3.2.3 Geology/Soils/Seismic/Topography

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 (CEQA).

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's Office of Earthquake Engineering is responsible for assessing the seismic hazard for Caltrans projects. Structures are designed using Caltrans's Seismic Design Criteria (SDC). The SDC provides the minimum seismic requirements for highway bridges in California. A bridge's category and classification will determine its seismic performance level and which methods are used for estimating the seismic demands and structural capabilities. For more information, please see Caltrans's Division of Engineering Services, Office of Earthquake Engineering, Seismic Design Criteria.

Affected Environment

Information regarding geology/soils/seismic/topography was obtained from the following reports:

- District Preliminary Geotechnical Report (DPGR) for the Proposed HDC, San Bernardino County Segment, San Bernardino County, California. Department of Transportation Division of Engineering Services, Geotechnical Services, Office of Geotechnical Design South, June 6, 2012.
- DPGR for the Proposed HDC, Los Angeles County Segment, Los Angeles County, California. Department of Transportation Division of Engineering Services, Geotechnical Services, Office of Geotechnical Design South, October 16, 2012.
- Initial Seismic Hazard Assessment Report, The HDC Project (Los Angeles County Section: SR-14 to 240th Street). Department of Transportation Division of Engineering Services, Geotechnical Services, Office of Geotechnical Design South, November 18, 2011.

Geologic Setting/Physiography

The proposed project, located within the High Desert region, is within the geologic region of California known as the Mojave Desert Geomorphic Province. This geologic region consists of unique defining features based on geology, faults, topographic relief, and climate. The Mojave Desert is bounded on the southwest by the San Andreas Fault Zone and Transverse Ranges, which includes the San Gabriel Mountains on the south; on the north and northwest by the Garlock Fault and Tehachapi and Sierra Nevada mountains; and to the east by the Sonoran Desert region. The Mojave Desert is characterized by desert alluvial fans with internal drainages, alluvial valley plains, and lacustrine basins (located north of the alignments).

Topography

The proposed project will occur in the southern California northeastern portion of the Mojave Desert region in the Antelope and Victor valleys. The Antelope Valley portion of the project area ranges in altitude from 2,450 to 3,200 feet with the surrounding mountain rising up to 4,000 feet, while the Victor Valley portion of the project area ranges in altitude from 2,660 feet at the Mojave River crossing to 3,200 feet near the limestone mines in the hills near Bell Mountain and Catholic Hill east of I-15.

The buttes are the most distinctive topographic feature in the Antelope Valley project area. Alpine Butte is the largest, located near Lake Los Angeles, and has an elevation of 1,200 feet. The topography varies from flat with occasional drainages and sand dunes on the Antelope Valley floor to steep foothill mountain areas (3,600 feet) to the south. The San Andreas Fault traverses the project limits parallel and just north of the San Gabriel Mountains and south of Pearblossom Highway.

The San Gabriel Mountains lie south of the HDC and the Sierra Pelona Mountains to the southwest. Bedrock hills and an unnamed alluvial valley between I-15 and Bell Mountain and Apple Valley are located at the eastern end of the project area in Victor Valley. A dry lake is located southeast of Apple Valley.

Surface Water and Groundwater

Surface Water

The HDC Project traverses numerous natural water features (refer to Figure 3.2.3-1) which range from natural washes, creeks, to rivers. Beginning from Los Angeles County at SR-14, the water features are Little Rock Wash and Big Rock Wash. Turner, Ossam, and Bell Mountain washes, the Mojave River, and Apple Valley Dry Lake are located in San Bernardino County. Water flows through these features seasonally and are most evident during rain, flash flood events, or snow melts from the San Gabriel Mountains, which occur as runoff. The Mojave River area near the Mojave Narrows has the added distinction of having an abnormally high water table; thus, water is seen flowing year round at this location.

