations)
- County Boundary



SOURCE: USGS (2006), Jacobs Engineering (2/2011), TBM (2010)



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FIGURE 3.11.1

Landforms and Topographic Features
 08-RIV-MCP PM 0.0/16.3; 08-RIV-215 PM 28.0/34.3
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“fault with a history of movement between 11,000 and 1.6 mya” (million years ago). These active and potentially active faults are capable of producing seismic shaking within the MCP study area that could be damaging to bridges and other structures. Figure 3.11.2 illustrates the major fault zones in the MCP study area.

There are several major active fault zones capable of generating ground shaking during a seismic event that could impact the MCP study area. The closest major faults that could affect the project are the San Jacinto fault zone (which includes the Casa Loma fault), located near the eastern end of the MCP study area; and the Whittier/Elsinore fault zone, located west of the MCP study area. These two fault zones are discussed in further detail below. Other faults capable of generating ground shaking that would affect the MCP study area include the San Andreas, Chino, and Cucamonga faults. Table 3.11.A summarizes the five major active faults/fault zones that could impact the MCP study area.

Table 3.11.A Active Faults in the Mid County Parkway Study Area

Fault/Fault Zone	Distance from Site – East End (mi)	Maximum Moment Magnitude (Mw)	Maximum Historic Earthquake Magnitude (Mw) with year	Probability of Occurrence in 100 years
San Jacinto/Casa Loma	0.2	6.75	7.0 (1918)	High
San Andreas	15.1	7.75	8.0+ (1857)	High
Whittier-Elsinore	23.2	7.5	6.0 (1910)	Moderate-High
Chino	32.4	6.5	Unknown	Unknown
Cucamonga	35.2	7.0	5.2 (1990)	High

Source: *Preliminary Geotechnical Design Report*, March 2008.

mi = miles

Mw = moment magnitude scale

The San Jacinto/Casa Loma fault zone extends from the Cajon Pass north of San Bernardino trending southeast to the California-Mexico border and beyond. Near the east end of the MCP study area, the San Jacinto fault consists of a number of fault segments and numerous fissures associated with crustal movement. The Casa Loma fault, a segment of the San Jacinto fault zone, crosses the eastern portion of the MCP study area. The Casa Loma fault was exposed in an aqueduct excavation southeast of the intersection of Warren Road and Ramona Expressway, and is considered active by the State of California. The fault is also included within the Alquist-Priolo Earthquake fault zone.