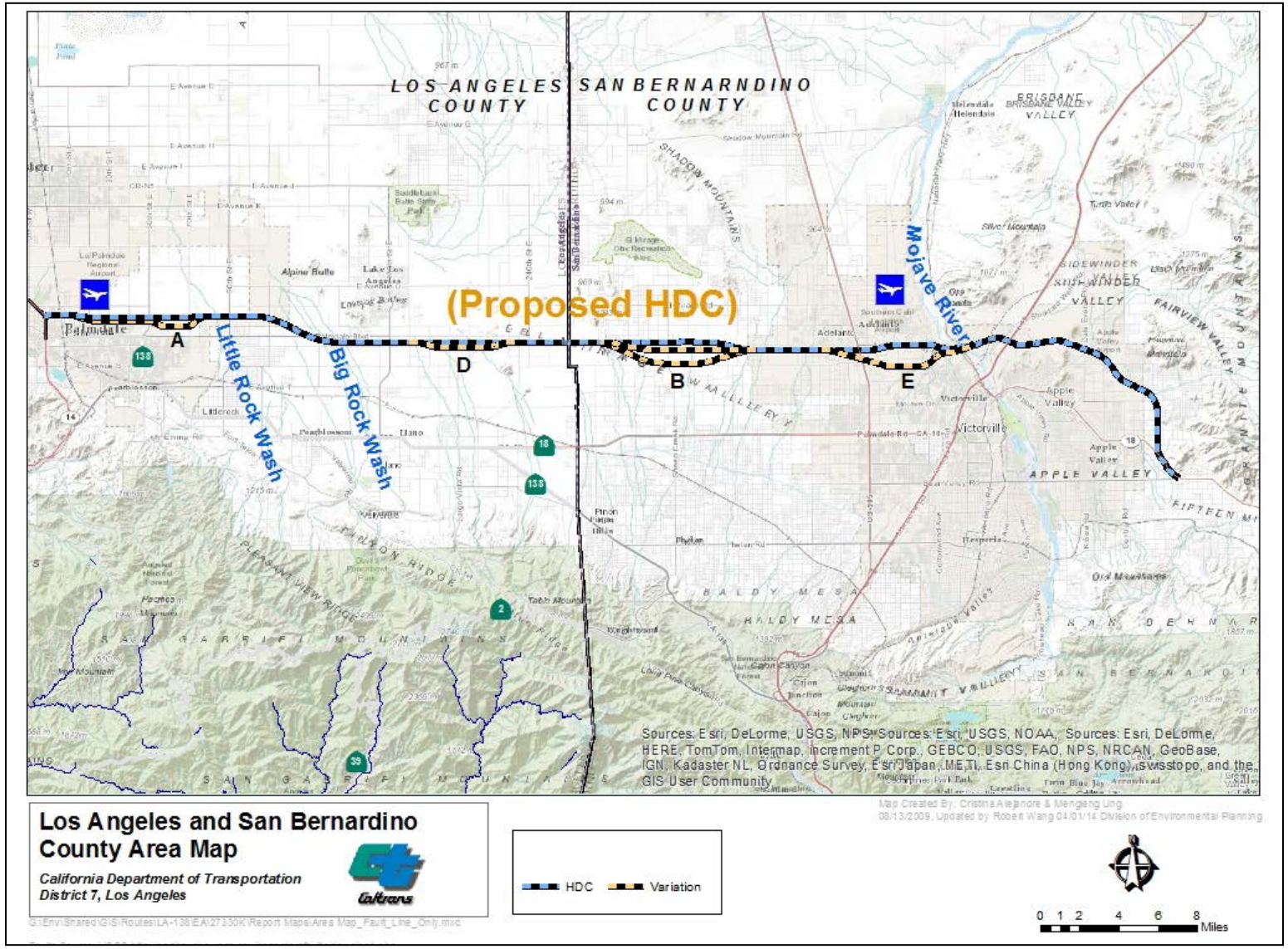
Groundwater

In general, shallow groundwater could be anticipated near the washes, creeks, and rivers for the HDC Project. The source of this shallow groundwater could be from runoff from the San Gabriel Mountains and seasonal variations in rainfall.

The depth to groundwater along the HDC in the Los Angeles County portion of the project is greater than 140 feet. The depth of groundwater along the Los Angeles County segment mostly would be limited to bridge areas along the washes where perched or isolated groundwater zones could be encountered near farmed areas due to irrigation, groundwater injection, and/or construction activities.

Groundwater depth along the HDC in the San Bernardino County segment is described in the DPGR as “deep below” the ground surface in this area. The only exception would be the area of the Mojave River (Mojave Narrows) where the ground water is shallow. However, ground water levels are subject to seasonal fluctuations and may vary over time.

Figure 3.2.3-1 Surface Water near the High Desert Corridor



Rock and Soils

The HDC in the Antelope Valley area is composed of Quaternary alluvium, which consists of sands, silty sands, and gravelly sands. In Palmdale, consolidated rocks make up the mountains and rocky buttes, while alluvial soils are found on streambeds and the valley floor. Pelona Schist underlies most of the mountainous portions of Palmdale. Situated beneath the alluvial soil lies the same hard rocks found in the mountain areas. Older alluvium deposits consist of sand, gravel silt, and boulders characterized by their ability to store and yield water. Hydrology maps show soil types to be from the Antelope Valley Series and the Little Rock Creek Series. Within this classification, the soils are further classified from Type A to D, A most pervious to D least pervious/high runoff potential. Project area soils include Types B, C, and D. Type B soils are characteristic of the alluvial deposits along the creeks and the alluvial fan of Little Rock Creek, while Types C and D are found in the upper watershed of Little Rock Creek.