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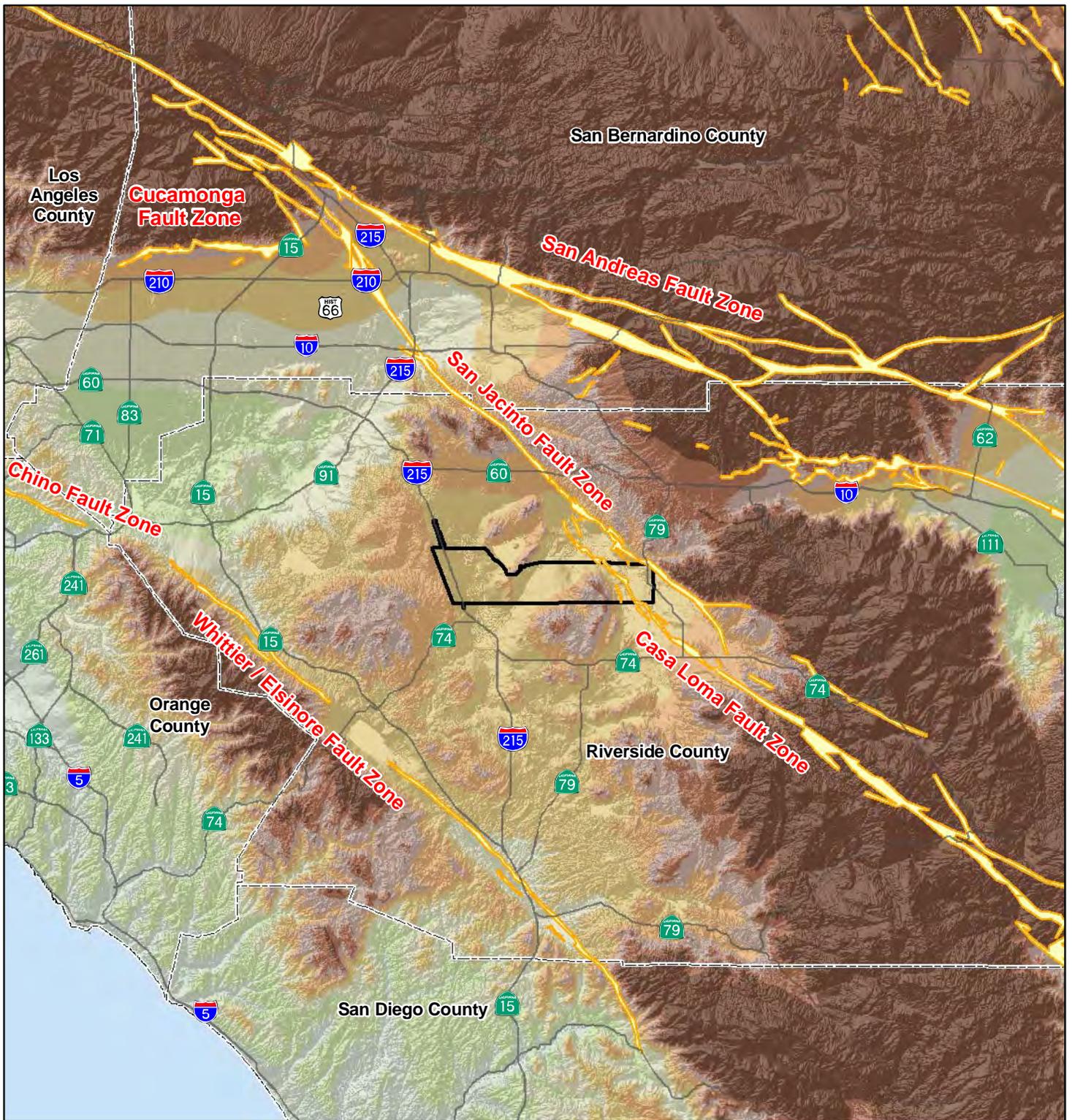
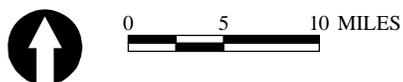


FIGURE 3.11.2

LEGEND

-  Fault Zone
-  Mid County Parkway Study Area
-  County Boundary

SOURCE: California Department of Conservation (1997), ESRI (2006), Jacobs Engineering (2/2011)



Fault Zones

08-RIV-MCP PM 0.0/16.3; 08-RIV-215 PM 28.0/34.3
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The Elsinore fault is located approximately 1.5 mi southwest of the existing Interstate 15 (I-15)/Cajalco Road interchange. The Elsinore fault is one of the largest in southern California, and historically has been one of the quietest. This fault is part of the greater Whittier-Elsinore fault system that extends from the Los Angeles Basin, south to the California/Mexico border and beyond. This fault zone is a series of northwest-trending faults forming the boundary between the Santa Ana Mountains on the west and Temescal Valley on the east.

3.11.2.3 Landslides

Landslides constitute a major geologic hazard because they are widespread and can cause substantial damage to life and property. Expansion of urban and recreational developments into hillside areas leads to more people that are threatened by landslides each year. Landslides commonly occur in connection with other major natural disasters such as earthquakes, volcanoes, and floods. Steep, bare slopes; clay-rich rock; deposits of stream or river sediment; and heavy rains can also cause landslides.

The average annual precipitation in the MCP study area is low, about 10.5 inches (in) annually. Natural slopes susceptible to instability occur primarily within the Bernasconi Hills. No known landslides have been mapped along or adjacent to the proposed MCP Build Alternatives in the MCP study area. The primary stability issue for bedrock slopes in the MCP study area is the possibility of rock fall on steep slopes. While the bedrock is generally steeply inclined, it is favorable for overall stability. However, existing slopes and future cut slopes may be subject to toppling, rock fall, and localized instability along fractures in the bedrock. Existing slopes underlain by older stream deposition and sedimentary bedrock are also subject to erosion and instability.

3.11.2.4 Liquefaction

Soil liquefaction occurs when saturated, loose soils lose their strength due to excess water within the soils. The space between the soil particles is completely filled with water, which exerts pressure on the soil particles, influencing how tightly the soil particles are pressed together. Prior to an earthquake, the water pressure is relatively low. However, the shaking caused by an earthquake can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other. When liquefaction occurs, the strength of the soil decreases and the ability of the soil to support building and bridge foundations is reduced. Liquefied soils also exert pressure on retaining walls, which can cause them to tilt or slide.

The primary factors affecting the possibility of liquefaction in a soil deposit are: (1) intensity and duration of earthquake shaking, (2) soil type and relative density, (3) overburden pressures, and (4) depth to groundwater. Soils most susceptible to liquefaction are clean, loose, uniformly graded, fine-grained sands, and nonplastic silts that are saturated. Silty sands have also been proven susceptible to liquefaction.

The presence and depth of groundwater in an area will determine if the land is more or less subject to liquefaction (the state of becoming liquid) and instability. Areas potentially prone to liquefaction include the San Jacinto River, the San Jacinto Valley, and the Perris Valley areas. During geotechnical borings, groundwater was encountered at depths ranging from 21 to 48 ft below ground surface. Groundwater was encountered at depths ranging from 35 to 48 ft in portions of Perris Valley adjacent to the Perris Drain, and at a depth of 21 ft at the eastern end of the project along State Route 79 (SR-79). At all other boring locations, groundwater was not encountered.

3.11.2.5 Soils

The entire MCP study area is located in a diverse geologic environment that may be prone to both collapsible and expansive soils. The potential for soils to collapse ranges from low to moderate for the majority of the alluvial soil deposits. The ability of these soils to expand when wet and shrink when dry (change volume) ranges from low to high, depending on the nature of the soils and underlying parent bedrock materials. Residual soils within the MCP study area may also be expansive.

Surface soils within the study area include artificial fill, colluvial soils, Holocene alluvium, Pleistocene older alluvium and fan deposits, Tertiary sandstone and siltstone, Mesozoic plutonic and volcanic rocks, and Mesozoic metamorphic rocks.

Artificial Fill

Artificial fill is associated with existing developments, such as roads and structures, and is present within the MCP study area. Fills are typically composed of materials derived from the surrounding terrain and, for engineering purposes, are generally required to meet certain specifications related to grain size, composition, and compaction. The fill materials generally consist of silty sands with gravel, sand with silt, and sandy gravel with local cobbles. The coarse-grained soils are generally loose to medium-dense with occasional stiff, fine-grained layers.

Colluvium

Colluvium, a collection of loose rock debris at the base of a hill or slope, can be found around most of the hillsides and valley areas within the MCP study area. This colluvium (dating from approximately 10,000 years ago to the present) has a variable thickness depending upon the location within the MCP study area.

Younger Alluvium and Fan Deposits

Alluvium, deposits of sand and mud formed by flowing water, underlie much of the MCP study area, including the Perris and San Jacinto Valleys and the San Jacinto River floodplain. These relatively young (dating from approximately 10,000 years ago to the present), nonmarine deposits generally consist of fine- to coarse-grained sand with various amounts of silt, clay, and gravel. Cobbles and boulders are common near the base of the deposits.

Alluvium and fan deposits (fan-shaped accumulations of alluvium deposited at the mouth of a ravine or foot of a mountain) are located in the portions of the MCP study area with steeper topography, including the Bernasconi Hills. These deposits consist of sands, silty sands, clayey sands, and sandy silts with occasional clay, gravel, and sandy gravel layers. These soils are medium-dense to very dense, and the fine-grained layers are stiff to very stiff. Portions of the alluvial soils are likely subject to collapse and consolidation when wet.

Older Alluvial Deposits

Alluvial deposits, including fan deposits, dating from approximately 10,000 to 2 mya are located within Perris Valley and adjacent to the San Jacinto River floodplain. These older alluvium materials are similar in composition and origin to the younger alluvial deposits but are more consolidated. These soils are medium-dense to very dense, and the fine-grained layers are stiff to very stiff.

3.11.3 Environmental Consequences

3.11.3.1 Permanent Impacts

Build Alternatives

The roadway, structures, slopes, and other features of the MCP Build Alternatives could be impacted by ground motion and liquefaction, and possibly ground rupture (deformation) to some degree. Design and construction of the proposed project to current highway and structure design standards would minimize the impact of these conditions to the MCP Build Alternatives.