The Victor Valley area of the proposed HDC consists of several soils, sediments, and rock types. Younger alluvial fan deposits, with bedrock outcrops in the local mountains, of quartz monzonite “granitics” and altered limestone deposits are located near the project area. Soils in the area are from the recent wash alluvium and consist of interbedded braided layers of sand and silts and gravel. Thin layers of caliche, or a weak carbonate cementation, are known to occur in the underlying sands and gravels at depth. In the area of the Sheep Creek alluvial fan, the soils consist of fine sands, silts, and clays with traces of fine gravel from the Pelona Schist from the San Gabriel Mountains south of the alignment. At the Mojave River, it contains sandy soils and a few “granitic” cobbles. Silts and clays may also be encountered on the southern segment of the alignment as it crosses the area of Apple Valley Dry Lake Playa. Hydrology maps show soil types to be from the Mojave River Area Series. Within this classification, the soils are further classified from Type A to D, A most pervious to D least pervious/high runoff potential. Project area soils include Types A, B, and D. Type D soils are characteristic of the alluvial deposits along the creeks and the alluvial fan of Sheep Creek, while Types A and B are found near the Mojave River and Apple Valley areas.

Caltrans Corrosion Guidelines Section 5.5 states that Caltrans considers site’s soils to be corrosive if one or more of the following conditions exist for soil and/or water samples taken from the site:

- Chloride concentration is greater than or equal to 500 parts per million (ppm)
- Sulfate concentration is greater than or equal to 2,000 ppm
- Percentage of hydrogen (pH) is 5.5 or less

Based on laboratory test results from the DPGR for the Los Angeles County segment of the HDC, the soils tested along the HDC may generally be considered noncorrosive with respect to the Caltrans guidelines, with the exception of one location of the Los Angeles County side of the HDC. The mechanically stabilized earth (MSE) wall adjacent to SR-14, just south of the Rancho Vista Boulevard undercrossing sample result, tested as corrosive.

The corrosion potential along the San Bernardino County segment of the HDC is currently unknown; however, based on historical soil conditions and soil types as course grained (sand), it was concluded that corrosive soils are not anticipated to be a design concern. Indicators of corrosive soil conditions are typically wet, fine-grained soils.

Geologic Hazards

Seismic Hazards

The entire southern California region is seismically active due to the influence of several earthquake fault systems resulting from the interaction of the Pacific and North American tectonic 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." The active faults in the study area are capable of producing seismic shaking that could be damaging to bridges and other structures. Potential seismic sources are as listed in Table 3.2.3-1.

Table 3.2.3-1 Potential Seismic Sources

Fault	Approximate Closest Distance to Study Area (miles)	Fault Type	Maximum Credible Earthquake Moment Magnitude*
San Andreas Fault (Mojave Section)	Palmdale Segment - 2.14 Lake Los Angeles Segment - 8.62 Adelanto Segment - 19.22 Victorville Segment - 20.62	Right Lateral Strike Slip (RLSS)	7.8
Helendale Fault	5.21	RLSS	7.3
Northridge Blind Trust	44.51	Reverse (R)	7.3
San Gabriel Fault	29.23	RLSS	7.2
Sierra Madre Fault Zones	27.82	R	6.8-7.2
Simi-Santa Rosa Fault Zones	37.45	Left Lateral Strike Slip (LLSS)	7.0
Santa Susana Fault Zone	41.03	R	6.7
Clear Water Fault	17.04	R	6.8
Cleghorn Fault Zone (Southern Cleghorn Section)	19.78	LLSS	6.5
Mirage Valley	6.75	RLSS	6.9
Lenwood Fault	19.12	RLSS	7.5

*Maximum Credible Earthquake is defined as the largest earthquake that appears to be reasonably capable of occurring under the conditions of presently known "geologic framework."

The nearest active fault to the project area is the San Andreas Fault. The HDC alignment is located approximately 1.5 miles north of the San Andreas Fault at its closest point, as shown in Figures 3.2.3-2 and 3.2.3-3. SR-14 at the Avenue S Bridge is located within the San Andreas Fault (Mojave Section) earthquake fault zone. As the HDC extends eastward towards San Bernardino County, the distance between the project and the San Andreas Fault increases to approximately 20 miles.

The San Andreas Fault is the boundary where the North American Plate and the Pacific Plate meet. The source of seismic activity is related to the tectonic activity of the right lateral movement of the Pacific Plate relative to the North American Plate. Relative movement along these plate boundaries is what causes earthquakes in this area. The San Andreas Fault extends more than 600 miles from the Salton Sea, northwest toward the Pacific Ocean at Point Arena.

The San Andreas Fault system has several fault traces that branch off the primary fault. Local faults that have the potential to influence the project area are faults of the San Andreas Fault system, which includes several major faults considered active by the State. The San Andreas Fault system is a right-lateral strike-slip network of faults, including the San Andreas, Llano, Mirage Valley, Helendale, and Lenwood faults. Any movement from the San Andreas Fault may activate one or all of the subsidiary faults.

Ground Shaking. Ground shaking is the primary cause of structural damage during an earthquake; it is considered to be the most likely damage-producing earthquake phenomenon related to this project. Magnitude, duration, and vibration frequency will vary greatly, depending on the fault and distance from the project area. The High Desert region is subject to moderate to strong ground shaking from local and more distant earthquake events.

The San Andreas Fault (Mojave Section) is the nearest major seismic source to the project area. Based on the moment magnitude of the Maximum Earthquake of 7.8 for this fault, this fault also has the highest average slip rate at 29.0+7.0 millimeters per year.

Liquefaction. Soil liquefaction occurs when saturated loose soils lose their strength due to excess water in the soils. The potential for liquefaction exists when fine silts and sands sit just below the water table. Liquefaction has been documented to affect soils to about 50 feet deep during prolonged periods of ground shaking.

When liquefaction occurs, the strength of the soil decreases and the ability of the soil to support building and bridge foundations is reduced. Liquefaction may result in settlement of the ground surface, additional forces pushing down on foundation piles as a result of soil settlement above the liquefied layers, and reduction of sheer strength of the liquefied soils, resulting in reduced load-carrying capacity. Liquefied soils can also exert pressure on retaining walls, which can cause them to tilt or slide.

Figure 3.2.3-2 The San Andreas Fault near the High Desert Corridor

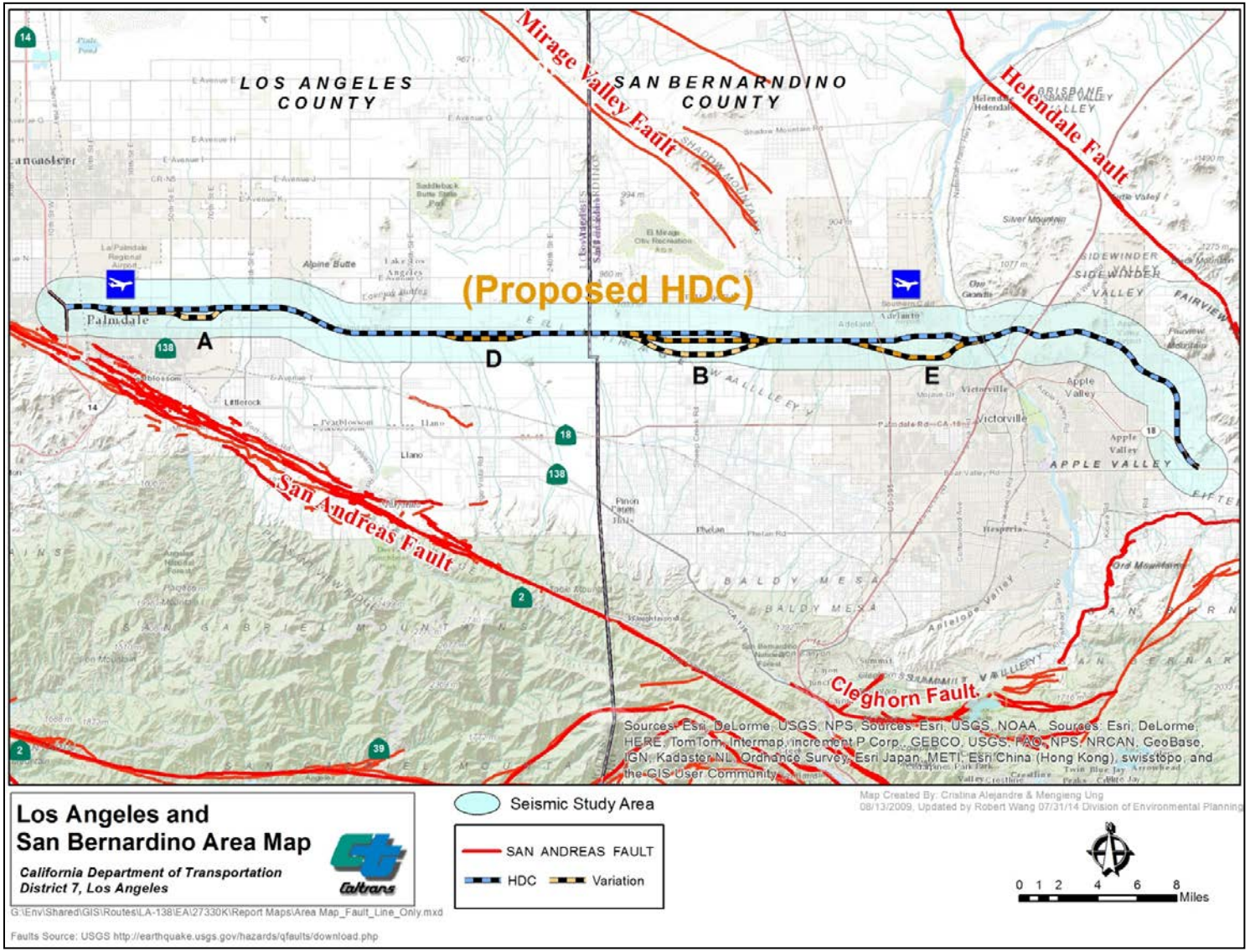
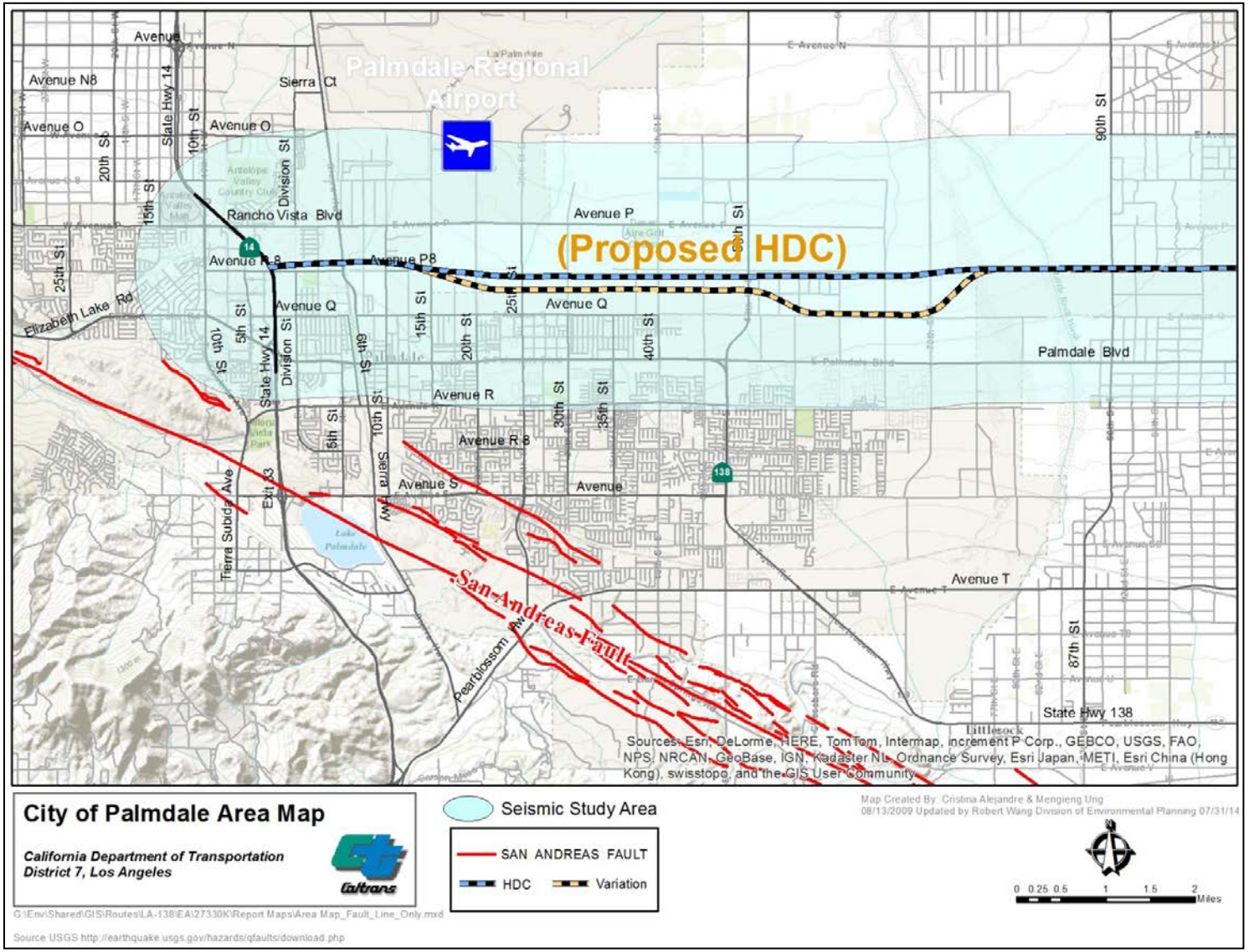


Figure 3.2.3-3 The San Andreas Fault near the High Desert Corridor at Palmdale



The primary factors affecting the possibility of liquefaction in a soil deposit are the intensity and duration of the earthquake shaking, the soil type, the relative density of the soil, the pressures of the materials above the soil, and the depth of the groundwater. Soils most susceptible to liquefaction are clean, loose, uniformly graded, fine-grained sands, nonplastic silts that are saturated, and silty sands.