The primary geologic and geotechnical constraints affecting the design and construction of any of the MCP Build Alternatives include:

- Moderate to high ground accelerations due to the presence of nearby active faults, including the Elsinore, San Jacinto, Casa Loma, and San Andreas faults.
- Fault rupture associated with the Casa Loma branch of the San Jacinto fault in the eastern portion of the MCP study area.
- Impacts to bridges or raised structures due to local shallow groundwater. Shallow groundwater has been identified near the downstream foundation of Perris Reservoir and locally near Perris Dam in the Perris Valley.
- Liquefaction and seismically induced settlement in areas of shallow groundwater and loose alluvial soils. Areas subject to liquefaction and seismically induced settlement include the San Jacinto River, the San Jacinto Valley, and the Perris Valley areas.
- Possibility of flooding within the San Jacinto River, the San Jacinto Valley, and the Perris Valley areas, and locally at or adjacent to drainage crossings.
- Slope stability in areas of steep natural terrain or proposed cut slopes.
- Erosion and surficial instability in hillside areas.
- Difficult bedrock excavation characteristics. Hard granitic and metamorphic bedrock is anticipated in the Bernasconi Hills.
- Collapsible soils in younger alluvium, primarily in the Perris Valley, the San Jacinto River, and the San Jacinto Valley areas.

Faulting/Seismicity

The eastern portion of the MCP study area is located within a designated Earthquake Fault Rupture Hazard Zone for the Casa Loma fault, a branch fault of the San Jacinto fault zone. This fault is considered active and crosses the Ramona Expressway approximately 700 ft east of Warren Road, a location that is common to all of the MCP Build Alternatives. The planned interchange at Ramona Expressway/Warren Road may lie near or within this fault zone.

The possibility of moderate to severe seismic shaking is the most considerable geologic hazard to the project. The MCP study area is located in a region of Southern California that is seismically active and under the influence of several fault systems that are considered to be active or potentially active. Table 3.11.A previously listed the fault systems capable of producing damaging seismic shaking in the MCP study area. The project facilities and structures elements would be designed consistent with applicable building and seismic codes. As a result, the Build Alternatives would be

anticipated to accommodate the expected ground shaking in this area, with the likelihood for structural damage substantially reduced or avoided through seismic engineering design.

Landslides

Landslides are rock, earth, or debris flows on slopes due to gravity. They can occur on any terrain given the right conditions of soil, moisture, and angle of slope. Landform alterations may create erosional impacts to the existing terrain. The most extensive alterations would be from construction of cut-and-fill slopes along the project alignment. The project design includes measures such as maximum slope ratios or provision of retaining walls to prevent landslides during project operation.

The MCP *Preliminary Geotechnical Design Report* identified the primary areas where natural slope instability may occur that would need to be considered in the design of the project. They are primarily within the Bernasconi Hills. None of the alignment alternatives are located in areas where landslides or instability are known.

Liquefaction

The *Preliminary Geotechnical Design Report* indicates a possibility for liquefaction along the proposed alternatives in areas of shallow groundwater and loose granular soils. Areas that may be prone to liquefaction include the San Jacinto River, the San Jacinto Valley, and the Perris Valley areas for all MCP Build Alternatives.

Impacts to the facilities and structures under the MCP Build Alternatives due to liquefaction and seismically induced settlement can be substantially reduced based on design and construction, consistent with the recommendations of the detailed geotechnical investigations prepared during final design. As noted earlier, detailed site-specific geotechnical investigations would be conducted during final design to evaluate the possibility of liquefaction and seismically induced settlement at specific locations along the alignments of the MCP Build Alternatives, and to provide measures for remediation if required.

Soils

The primary areas where natural slope instability may occur that may influence project design are within the Bernasconi Hills. Deeper fills are anticipated within the embankments associated with the Interstate 215 (I-215) freeways and locally along the proposed alignment alternatives. Embankment fill slopes constructed at an inclination of 1:2 (horizontal:vertical) or less, like the fill slopes planned as part of the project, should have adequate stability during a major seismic event and not be

subject to failure or landslides. Therefore, the MCP Build Alternatives would not result in adverse impacts related to slope instability.