Based on the analysis results of soil boring/drilling samples taken throughout the HDC alignment, it was concluded that due to the significant depth of groundwater, liquefaction potential is considered low; however, near-surface soils at bridge sites that are crossed by the Mojave River and washes (when flowing) may be susceptible to soil liquefaction hazard during the wet season.

Fault Rupture. An analysis of fault rupture hazard for a particular fault requires that the fault be located exactly and its approximate potential for rupture to be known.

In the Los Angeles County segment of the HDC, the closest well-defined fault trace is the San Andreas Fault, less than 2 miles south of the proposed project at the SR-14/ Avenue S bridge site. This location is considered to be susceptible to fault rupture hazard. Based on preliminary estimates, the median maximum and average horizontal ground surface displacements at this bridge location due to an earthquake of Mmax=7.8 associated with the nearby Mojave Section of the San Andreas Fault may be taken as 30 feet and 16.5 feet, respectively. Other potential bridge locations within the Los Angeles County segment of the HDC are not considered to be susceptible to ground surface rupture or displacement hazard due to fault movements because none of these bridges are mapped in the Earthquake Fault Rupture Hazard Zone except the SR-14/Avenue S Bridge site.

Because there are no known active or potentially active faults that transect the San Bernardino County segment of the HDC or faults contained in an Earthquake Fault-Rupture Hazard Zone, this segment is not considered to be susceptible to ground surface rupture or displacement hazard due to fault movements.

Tsunami. Tsunamis evolve through three overlapping physical processes: generation by any force (e.g., earthquake) that disturbs the water column, propagation from deeper water near the source to shallow coastal areas, and finally, inundation of dry land. Based on the elevated inland location of the High Desert region, the project area is not considered susceptible to tsunami hazard.

Seismically Induced Landslides/Rock Falls. Landslides are rock, earth, or debris flows on slopes due to gravity and can occur in connection with earthquakes. They can occur on any terrain given the right conditions of soil, moisture, and angle or slope.

There are several natural slopes in the area of the Mojave River, and the hills adjacent to I-15. These slopes are underlain by crystalline bedrock and are not prone to natural slope instability or landsliding.

Settlement and Subsidence. Settlement may result from liquefaction. Based on the depth of groundwater and the medium dense to dense nature of subsurface soils in the area, settlement due to liquefaction is unlikely. In addition, because of the dense nature of the subsurface soils, seismic settlement of dry in-situ soils is expected to be negligible.

In addition, because the subsurface soils are predominantly granular, the soils are not expected to undergo consolidation settlement (i.e., settlement over long periods of time); however, the soils can undergo "immediate" elastic settlement, which usually occurs during earthwork activities and shortly thereafter. Elastic settlement is anticipated to range from less than 0.25 to 2.5 inches because of the medium dense to dense nature of the subsurface soils.

Subsidence is the downward movement of ground caused by many factors, such as soils that shrink or expand (e.g., clay soils), vegetation seeking water, leaking drains that soften or wash away the ground under foundations, or collapsing underground structures (e.g., old mines). Because these factors are generally absent in the project area, the occurrence of subsidence along the project corridor is unlikely.

Volcanic Hazards

The nearest volcanic hazard to the HDC Project is the Coso Volcanic Field located within the boundaries of Naval Air Weapons Station in China Lake. Due to the distance of the HDC Project (more than 100 miles from Bakersfield), it is unlikely that any volcanic activity from the Coso Volcanic Field will affect the HDC Project.

Economical Resources/Mineral Hazards

The project area is a source of gravel, aggregate base, and sand as indicated by several gravel and sand quarries. These mineral resources do not pose a hazard to the proposed HDC Project. These gravel and sand quarries are not located in or near the proposed HDC site (refer to Figures 3.2.3-4 and 3.2.3-5); therefore, there is no landslide hazard posed to the resources. Detailed analysis of caving or landslide hazard at the project site will be provided during the design phase of the project. A limestone mine is also located in the eastern portion of the HDC past I-15.

Environmental Consequences

No Build Alternative

Because no ground disturbance would occur under the No Build Alternative, there would be no impacts on geology, soils, seismicity or topography. Existing geologic and seismic hazards would remain.