No Build Alternatives

Under the MCP No Build Alternatives, the permanent impacts discussed above for the MCP Build Alternatives would not occur for the MCP project itself, but earthquake and seismic safety concerns would be issues that would be analyzed as part of the environmental and engineering studies for the other transportation improvement projects included in the MCP No Build Alternatives. The extensive grading and use of cut-and-fill slopes required for the MCP project would not occur under the MCP No Build Alternatives.

3.11.3.2 Temporary Impacts

Build Alternatives

Temporary impacts are related to construction activities. Each of the MCP Build Alternatives would alter existing landforms due to grading and construction of various cut-and-fill slopes. Construction activities may also temporarily disturb soil outside the facility footprint, and within the project right of way, primarily in the trample zone around work areas, heavy equipment traffic areas, and material laydown areas. Temporary impacts would include soil compaction and increased possibility of soil erosion.

Faulting/Seismicity and Liquefaction

The construction activities associated with the proposed MCP Build Alternatives could be impacted by ground motion and liquefaction, and possibly ground rupture (deformation) to some degree, if an earthquake were to occur during construction. Implementation of safe construction practices and compliance with Caltrans and California Division of Occupational Safety and Health Administration requirements would minimize the impacts of these conditions.

Cut-and-Fill Slopes

Cut-and-fill slopes would be required to construct any of the MCP Build Alternatives. As described in Chapter 2, extensive use of bridges is proposed to reduce the amount of cut-and-fill slopes. The proposed cut (excavated) slopes are generally located in hard granitic and metamorphic bedrock. Other than local areas of rock fall or surface instability, no landslides or other evidence of major bedrock instabilities were observed in the areas of the proposed cut slopes. Cut-and-fill slopes would also be required in the McCanna Hills area for all the MCP Build Alternatives.

Table 3.11.B shows the estimated cut-and-fill material for each alternative.

Table 3.11.B Cut-and-Fill Material by Alternative

Alternative	Quantity and Type of Earthwork (cubic yards)			
	Excavation	Fill	Imported Borrow	Disposal Off Site
Alternative 4 Modified	6,585,986	14,363,672	7,777,686	0
Alternative 4 Modified SJN DV	7,270,774	14,719,050	7,448,276	0
Alternative 4 Modified SJRB DV	6,585,986	14,658,892	8,072,906	0
Alternative 5 Modified	6,888,583	13,470,980	6,582,397	0
Alternative 5 Modified SJN DV	7,573,371	13,826,358	6,252,987	0
Alternative 5 Modified SJRB DV	6,888,583	13,766,200	6,877,617	0
Alternative 9 Modified	7,907,827	11,975,678	4,067,851	0
Alternative 9 Modified SJN DV	8,592,615	12,331,056	3,738,441	0
Alternative 9 Modified SJRB DV	7,907,827	12,270,898	4,363,071	0

Source: Jacobs, 2011.

SJN DV = San Jacinto North Design Variation

SJRB DV = San Jacinto River Bridge Design Variation

Due to the hardness of the bedrock in the McCanna Hills areas, blasting may be required during construction activities of the cut-and-fill slopes. The entire process of an individual blast event to remove hard rock (excavation, drilling holes in the hard rock, placing charges and detonation cords, detonation at specific time intervals, and removal of pulverized rock) can range in length from several days to several weeks, depending on the size of the area planned for each blast event. Typical blast events “pulverize” from approximately 8,000–40,000 cubic yards of in-place rock. The drilling contractor generally utilizes 3 or 4 in diameter holes, and spaces the drill holes in a 9 ft x 9 ft grid pattern. Depending on the project grade requirements, each blasting detonation can vary in depth from 10–40 ft. While the individual blast events would vary in size and depth depending on the final results desired by the blast event, a blast size of approximately 9,000 cubic yards of in-place rock would require approximately 21,000 pounds of ammonium nitrate fuel oil.

To minimize the possibility of damage at or adjacent to the project site, test shots would be performed to determine hole depth, charge size, and depth of charge burial. These small charges would help reveal natural fractures in the rock that can create rock fragments, which are propelled through the air by the force of the blast and could endanger humans and nearby structures or equipment. The test shots would also monitor noise vibrations due to blasting. The test blasts would allow the blast

contractor to minimize the possibility of damage at, or adjacent to, the proposed project site.