Figure 3.2.3-4 Aggregate Mines in Los Angeles County near the High Desert Corridor

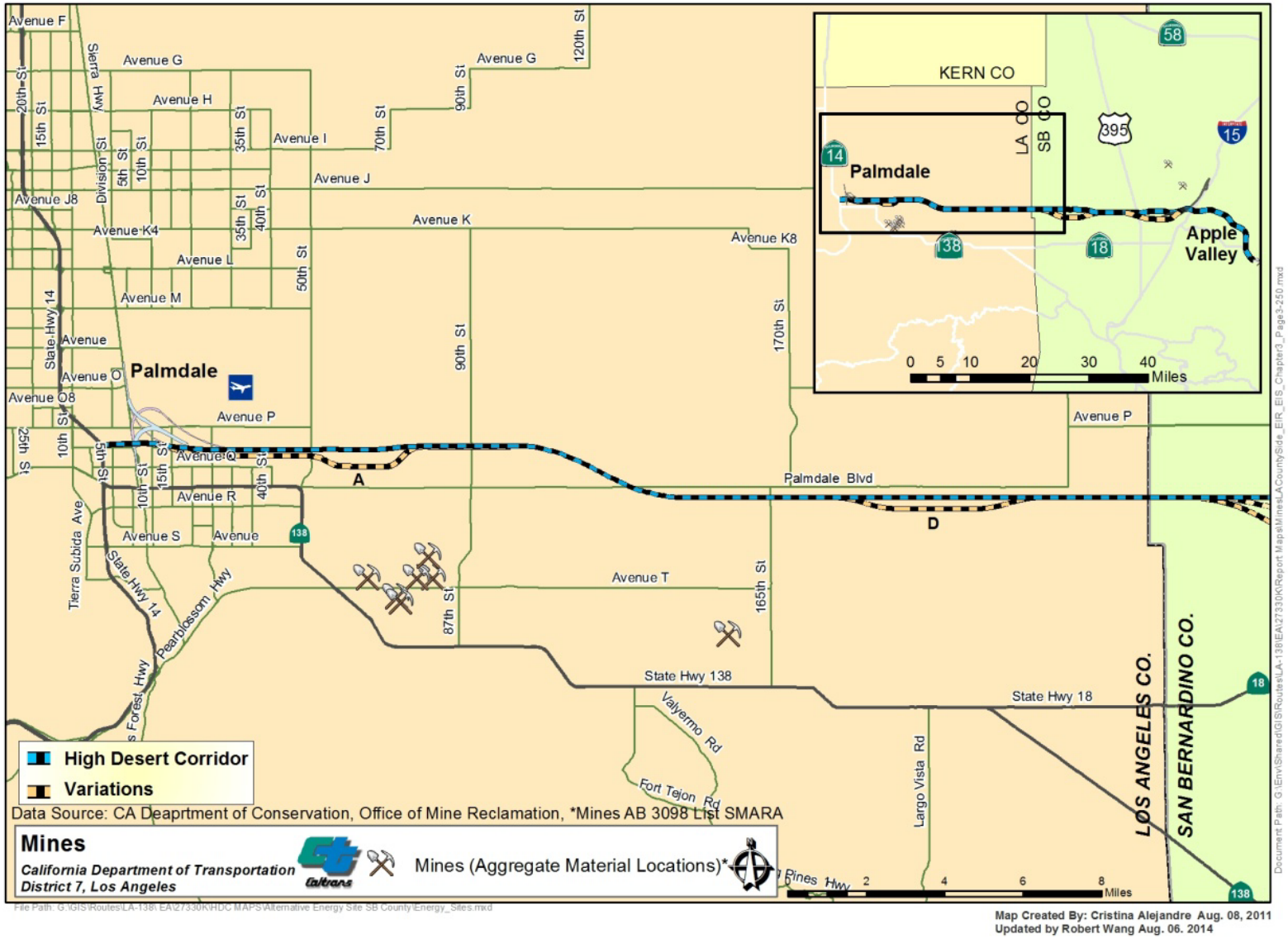
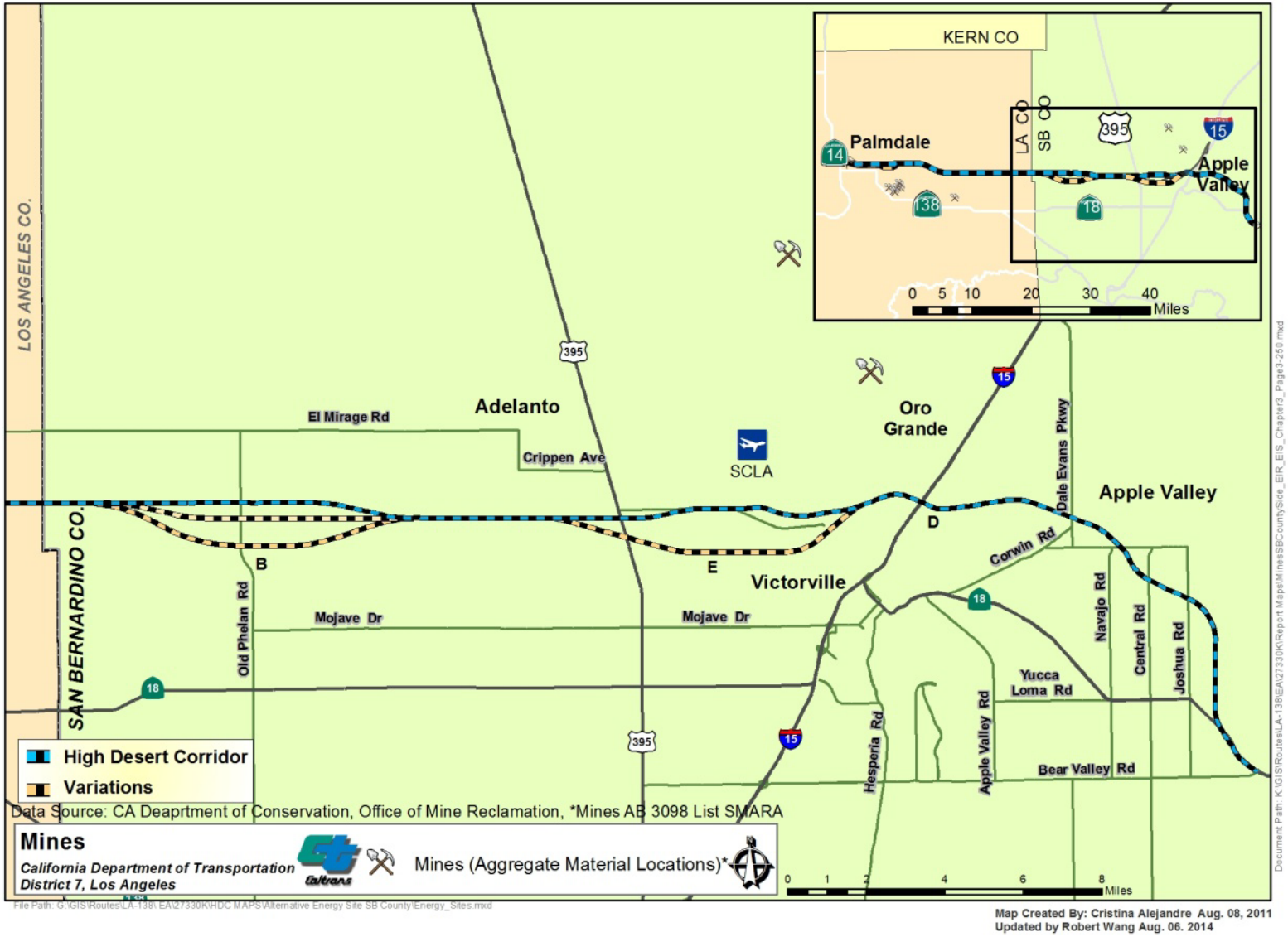