Soils

Landform alteration throughout the MCP study area would occur due to construction grading. Erosion and sedimentation impacts could occur due to project construction. These impacts are discussed in Section 3.10, Water Quality and Storm Water Runoff.

No Build Alternatives

Under the MCP No Build Alternatives, the temporary impacts discussed above for the MCP Build Alternatives would not occur for the MCP project itself. Similar impacts would occur for the other transportation improvement projects included in the MCP No Build Alternatives.

3.11.4 Avoidance, Minimization, and/or Mitigation Measures

While implementation of standard design and construction practices will reduce the MCP project's risk for geologic hazards such as soil erosion and slope instability, Mitigation Measures GEO-1 through GEO-4 listed below will also reduce potential impacts to liquefaction, soil, seismic issues, and erosion from implementation of the MCP project. The following measures would apply to all of the MCP Build Alternatives. Also, refer to Mitigation Measure HW-13 regarding blasting during construction.

GEO-1 Final Geotechnical Report. During final design, the Riverside County Transportation Commission (RCTC) will contract with a qualified geotechnical/geologic engineer to prepare the Final Geotechnical Report. This report will build on the information in the Preliminary Geotechnical Report, focusing the analysis on potential geotechnical constraints to the selected build alternative and the specific design features included in the final engineering to address those constraints. The Preliminary Geotechnical Report identified soil-related constraints and hazards, such as slope instability, settlement, liquefaction, or related secondary seismic impacts, that may affect the project. The detailed analysis in the Final Geotechnical Report will address those constraints along the entire alignment of the selected alternative with appropriate design features addressing those constraints included in the final project design.

The report will specifically include:

- Evaluation of expansive soils along the selected alignment and recommendations regarding construction procedures and/or incorporation of design criteria in the final design to minimize the effect of these soils on the project.
- Identification of potential liquefiable areas within the project limits and recommendations and/or design criteria to minimize the effect of liquefaction on the project.
- Demonstration that side slopes can be designed and graded so that surface erosion of the engineered fill will not be increased compared to existing, natural conditions.
- The performance standards for this report will be the geotechnical design standards of the California Department of Transportation (Caltrans) and the local agencies with jurisdiction over the Mid County Parkway (MCP) project right of way. Acceptance of this report will be needed from the local agencies with jurisdiction over the MCP project right of way and Caltrans for the parts of the MCP project within State highway right of way.

GEO-2 **Vegetation.** During construction, and as included on project plans during final design, the RCTC will require planting of native vegetation with good soil-binding characteristics and low water requirements on engineered slopes to reduce erosion and slope instability. These types of plants include species that are compatible with existing adjacent habitat and native to the project area, including but not limited to the following: brittlebush (*California encelia*), California buckwheat (*Eriogonum fasciculatum*), California sagebrush (*Artemisia californica*), and deerweed (*Lotus scoparius*). Sixty percent of the planting coverage shall be completed within the first 5 years of construction.

GEO-3 **Quality Assurance/Quality Control Plan.** The RCTC will maintain a quality assurance/quality control (QA/QC) plan during construction. The plan will include observing, monitoring, and testing by a geotechnical engineer and/or geologist during construction to confirm that geotechnical/geologic recommendations identified in Measure GEO-1 are fulfilled, or if different site conditions are encountered, appropriate changes are made to accommodate such issues. During site preparation, grading, excavation, and construction, the geotechnical

engineer will submit weekly reports to the RCTC Resident Engineer describing that week's activities and the compliance with the relevant recommendations from GEO-1.

GEO-4 **Blasting.** During final design, if it is determined that blasting will be required, the RCTC Project Engineer shall require the Construction Contractor to prepare a blasting plan to minimize potential hazards related to blasting activities. The blasting plan will address all applicable standards in accordance with the United States Department of the Interior, Office of Surface Mining. The issues to be addressed in the blasting plan will include, but are not limited to, the following: hours of blasting activity, notification to adjacent property owners, noise and vibration, and dust control.

RCTC's Resident Engineer shall require the Construction Contractor to implement the blasting plan prior to and during any blasting during construction.