Figure 3.2.3-5 Aggregate Mines in San Bernardino County near the High Desert Corridor



Common to All Build Alternatives

The proposed project alignment is not located within an Alquist-Priolo Earthquake Fault Zone and is not located over a previous well-defined fault trace, with the exception of the SR-14/Avenue S Bridge site. The potential for impacts from geologic and seismic hazards to the components under each build alternative is considered low. In addition, the potential of exposure of construction workers and the traveling public (once the HDC is operational) to these hazards is considered low.

Impacts related to erosion occurring during construction and after completion of the project that may affect the traveling public or the project facilities would be reduced through project design, including the use of appropriate grading techniques such as vegetation, flatter slopes, and jute mesh. Refer to Section 3.2.2, Water Quality and Stormwater Runoff, for additional discussion regarding construction-related water quality impacts and mitigation, including Best Management Practices (BMPs).

Construction of the HDC Project would not affect any designated natural landmarks because there are no officially designated natural landmarks or other major geological features within the project area.

As a beneficial impact, the HDC may facilitate the movement of economic mineral resources (i.e., aggregate base, sand, and gravel) from the area by providing lower transportation costs and easier access for trucks and equipment. It may also facilitate the development of more sand and gravel quarries.

Avoidance, Minimization, and/or Mitigation Measures

Standard Conditions

SC-G-1: During final design, prepare a design-level geotechnical report to identify soil-related constraints and hazards such as slope instability, settlement, liquefaction, or related secondary seismic impacts that may be present along the project segments for consideration in the design of the project. The report shall be prepared by professional geotechnical engineers for review and approval by Caltrans.

SC-G-2: Apply erosion prevention measures, such as hydroseeding of slopes or erosion control mesh, at the fill embankments and cut slopes.

SC-G-3: If blasting is required, prepare and implement a blasting plan to minimize potential hazards related to blasting activities. The blasting plan shall meet applicable standards in accordance with the U.S. Department of Interior, Office of Surface Mining. The blasting plan shall include, but not be limited to, hours of blasting activity, notification to adjacent property owners, noise and vibration, and dust control.

Minimization Measure

G-1: Install Cast-in-drilled hole (CIDH) piles at the two viaducts over Little Rock Wash. Appropriate type of piling at the three connectors at the SR-14/138 interchange, bridge abutment supports, and other supports shall be identified during the final design.